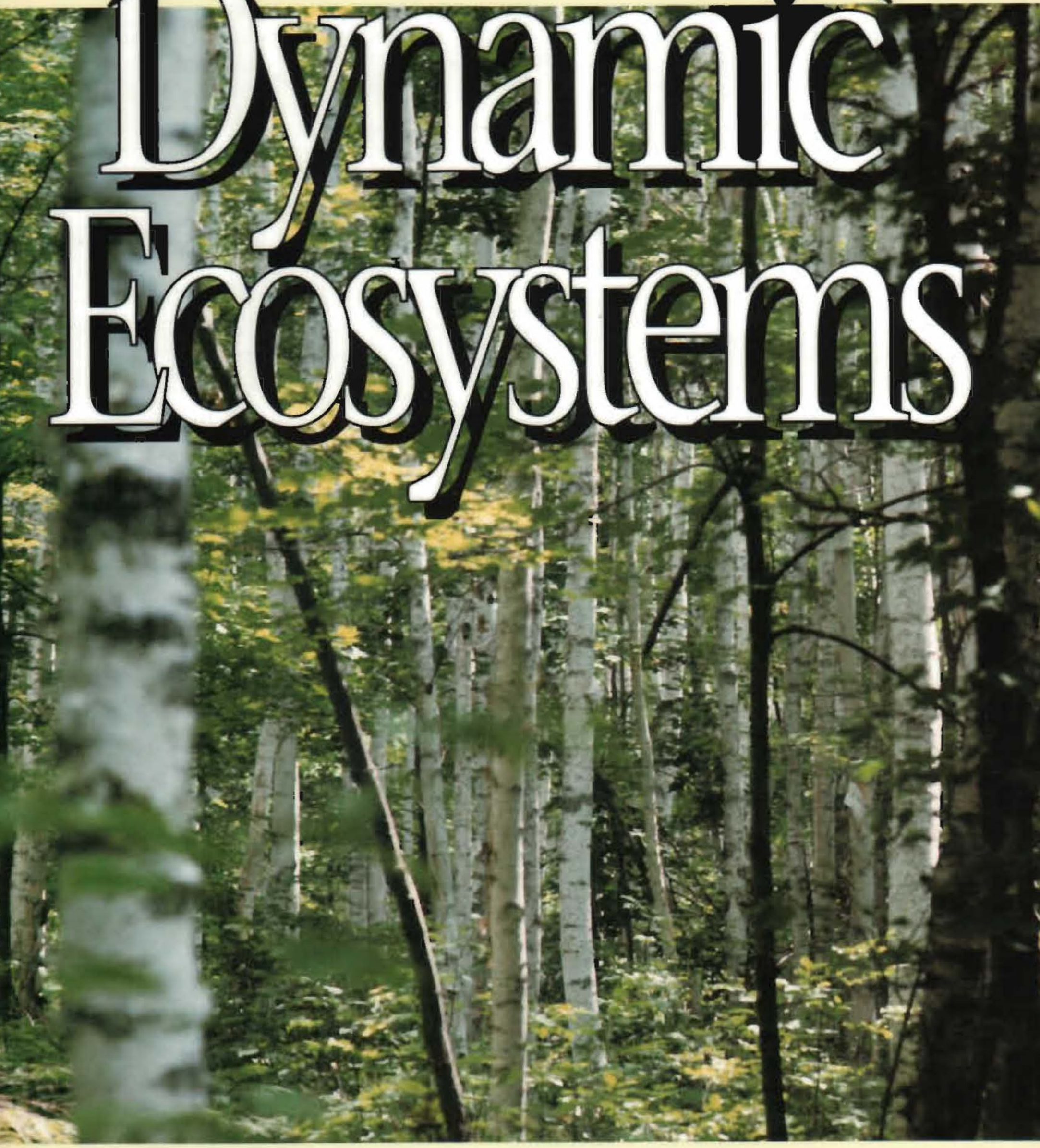
# Management of Dynamic Ecosystems



Proceedings of a Symposium held at the 51st Midwest Fish and Wildlife Conference, Springfield, Illinois

# Management of Dynamic Ecosystems

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# Preface

When the request for 1989 symposium topics was announced, I had just read Chris Madson's (Wyo. Wildl. 5:4–13, 1987) critique of preservation and Iverson's et al. (J. Wildl. Manage, 51:448–458, 1987) paper on the degradation of sandhill crane habitat on the North Platte River caused by stable water flows. During 1985–1987 I studied the decline of aspen in Jackson Hole, Wyoming. While the individual trees were dying from pathogenic fungi, the overriding factors were a stable elk population and fire suppression. Management had temporarily stabilized a system that was not intrinsically stable. Hence was born the major premise for the symposium: that the quality of many of our wildlife habitats has decreased because their renewal is dependent on dynamic events, e.g. fire or flood. Because of man's influence, the frequency and magnitude of these catastrophic events has been greatly reduced.

The title of the symposium was *Static Management of Dynamic Ecosystems* which emphasized the problem. The word "static" was deleted from the title of the proceedings because the authors wanted to stress that change is paramount to long-term productivity. The Yellowstone fires of 1988 certainly raised the level of the debate on natural resource management and focused public attention on the issue. It is hoped the chapters which follow will show how past decisions to achieve stability have affected our wildlife and what needs to be done in the future, both biologically and educationally, to change the situtation.

I express appreciation to members of the North Central Section of The Wildlife Society for sponsoring this symposium, and especially to Wayne R. Porath, Harmon P. Weeks, Jr., and Diana L. Hallett. Henry Campa III and Glenn Belyea are thanked for their work on the publicity committee and Dale Burkett and John L. Roseberry for their superb job on local arrangements. James M. Sweeny guided the peer review process, edited the manuscripts, and coordinated publishing arrangements for the proceedings. Don Meyer made the opening remarks and acted as moderator. The effort and time of many anonymous reviewers of symposium manuscripts are also gratefully acknowledged.

John H. Hart
*Symposium Coordinator*

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# Introduction

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It is always timely to discuss and reflect on the role of ecosystems in our lives and in our society. Ecosystems are dynamic—often times in the short term and always in the long term. We must also recognize that people are a part of the overall ecosystem. Many people generally have a focus on and relate to "what they see now." As you read through the topics in this proceeding continue to keep the publics, their attitudes, and level of understanding well in mind.

Many different perspectives and viewpoints exist today on virtually all subjects—ecosystems and resource management are not exceptions. The purpose of this symposium was to share some of those perspectives. With the 20th anniversary of Earth Day fast approaching (April 25, 1990) and the 1990's being termed the "Decade of the Environment," these discussions are not only timely, but essential.

As professional resource managers or scientists, it is all too easy to get caught up in what Richard Behan once called "The Myth of the Omnipotent Forester" (you can read any discipline or interest in lieu of "forester"). Science and professionalism are critical components as we deal with the ecosystem and resource challenges of the Midwest, the Nation, and the World. However, we need to keep our antennae attuned to the values of society. These values are changing, and in my opinion changing dramatically in a relatively short period of time. These changes have had, and increasingly will have, a significant effect on ecosystems and ecosystem management decisions.

One assumption commonly made by resource managers a few short years ago was that society readily adopted the concept of maximum sustained yield for our forests. Increasingly, this concept is being intensely, vocally, and broadly challenged. As we consider the discussions within this proceeding, we must begin to look at and seriously address some nontraditional values. Sustainable development must include consideration of and objectives for the entire spectrum of ecosystem components—and not just focus on what are huntable, catchable, harvestable, or usable products. Our ecosystems are a legacy we leave for future generations. We all can and should play a key role in nurturing, and maintaining, and improving that legacy.

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# Nothing Is Permanent Except Change

John H. Hart

*Abstract:* The quality of many of our habitats has been decreasing because society has been imposing stability where historically the productivity of these areas has been renewed by dynamic events such as fire or flood. Man has greatly reduced the frequency and magnitude of these catastrophic events. Fire and flood suppression have accompanied the concept of maximum sustained yield from our forests and agricultural lands. In addition, these lands may have received other management designed to further stabilize the desired outputs. Change, however, is often paramount to long-term productivity. The health of some ecosystems, particularly from the viewpoint of wildlife, is now in question because of the lack of change. How we nurture the public's acceptance of change will be a major challenge of the 1990's.

*The world hates change, yet it is the only thing that has brought progress.*
—*C. F. Kettering*

If Kettering is correct, and I believe he is, why does mankind resist change, especially in the management of our wildlands where change is inevitable? Why are many of our management activities aimed at stabilizing ecosystems when we should be welcoming natural change? Madson (1987) pointed out that "The places we have chosen to preserve are special to us—we do not want them to change. We fail to recognize that change is at the root of all natural systems. No matter what we do to protect our parks and wilderness from man-made changes, we have no choice but to watch them change, often drifting away from the near perfection we were originally trying to protect."

Another problem is the length of our perspective. The whole nature of our society is short-term oriented. Thus, our natural resource management agencies are faced with a nearly impossible task. They must keep the ecosystem intact for the long term while satisfying the immediate interests of a widely varied public.

We must have long-term ecological stability even if it means "biting the bullet" in the short term. We must lengthen our perspective so that our actions are self-perpetuating rather than self-destructive. Resisting natural change through human intervention is not maintaining the status quo, which is what many preservationists believe, but rather the opposite (Lewin 1986).

An additional problem is political reality which often dictates the sacrifice of long-term resources for short-term gains. As natural resource managers we may embrace the "let nature take her course" philosophy for political reasons. Then when something goes wrong, the agency can always blame "nature." For the most part doing nothing is easier than doing something, especially if that something (e.g., prescribed burning) carries a significant risk with it. However, I am firmly convinced that the future of maintaining productive wildlife habitats lies in purposeful disturbance—not protection from perturbations.

The last problem, and perhaps the most important, can best be described by the words of Strother Martin in the famous scene from the movie, *Cool Hand Luke:* "What we have here is a failure to communicate!" We have plenty of technical information, although more would be desirable. The problem is one of technique and skill in getting the information across. The public, as well as natural resource professionals, must have better access to accurate information.

Part of the communication problem is that there has been a gradual erosion of public respect for natural resource professionals. We have lost credibility. How do we expect the public to listen to us when half of us condemn the Park Service and Forest Service for the great Yellowstone fires of 1988, while the other half defend them as natural events leading to the rebirth of the ecosystem?

## Fire

Since man alone can create fire or extinguish it deliberately, we have a unique responsibility to manage fire and its effects. Fire is a profound biological event and has been a dominant fact of forest history (Spurr and Barnes 1973). The great majority of the temperate forests of the world have been burned at more or less frequent intervals for many thousands of years. In fact, many terrestrial environments have been shaped by fire, especially anthropogenic fire. Fire, or the lack of fire, is the foremost medium through which mankind has modified the natural environment. The fact that mankind can alter a landscape as much by excluding fire as by introducing it has only recently been understood. Fire suppression reduces litter decomposition, slowing down the nutrient cycling of many ecosystems and making possible future fires of holocaust proportions as well illustrated by the Yellowstone fires of 1988. Thus the refusal to tolerate small, low-intensity fires tends to be self-defeating.

Fires caused by lightning should be considered as important an element of climate as rainfall and temperature. Lightning fires have occurred in almost every terrestrial environment on the globe, contributing to a natural mosaic of vegetation types. Approximately 44,000 thunderstorms and 8 million lightning flashes occur daily around the world (Williams 1988). In the United States 10,000 forest fires are started annually by lightning. The persistence throughout geologic time of lightning fires has no doubt led to the evolutionary development of pyrophytes and plants which depend on frequent fire for their existence. Such ecosystems do not merely tolerate fire but require it at periodic intervals. For example, jack pine (*Pinus banksiana*), with its serotinous cones and volatile flammability, creates a fire-susceptible environment highly favorable to its perpetuation.

## Prescribed Fire

In 1902 the San Francisco *Call* published a letter and editorial attacking the protectionist policy of fire control because it allowed fuel hazards to accumulate (Pyne 1982). The consensus among foresters, however, including those within the Forest Service, was that forestry would be impossible if any fires were tolerated.

In the 1930's the tide began to change. Manuscripts prepared at the Southern Research Station in 1933 showed the value of controlled fire in wildlife management, but publication was suppressed until 1939. By the 1970's the forestry profession, including the Forest Service, asserted with equal conviction that forestry and land management would be impossible if prescribed fires were excluded (Pyne 1982). By this time it was recognized that the absence of fire modified an environment as much as the presence of fire.

Literature on prescribed burning for wildlife is voluminous, and numerous studies documenting the effects of wildfires on animals and their habitats have been conducted. Prescribed burning is by far the best and most cost-effective method of achieving certain habitat improvement objectives. Yet land managers are becoming increasingly concerned with public acceptance of prescribed burning and public perception of burned areas. Certainly an anthropogenic fire that escaped its prescription could do irreparable political damage to the idea of prescribed burns. Negative effects on public use of burned areas may have greater weight politically than positive ecological results. These restrictions, plus administrative constraints involved with using fire, especially when done primarily for wildlife habitat modification, will continue to hamper management of species dependent on a fire environment.

There is probably no technique that can be used in the Lake States in the management of ruffed grouse (*Bonasa umbellus*) or white-tailed deer (*Odo-*

*coilus virginianus*) that equals the total benefits to be gained from the wise use of fire (Gullion 1984). Forest and shrubland succession have degraded many bighorn sheep (*Ovis canadensis*) ranges (Risenhoover et al. 1988). In addition to improving habitat visibility for sheep (Etchberger et al. 1989), fires may increase forage quantity and quality.

In addition to using prescribed burns as a method of reducing high fuel loads, I believe fire should be used as a pro-active management tool in all areas to allow the many species of plants and animals that have evolved with fire to thrive. Prescribed burning may be more generally accepted than land managers sometimes believe. Taylor and Daniel 1984 reported that the public they surveyed was reasonably well informed about, and tolerant of, prescribed burning.

There are, however, 2 major problems with prescribed fire: smoke and escape. The 1980 Mack Lake fire was a prescribed fire set by the Forest Service to improve habitat for the Kirtland warbler (*Dendroica kirtlandii*), an endangered species. The warbler requires stands of jack pine at a certain stage of development (Niemi and Probst, this proc.). The fire escaped control and burned nearly 50,000 acres, numerous homes and took 1 life. In 1976, a lightning fire began on the Seney National Wildlife Refuge in the Upper Peninsula of Michigan. The fire was treated as if it were a managed natural fire. The fire eventually left the refuge and burned thousands of acres of private and state lands. These fires, as well as the Yellowstone fires of 1988, have shown that with the restoration of a wild environment the potential for large fires has also been restored.

While beneficial, prescribed fire is very dangerous and should be managed with respect and responsibility. Errors were made in the setting or management of the fires just mentioned. Disastrous errors occasionally occur in air travel, too, but man continues to fly. The total benefits of using prescribed burning for fuel reduction or for desired ecological change outweigh the rare errors associated with its use.

## Yellowstone Fire

The Yellowstone fires of 1988 brought to the forefront the role of fire in perpetuating and maintaining wilderness ecosystems. The last fire to rival the 1988 fire in intensity in the Yellowstone area occurred in the early 1700's. Before the establishment of Yellowtone Park in 1872, fires of moderate size commonly occurred every 20–25 years. Many of these fires were believed to be of anthropogenic origin, suggesting that a truly natural approach would be to include in any management plan fires set by man. In 1886 the Park Service began a program of total fire suppression. This continued until 1972 with the introduction of the policy which stated that when fires pose no threat to life or structures and are naturally occurring, they will not be suppressed.

A century of fire suppression resulted in accumulation of much downed and standing fuel. Successional changes in fire-adapted vegetative communities diminished the value of these communities as wildlife habitat. As ecologists are prone to state, the fires "reset the successional clock." The Yellowstone fires, burning with different intensities for a myriad of reasons, left a mosaic of burned and unburned timber, creating a patchwork of openings in the monotonous sea of conifers. The vigorous regrowth of grasses, forbs, and shrubs springing up from the burns will provide greatly-improved habitat for the park's herbivores.

Birdlife has been and will be affected both positively and negatively by the fire. Raptors were attracted to the area and a feeding frenzy occurred as hawks took advantage of fleeing and displaced prey. Sandhill cranes (*Grus canadensis*) and great blue herons (*Ardea herodias*) were seen seeking prey in the meadows just in front of the fires. Both the three-toed (*Picoides tridactylus*) and black-backed woodpeckers (*P. arcticus*) will increase in numbers, at least temporarily. Species dependent on old-growth vegetation, e.g. boreal owls (*Aegolius funereus*), will likely decline in numbers.

Woody fuels cannot be expected to accumulate forever in a semi-arid environment where natural decay occurs slowly and lightning storms are common. If the fires had not occurred in 1988, they probably would have happened sometime soon anyway. If any wild area receives a drought as Yellowstone did in 1988, it will eventually burn (Barrett 1988), regardless of precautions or politicians.

Tourism suffered little, if any, in Montana, Idaho, and Wyoming. Supplies for firefighters were purchased locally whenever possible, which translated into a boom at the cash register for some businesses. The driving public flocked to Yellowstone in the autumn of 1988 in record numbers, probably to see the effects of the fires. In 1989, people continued to flow into Yellowstone in record numbers. Wyoming tourism officials promoted the blaze at Yellowstone into 1989's top tourist attraction, noting a once-in-a-lifetime opportunity to observe nature's awesome ability to respond to cataclysm. But in the final analysis, is it more important to maintain smokeless vistas and a high tourist count, or to allow the continuation of natural processes which created Yellowstone?

## Educating the Public About the Role of Fire

Ecologically the burned landscape in Yellowstone may or may not be new; culturally, however, it is unprecedented. The biggest negative effect of the fires may be the public's misconception about the actual damage done by the fires, thus creating a political backlash that could threaten the wise use of fire in forest ecosystems. Yellowstone was probably hurt more by a public relations nightmare than by the fire itself. We must not return to the old mentality of suppressing all fires regardless of their potential environmental benefits.

Since the fires have been laid to rest, the media, especially the print media (e.g., Jeffery 1989), have tried to present a more balanced view. Park officials are developing a video game to give the public a better understanding of the fires. The Rocky Mountain Elk Foundation and the U.S. Forest Service produced a video tape, *Fire and Wildlife, the Habitat Connection,* which shows the positive use of fire in our wildlands. Several pamphlets outlining the role of fire in wilderness ecosystems were written and distributed to park visitors beginning in the summer of 1989. An educational exhibit on the 1988 fires was developed and is now a permanent part of the visitor center in Grant Village in Yellowstone. Donations from children are being used in Yellowstone to finance a "Children's Fire Trail" through both burned and unburned areas that will be used to educate children on the effects of fire on forests.

These educational undertakings may be the most important fallout of the fire. A survey in Wyoming indicated that only 9% of the respondents showed an awareness that there are any ecological benefits from forest fires (Thuermer 1989*a*). Even recreationists who recognize the ecological benefits of fire have been known to show a bias toward suppression (Nielson and Buchanan 1986).

If the public generally is ignorant about wildfires and their environmental effects, perhaps Smokey Bear may be partially to blame. The long-term promotion of fire suppression programs, such as Smokey, needs to be recognized as a significant contributor to fire hazards. To the credit of the Forest Service, its members on the federal task force studying federal fire policy supported the idea of letting natural fires burn in parks, wilderness and wildlife refuges. Now the Forest Service wants to change Smokey's image from "all fires are bad" to "natural fires may play a beneficial role in forests but human-caused fires remain taboo." While this is a step in the right direction, are we not making the use of prescribed fire even more difficult?

For more than 40 years Smokey's message has been "Only you can prevent forest fires." To change that message now to "Natural fires are good (sometimes) and anthropogenic fires are bad (sometimes)," is going to be a very difficult task. I am afraid I must agree with the Red Queen in Lewis Carroll's *Alice in Wonderland,* who said "It's too late to correct it. When you've once said a thing, that fixes it, and you must take the consequences." The "consequences" in this case are that Smokey has outlived his professional usefulness and should retire gracefully. The *Washington Times* quoted William Penn Mott Jr., recently retired head of the National Park Service, as stating "Even the Forest Service admits Smokey Bear is no longer valid."

Several studies (Stankey 1976, Cortner et al. 1984, Nielsen and Buchanan 1986) have shown that as the public becomes aware of fire ecology, it becomes more receptive to fire-management policies, even controversial ones. There is a significant relationship between the public's fire knowledge and its tolerance of fire in forest ecosystems (Stankey 1976). Those of us in the natural resource management profession must become better at educating the public about the role of fire in forest ecosystems. The time is right to gain public support for fire management in the United States, but it will require a major communication effort (Reeves 1989). I strongly recommend the position statement on fire of the Society of American Foresters (J. For. 1989, 87(5):56–58) as an excellent document with which to begin the educational process.

In its December 1988 report, the Federal Fire Policy Review Team (Deps. Agric. and Inter.) stated that natural fires should be allowed within proper constraints. The team also recommended that the agencies use prescribed burning to complement managed natural fire programs. Interior and Agriculture endorsed the team's report as a long-range plan for national parks and wilderness areas. However, until local area managers can rewrite their fire management plans to reflect the new policy, all fires will continue to be suppressed from the moment of detection.

## Grassland Ecology and Fire

Except for the area west of the 100th meridian where the short-grass plains were more or less determined by climate, nearly all the grasslands in North America developed because of frequent fire, generally of human origin. In some areas, particularly where the land was well drained, oak or pine savannahs developed following fire. Following European settlement of the Midwest, most of the warm-season grasses were gradually destroyed by domestic-livestock grazing and cultivation. When the burning stopped as a result of farming, the land reverted to brush and trees. Areas that remained in grasses were often converted to cool-season grasses and were sometimes invaded by exotic species.

During the last decade there has been increased interest in reestablishing warm-season, native grasses such as switchgrass (*Panicum virgatum*), big blue stem (*Andropogon gerardii*), and Indian grass (*Sorghastrum nutans*). The attractiveness of these grasses, particularly for ring-necked pheasants (*Phasianus colchious*), depends on frequent burning to stimulate new growth. Warm-season grasses have evolved to respond favorably to early spring fires and should be burned every 3 to 5 years. Land managers should be aware of the importance of fire in management of these species. Many avian species, some of which have declined precipitously as the prairies have been destroyed or fragmented, are dependent on grasslands for survival (Ryan, this proc.). Burning tallgrass prairies at least every 3 years decreased rates of nest predation and brood parasitism for 5 bird species compared to areas less frequently burned (Johnson and Temple 1990). Prescribed burning of large grasslands is a cost-effective management technique for improving range quality for antelope (*Antilocapra americana*) as well as for other prairie animals (Courtney 1989).

## Flood

Fire and flood share many similarities. Not least among these resemblances are the environmental problems that have been experienced in recent years as a result of protection efforts (Pyne 1982). Impounding rivers or regulating water levels in lakes for the dual purposes of flood prevention and crop irrigation is analogous to managing fire in order to eliminate wildfire and to introduce prescribed burning.

Fire and flood do differ in several important respects. To the best of my knowledge no one has ever suggested, much less conducted, a "prescribed flood." Fires can be started by man; floods generally cannot.

Sandhill cranes and piping plovers (*Charadrius melodus*) illustrate dramatically the costs to wildlife when floods are reduced and water levels held constant. The life histories of both species are tied to the historic qualities of rivers. Without frequent flooding to scour sand bars of woody vegetation and regular deposits of silt and sand to maintain those same bars, the birds' habitat will deteriorate.

Areas devoid of woody vegetation on the North Platte River are the principal roost habitats used by sandhill cranes during spring migration (Iverson et al. 1987). Numerous water diversion projects along the Platte and North Platte rivers have reduced the flow of the river by 70%, eliminating the annual floods which created the open sandbars (Krapu et al. 1982). Woody plants have invaded the flats where the cranes like to stand. Cranes roost on these open sand bars during their annual migration, taking advantage of the protection from predators provided by such sites. The broad shallows and sandbars present before the many reservoirs were built have largely been replaced by deep channels and thickly-wooded islands. The only prudent course of action now appears to be an active management program to mechanically remove the woody vegetation from the sandbars in order to provide needed river roosting habitat (Iverson et al. 1987, Krapu et al. 1982).

Piping plovers are specialized for wide beach habitat or similar unvegetated areas (Lambert and Ratcliff 1981, Gaines and Ryan 1988). Narrow beaches or those with too much or too widely-distributed vegetation are not suitable for plover nesting. Both sandbars and beaches are dynamic habitats balanced between intermittent disturbance and vegetational succession. Severe storms, fluctuating water levels, and ice scouring are all natural disturbance factors without which plover nesting habitat is reduced. In the absence of these natural disturbance factors, prescribed burning, herbicide application (Gaines and Ryan 1988), or mechanical removal of vegetation (Tom Allan, Lake Superior State Univ., pers. commun.) might be used.

## Wilderness

"Wilderness" is a relative term, one defined in relation to human values and not according to some absolute natural standard. Wilderness areas should be protected in support of natural processes and for their aesthetic and recreational values. "Wilderness areas are assumed to represent natural templates against which man-made imbalances can be measured; genetic banks, where natural species and natural ecosystems retain molecularly coded wisdom acquired over eons of evolution; unspoiled sanctuaries, aesthetically pure and uncontaminated by the impediments of civilization" (Pyne 1982).

The term "wilderness" has 2 very different meanings. From the time of the pilgrims to Teddy Roosevelt, wilderness was an antagonist in need of "taming." The preservation-versus-development debate was highlighted by the public quarrels between the first chief of the Forest Service, Gifford Pinchot, who believed in development of resources, and naturalist John Muir, who called for much of the public land to be preserved intact. Gradually wilderness acquired a complimentary rather than a negative image, at least with a significant segment of the American population. When Lyndon Johnson signed the Wilderness Act on 3 September 1964, he set aside 9 million acres to remain pristine. Today the Wilderness system includes almost 91 million acres in 44 states. It is now something to be preserved, restored or even created; a place to remain untrammeled by man.

We should be thankful that we can afford wilderness areas where natural processes, including fire, can hold sway. Through wise management of the majority of timberland, we can produce an abundance of timber products and all the other less tangible but equally important outputs.

## Manage Nature or Let Nature Alone?

Are wilderness areas places where nature will be left to run her course or are they to receive planned management to prevent exploitation, destruction, or neglect? Phrases such as "wilderness preservation" (Robinson, this proc.), "permanent preservation" (Niemi and Probst, this proc.), and "presettlement conditions" (Haney and Apfelbaum, this proc.) mean different things to different groups. No matter what we do or do not do, these areas will change. We cannot encase them in glass and "freeze" the ecosystems forever as they are now. Wilderness is not a static state but a continually-changing state of nature.

Peyton (this proc.) asks an excellent question: "If a group proposes wilderness protection, what values are they trying to protect?" Many environmentalists have suggested that we return to "presettlement conditions." Exactly why we should want to do this is unclear to me, but it probably has something to do with reducing our guilt about the changes we have made since settlement. But more importantly, to what date do we wish to return? Do those who espouse this concept believe that environmental conditions were constant from the last glaciation until the white man arrived on the scene? The bison (*Bison bison*) crossed the Mississippi River about 1000 A.D. and had reached Massachusetts by the 17th century (Roe 1970). This expansion was largely facilitated through the presence of anthropogenic fire which created the eastern prairies and open oak savannahs. The conditions of 1700 A.D. were different from those of 100 A.D., but there is nothing more pristine about 1000 than 1700 or any other date one wishes to choose. To discriminate between influences of climatic change, natural fire, and aboriginal fire is all but impossible. Besides, we cannot go back, even if we wished, and even if we knew precisely what the conditions were, which we do not.

Changes are occurring in our wild areas due to the backcountry recreational boom. "Powered by granola and gorp and carried along by Kelty packs, avid outdoorsmen and women have left their Vibram imprints throughout the countryside" (Thuermer 1989*b*). Much of the degradation comes from those who treasure the country the most. Vegetation in and around campsites has been decimated (a striking example is the Boundary Waters Canoe Area in Minnesota), trails have become eroded, noxious weeds introduced, and meadows grazed to the stub. Some of these ills may be mitigated by a permit system, limiting access to the more popular sites (already in place in some areas), but restrictive permits run counter to the "freedom value" of wild areas.

### Fire and Wilderness

Profound questions remain about fire management in wilderness areas. Wildfire is both inevitable and important in wilderness areas. Lightning fires, an essential component of any environment managed in a natural state, have been incorporated into most land management plans in the last several decades. But whether we apply or withhold fire, we cannot avoid the responsibility for fire management.

As outlined by Robinson (this proc.) neither total suppression nor total non-interference with fires is a realistic alternative. Thus, wilderness areas will follow a course of "planned management" rather than nature being allowed to "run her course." Both modified suppression and prescribed burning should be viable options under this scheme of management. However some oppose prescribed burning as "unnatural." Man makes a distinction between natural and anthropogenic fires; nature does not. Surprisingly, many who want to return to "presettlement conditions," conditions which were markedly influenced by anthropogenic fires, are those most opposed to prescribed fire, considering it to be an intrusion by man.

Simply eliminating fire control will not re-create a natural fire environment. The lack of supression of lightning fires does not mean the landscape will return to pre-Columbian appearances. The return of natural fire to wildlands is less likely to restore an ancient landscape than it is to fashion a landscape that never has existed before. Many landscapes are a direct result of Indian fire practices, and their effects cannot be dismissed. Studies of fire scars in pines growing in northern Minnesota reveal that major fires occurred in 1714, 1803, 1811, 1820, 1865 and 1886, before protection arrived in 1894 (Spurr 1954). These fires were said to be purposely set by Native Americans to kill the timber and to create better foraging areas for moose and deer (Spurr 1954). The natives knew that an unbroken expanse of mature forest produced little game.

## Forest and Wildlife Management

Clements (1916) described an orderly process of progressive change (succession) heading to a stable plant community (climax vegetation). The role of disturbance as a normal, recurring influence on the structure and maintenance of numerous plant communities was not emphasized (Abrams and Scott 1989, Patterson 1986). Yet ecologists recognize that changing climate and recurring natural disturbances make attainment of the climax state more an oddity than the norm (Patterson 1986). Destructive events (e.g. fire, windthrow, and insect and disease outbreaks) that are improbable in the short term are inevitable with time (Harris 1984). Forest ecosystems are dynamic, continually changing in time and space.

## The Clearcutting Debate

All those involved in this debate should realize that humans have been dramatically influencing forest development for thousands of years. Houston (1989) has succinctly and aptly described the problem: ". . . the general public tends to judge the present forest by assessing the amount of change that has occurred versus memory's snapshot of how it should look. This view often expresses the notion that the forest is a gift from some long-ago guardian who kept it virginal and ready to pass along in an ageless state, full of grace and beauty. Any change is regarded with suspicion. Sudden change is anathema." On the other hand, to the forester "change is accepted with clinical nonchalance as inevitable. Sudden change can be downright economically attractive."

Clearly political strategies and biology have become so inextricably tangled that participants in the clearcut management drama seem uncertain of where science ends and politics begin. Environmentalists, through appeals of forest management plans, have greatly reduced the amount of clearcutting because they believe it to be incompatible with recreation, wildlife, and how a place should look. For example, the Jackson County Board (Ill.) has called for a ban on clearcutting of timber in the Shawnee National Forest. A preservationist group, the Regional Association of Concerned Environmentalists, contends that clearcutting ruins the forest for recreation and hunting and is harmful to oaks and other hardwoods. One group, Lighthawk, even placed a full-page ad in the *New York Times* requesting donations from readers to help fight clearcutting. The Forest Service counters by saying that clearcutting can be healthy for hardwoods and wildlife when properly done. However, to most of the public, who knows little or nothing about forestry, trees are pretty and clearcuts are ugly.

The political arena is as muddled as ever. Rep. John Bryant (D-Texas) has introduced legislation which would severely restrict clearcutting on many national forests. He believes the practice is irresponsible and wasteful. On the other hand, Rep. Jim Chapman (D-Texas) is a proponent of clearcutting even if it means destroying a red-cockaded woodpecker (*Picoides borealis*) colony. He says he does not care if the woodpecker becomes extinct; "Humankind can get along just fine without this bird."

The answer to the clearcutting question is ambivalent. Clearcutting is a valuable forest management tool and, in some cases, is vital for maintaining habitat for certain wildlife species. It is equally true that clearcutting has been done improperly in certain areas (Smith 1987). Some unfragmented forest stands are necessary components for some wildlife species (Thomas et al. 1988).

Fire suppression and certain other forest practices (e.g. plantation management) have resulted in the development of forest communities that never existed or only rarely occurred. Along with the resulting unnatural combination of tree ages and species have come serious problems of insect pests and diseases. Historically fire provided a self-correcting check on insect and disease outbreaks (Hawksworth and Johnson 1989, Swetnam and Lynch 1989). However, many forest stands will continue to be managed primarily for wood fiber production with fire generally excluded. From both a biological and an economic perspective, clearcutting is a viable substitute for fire as a pest-reduction tool. For example, southern pine bark beetle (*Dendroctonus frontalis*) is most effectively controlled by cutting the infested trees and other pines within an 80-foot area around each infestation. Other examples in which clearcutting is an effective control strategy are dwarf mistletoe (*Arcethobium* sp.), spruce budworm (*Choristoneura fumiferana*), and jack pine budworm (*C. pinus*).

To many people burns created by natural fire are great but clearcuts made by man are abhorred. The mosaic left by the Yellowstone fires, for example, is touted as a boon to the Park's wildlife. Show the same people a similar patchwork of clearcuts and they respond negatively (Langenau et al. 1977). It is important for these individuals to realize that clearcuts can be very similar to fire in terms of their effects on ecosystem processes. This phenomenon should also be borne in mind by some in the forestry community who denounced the fires of 1988 but who have traditionally defended clearcutting.

Timber harvest plans should be based on the best available information, tempered with professional judgment. The potential consequences, both biological and economical, of each management action should be weighed carefully. Decisions which are sound biologically should not be compromised for political expediency. Both fiber and wildlife are products of the forest; clearcutting, like prescribed fire, is sometimes a useful tool to produce more of both outputs.

## Wildlife Management

Elk management in northwest Wyoming vividly illustrates how static management can lead to instability in the total ecosystem. The situation there appears similar to the acacia-elephant interaction recently described by Lewin (1986). The aspen-elk interaction has been succinctly outlined by (DeByle 1979). The large stands of aspen owe their existence to a confluence of events at the end of the 19th century. Aspen is a clonal species that regenerates primarily from root suckers following fire. Much of northwest Wyoming burned in the 1880's, resulting in vast stands of relatively even-aged aspen. Unregulated hunting at that time plus the severe winters of 1889–1891 and 1909–1911 resulted in low elk numbers. The National Elk Refuge was established near Jackson, Wyoming, in 1912. Regulated hunting seasons, predator control and the winter feeding program have allowed the elk population to increase. But more importantly these practices (especially the winter feeding program) have prevented the historical fluctuations in the elk population. The result is a stable elk population.

As the elk and other herbivore populations increased and stabilized, the browsing pressure caused the deterioration of the mature aspen and prevented aspen suckers from growing above the browse line (Krebill 1972, Hart 1986). The decline in the aspen communities resulted in a reduced beaver population. Preventing change in the number of elk over the short term resulted in community degradation and a decrease in species diversity.

The coexistence of a large, stable herbivore population and thriving aspen stands appears impossible. For the two to occur together we must allow periodic, severe perturbation of the system. Keep the elk populations stable and suppress fire, and the aspen stands will disappear, reducing overall diversity. That, of course, is precisely what is and has happened in western Wyoming. The land managers in that area have tried to stabilize an ecosystem that is intrinsically unstable. The irony of the situation is that to achieve the stability they are aiming for they must allow fires to burn and the herbivore populations to fluctuate. Whether that is politically possible in the short run is questionable, but in the long term it is essential.

## Epilogue

An old German legend has it that a man named Faust made a deal with the devil for youth, sex, wealth, and other desirable things on a credit card basis. That is, he was to have immediate enjoyment of these goodies and at the end of 24 years could pay for them with his soul. This, in my opinion, is the philosophy that has guided the management of the nation's wildlands for the past half century. Our thinking is that we will take from next year's biomass to pay for some need of the current year. While this may succeed for a while, we will eventually have to pay. It is true that in Goethe's version of the Faust story the hero is saved by the intervention of a good woman. I do not see that as likely in the present dilemma.

The idea of preservation has two great appeals. It is simple, and, far more important, it offers an easy way of sliding out from under responsibility. We will let nature take its course, the thinking goes. Surely, the natural forces at work in each of our preserves will reach some kind of equilibrium. And, of course, they will. The question is whether that equilibrium will be to our tastes, whether it will preserve all the special assets we set out to preserve. Either way, we will find that our unwillingness to make a management decision is a management decision in itself. And we will find that the responsibility for that decision remains with us in spite of our best efforts to escape it (Madison 1987).

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# 2 Structure and Dynamics of Midwest Oak Savannas

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# Structure and Dynamics of Midwest Oak Savannas

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*Abstract:* Studies of 24 oak woods in the Upper Midwest are underway to determine the current stability, historic composition, and optimal management to maintain or restore structure and composition of pre-settlement oak savannas. Oak woods occur along successional, physiographic, and climatic moisture and fire gradients. Fire regularly occurred in even the most mesic oak woods and was an important factor in the evolution and development of oak savannas. Most trees, except for the youngest in woods where fire has been excluded, were in distinct cohorts correlated to gaps of several years during which the normal sequence of frequent recurring fires was interrupted. Recruitment of oaks usually occurred with sprouts from established root stocks of unknown age. Fire suppression lead to increase of more mesic species, including exotics. Expanding cover of mesic trees and shrubs suppressed oak regeneration and altered the associated shrub and herbaceous composition of oak savannas resulting in <80% decrease in invertebrate, bird, and herbaceous species. Our observations indicate that prescribed fire shifted the structure and composition of oak woods toward pre-settlement savanna conditions and, in all instances, resulted in a net increase in species richness in all trophic levels studied.

More than 75 years ago, Gleason (1913) lamented that forests protected from fire had grown up with thickets of invading species. Others, before and since, have documented the instability of oak savannas. In the absence of regular fire oak savannas are infused with native and exotic trees, shrubs, and herbs, which lead to the demise of many species that originally characterized oak savannas (Engelmann 1863, McCune and Cottam 1985, Anderson and Brown 1986, Nuzzo 1986, Packard 1988, Pallardy et al. 1988).

Together with many colleagues, we initiated studies in 1986 in 24 oak woods in northwestern Indiana, northeastern Illinois, and southern Wisconsin. Our objectives were: (1) to document and describe both the original and current vegetation composition and age structure of oak savannas; (2) to relate past and present composition and age structure to successional, physiographic, and fire gradients; and (3) to monitor community responses to prescribed fire. With this extensive study, we hope to gain the under-

*Table 1.* Nomenclature of species mentioned in text (after Kartesz and Kartesz 1980).

| | |
|---|---|
| American hazelnut (*Corylus americana*) | Pennsylvania sedge (*Carex pennsylvania*) |
| Basswood (*Tilia americana*) | Pin oak (*Quercus palustris*) |
| Black cherry (*Prunus serotina*) | Post oak (*Q. stellata*) |
| Black oak (*Quercus velutina*) | Red elm (*Ulmus rubra*) |
| Blackjack Oak (*Q. marilandica*) | Red maple (*Acer rubrum*) |
| Bracken fern (*Pteridium aquilinum*) | Red pine (*Pinus resinosa*) |
| Bur oak (*Quercus macrocarpa*) | Sassafras (*Sassafras albidum*) |
| Choke cherry (*Prunus virginiana*) | Shagbark hickory (*Carya ovata*) |
| Crabapple (*Crataegus* spp.) | Smooth buckthorn (*Rhamnus frangula*) |
| European buckthorn (*Rhamnus cathartica*) | Smoth sumac (*Rhus glabra*) |
| Garlic mustard (*Alliaria petiolata*) | Sugar maple (*Acer saccharum*) |
| Gooseberry (*Ribes* spp.) | White ash (*Fraxinus americana*) |
| Hill's oak (*Quercus ellipsoidalis*) | White oak (*Quercus alba*) |
| Jack pine (*Pinus banksiana*) | White pine (*Pinus strobus*) |
| Northern red oak (*Quercus rubra*) | |

standing needed to develop management programs for restoring structure and composition of oak savannas. In this paper, we present preliminary results and provide a general overview.

We apply the term "oak savanna" to the communities characterized by scattered trees, usually oaks (see Table 1 for scientific nomenclature), with an understory sparse in shrubs and a ground layer rich in grasses and forbs. Because the herbaceous layer dominates a savanna (Curtis 1959), these community types might be called prairie savannas, or in the case of those on black loams in the Midwest, tallgrass savanna (Packard 1988). Early settlers commonly referred to these communities as barrens, oak openings, or prairie groves. Dyksterhuis (1957) reviewed the savanna concept and described several types. Because our work includes all phases of savannas, we have used the more general term, oak savanna. Historically, all were characterized by $\geq 1$ species of oaks (Table 2).

To evaluate the relationships between species composition of presettlement oak savannas and present-day oak woods, it is necessary to compile data from communities that represent as much of the successional and physiographic gradients as possible. Successional communities occur along fire frequency and intensity gradients which, in turn, are related to physiography. In the last 100 years, succession was also modified by invasion of exotic species. A large data base is required to evaluate the complex interactions of variables overlaid with the responses to prescribed fire management. Our aim is to use discriminant function analysis to develop hypotheses for subsequent testing. At this time (Apr 1989), we have collected vegetation data from 24 communities representing a broad range of all gradients. Additionally, we have data on stand age-structure, resident bird populations, invertebrates, soil characteristics, physiographic variables, and vegetation responses after prescribed fire in several of these communities. This paper is a summary of the literature and a preliminary review of data; we plan to continue our sampling to expand our data base.

## Methods

We have used standardized sampling methods but have not been able to introduce controlled replicated treatments such as prescribed fire in all communities or under the same conditions. We have studied communities along major temporal and spatial gradients, but will not be able to test some relationships because of location or size of study areas.

### Study Site Selection

All communities scheduled for study were dominated by overstory oaks, but varied widely in the shrub and herb layers, depending on how long fire had been excluded, soil type, and presence of exotic shrubs, especially buckthorn. Soils varied from sands to loams and silty-clay. Drainage varied from excessive, on sandy ridges, to poor in silty-clays near water table. Size varied from 2 to several hundred hectares depending on how communities are defined. Many of the tallgrass savanna remnants, the least common community type, were fragments isolated by urban development in the Chicago region. When possible, we attempted to include sites: (1) that were in public ownership, (2) on which we could establish burn and no-burn treatments, (3) for which stewards or owners wanted to restore communities to presettlement conditions, (4) where extensive timber harvest or drainage modification had not altered community structure or site conditions signif-

*Table 2.* Savanna types with characteristic oak species in the upper Midwest.

| Savanna Type | Bur oak | White oak | Black oak | Hill's oak | Northern red oak | Pin oak | Post oak | Swamp white oak |
|---|---|---|---|---|---|---|---|---|
| 1. Tallgrass savanna | X | | | | | | | |
| 2. Eastern sand savanna | | X | X | X | | X | | |
| 3. Dry sand savanna | | | X | | | | X | |
| 4. Mesic savanna | X | X | X | | X | | | X |
| 5. Northern sand savanna | | | | X | X | | | |

icantly, and (5) where sufficient area existed to minimize edge effects, and permit prescribed fire.

### Sampling

Woody and herbaceous vegetation on all sites was sampled during the growing season. On some sites, additional sampling was done to document lichens and bryophytes, ground litter invertebrates, butterflies and leafhoppers, breeding birds, and small mammals. Soil characteristics and surface hydrology were described in all communities, but analysis of soil samples has not yet been completed. Likewise, site histories are still being compiled. In one oak woods, dendrochronological methods were used to determine historic drought patterns.

Vegetation was sampled in 50-m segments along randomly selected transect lines. The line intercept method was used to estimate canopy cover for trees and shrubs while circular 1-$m^2$ plots were used at 10-m intervals along the lines to estimate the herb layer and litter cover, including all woody plants <1 m tall. Tree diameters were tallied by species within a 2-m strip along transects. Selected trees were cored to determine age. Shrub layer (stems <2″ dbh) stem density was tallied by species within a 1-m strip along each transect. Composite soil samples were taken along each transect in larger, heterogeneous sites with multiple community types, and randomly within the site supporting smaller, and more homogeneous communities.

All zoological sampling was done using baited live traps, pit-falls, and observations along the same permanently marked transects. Sampling periods varied, but centered on late spring and early summer.

## Results and Discussion

Based on tree ages, growth rates, and density, we determined that presettlement oak savannas supported canopies that varied from 10% cover to about 90% cover. The most open communities apparently were burned most intensely, but included some of the mesic communities such as tallgrass savanna on silty-clay soils. Presettlement canopies of many of the eastern sand savannas, such as occur near Hoosier Prairie and Jasper-Pulaski Fish and Wildlife Area in Indiana, were nearly closed, but were opened 26% by 1 intense prescribed fire in experimental blocks at Jasper-Pulaski. Oaks made up >80% of the canopy of presettlement oak woodlands.

In contrast to the variance in the canopy, the shrub layer of presettlement oak savannas was consistently open. Historic descriptions of many oak savannas provide striking descriptions of the open understory and rich herb layer (Curtis 1959). Packard (1988) argues that many of the herbaceous species, and certainly the associations, were distinctive to tallgrass savannas; we believe this is equally true of other savannas. The most striking response of oak woods to prescribed fire was the dramatic decrease in the shrub layer and increase in cover and richness of the herb layer. This included the appearance of species known to inhabit savannas that were not apparent before fire. These observations agree with Vogl (1964) and White (1986).

The presence of oak in canopies declined in the long-term absence of fire. Many presettlement communities that were nearly closed oak savannas now support <20% oak cover. Many other tree species are now present in these communities and canopies typically remain closed. Moreover, most woods that we examined where fire and grazing have been excluded, now have heavy shrub understories. The herb layer was often extremely depauperate.

A brief discussion of each of the 5 Midwest oak savanna types follows. Those types are a subjective classification based on field observations. We intend to test the validity of this classification by ordination when we have a more representative data base.

*Tallgrass savanna.*—Historically, this savanna was characterized by an open canopy of bur oak and, perhaps, >300 species of herbaceous plants (Packard 1988)(Fig. 1). The tallgrass savanna occurs on silty-clay-loam soils that are less subject to extreme drying. Without fire, these rich sites are soon invaded by aspen, smooth sumac, American hazelnut, and the exotic smooth and European buckthorns. The latter 2 species, especially, displace most other plant species on mesic sites. Buckthorns more readily invade communities with open canopies. We found the maximum buckthorn in woods with 70% canopy, and buckthorn cover decreased proportionately to near zero in both fully open and fully closed communities (Apfelbaum and Haney 1989).

By comparing a range of savannas that demonstrated various degrees of degradation following fire exclusion, we found that breeding-bird use of savannas declined with the decrease in vegetation richness (Fig. 1), a relationship also revealed in the Great Lakes pine forests (Apfelbaum and Haney 1986).

Tallgrass savanna soils can support excellent crops or pasture. Agricultural and residential development, succession, and invasion of buckthorn have nearly eliminated well preserved examples of the tallgrass savanna. The best example we have found is in a Chicago suburb along a railroad where frequent fire apparently maintained it. This example is very similar, we believe, to the presettlement condition (Fig. 1).

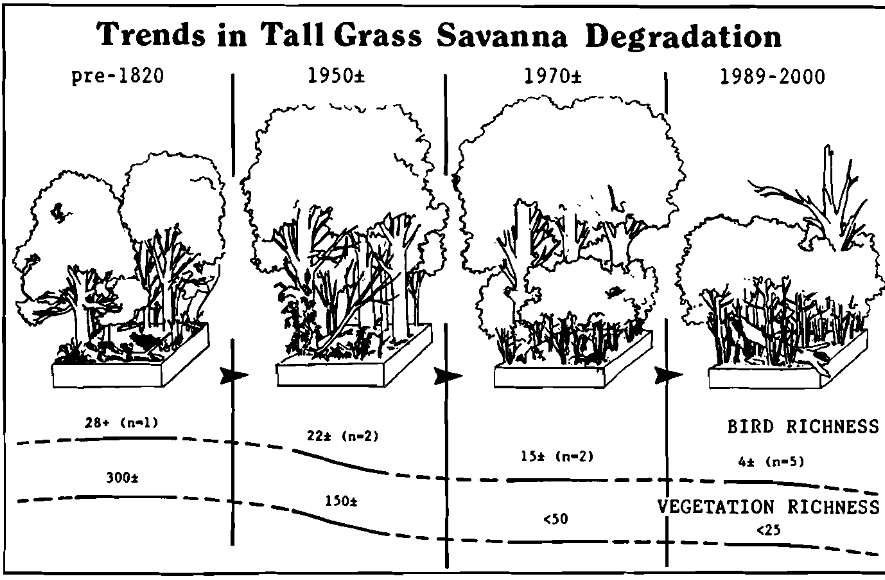


*Fig. 1.* Presettlement tallgrass savanna had an open canopy of scattered bur oak, little understory, and rich biotic diversity. With fire exclusion, mesic trees and shrubs soon invade, eliminating many of the herbaceous species. Eventually closure of the subcanopy prevents bur oak regeneration and leads to loss of most herbaceous species and a remarkable decline in avifauna richness. *N* is number of communities we have studied upon which richness data and degradation pattern is based. Time is estimated.

*Eastern sand savanna.*—This is the most common savanna in the Midwest; it occurs widely on sandy ridges throughout northern Indiana. Dominated by black oak, the canopy typically contains white oak, while Hill's oak integrades to pin oak on slopes and flats near the watertable. Black cherry and sassafras are common cohabitants. Intense fire opens this community, but it typically has a nearly closed canopy with an abundance of sedges, especially Pennsylvania sedge, and associated forbs, including bracken fern in the herb layer.

Unlike the tallgrass savanna, the eastern sand savanna is remarkably resistant to successional change and invasion by exotics. Soils are poorly suited to agriculture. In the less populated areas where many of these remnants remain, wildfire has been common. Many sand savannas have been grazed and, except where grazing was severe, this has helped maintain the community structure and diversity.

At Jasper-Pulaski State Fish and Wildlife Area, the Indiana Division of Nature Preserves has established 9 40-acre experimental blocks through an extensive sand savanna complex. Using an area in which fire has been excluded for >30 years as a control, blocks were burned with either low or high intensity prescribed fire. Vegetation was surveyed before and after burns. In all instances, cover of the herb layer increased following high and low intensity fire by an average of 40% and 37%, respectively. Total number of herbaceous species increased 36% and 28% compared to unburned controls. Cover in the shrub layer decreased after intense fire by 65% while the canopy cover was reduced by 26%. Low intensity fire only modestly decreased shrub cover. Cover of canopy trees that were not oaks decreased, in contrast, by 62% and 42% in high and low intensity fire, respectively. Low intensity fire did not alter significantly total canopy cover, but selectively did favor oaks, mostly black oak. These treatments clearly demonstrated that fire intensity, and probably frequency, was an important variable in shaping community structure and in maintaining savanna diversity.

*Dry sand savanna.*—In north central and eastern Illinois, there are savanna communities distinctly different from the eastern sand savanna. These are usually much more open with scattered clusters of stunted post, black, and blackjack oak in sand prairie. We have collected no data from these communities.

*Mesic savanna.*—We have studied several examples of oak woods in loess or upland silt-loam soils that are quite unlike the other savannas. Some grade into tallgrass savannas along moisture gradients. Mesic savannas contain the most diverse woody floras. White oak and northern red oak are more common that bur oak or black oak, although all native oaks except pin and post are typically present. Sugar and red maple may have been infrequent in presettlement savannas, but have become much more common with fire exclusion (Hagen and Runkle 1988), together with red elm, basswood, shagbark hickory, and black cherry.

In the Reed-Turner Nature Preserve in Long Grove, Illinois, prescribed fire was used in one section of a mixed hardwood forest that developed from a mesic savanna while the adjacent section was kept as an unburned control. Small diameter (<2" dbh) stem density increased dramatically after fire because of stump and root sprouting. Most shrub-sized *Crataegus* sp., choke cherry, and *Viburnum* spp. were top killed by fire whereas larger stems showed less response to fire. About 10% of the 2–4" dbh stems of basswood, buckthorn, and black cherry were top-killed whereas no sapling oaks died following the light ground fire.

Richness in the herb layer increased 10% (12 species lost following fire compared to an appearance of 16 not found before the fire). Species that decreased in the herb layer after fire included seedlings of exotic woody plants such as buckthorn, choke cherry, gooseberry, and crabapple. In more open areas, white ash seedings, dandelion, and bluegrass decreased.

*Northern sand savanna.*—This community looks similar to the eastern sand savanna, but differs geographically and floristically. It occurs throughout central Wisconsin on sands and tills. Northern red oak and Hill's oak dominate the canopy. Black oak is less common but may be present. Intense fire converts this savanna to a closed jack pine forest, when a seed source is present, that successionally reverts to an oak or mixed oak-pine savanna. Eastern white pine and red pine are sometimes present; American hazelnut, *Vaccininum* spp., and a few understory shrubs occur, but the herb layer is typically a rich association of sedges and forbs. In the absence of disturbance, the northern sand savanna is invaded by red and sugar maple, basswood, witch hazel, white pine, and paper birch while oaks fail to regenerate.

The composition of this community type and its successional response to fire suggest that it is transitional between northern hardwoods and the Great Lakes pine forest (GLPF) further north. Whereas the GLPF succeeds to spruce-fir in the absence of fire, the northern sand savanna succeeds to northern hardwoods. Intense fire in both commonly results in a seral jack pine community. Much as fire is necessary in the GLPF to maintain the rich mosaic of community types found there (Apfelbaum and Haney 1986), fire maintains a mosaic of community types throughout the forest-prairie ecotone where savanna formations represent distinctive associations structured and maintained by fire. Although we found little evidence that the northern sand savanna was successionally stable, Whitford and Whitford (1971) reported one that was.

## Community Structure and Recruitment

One of the striking consistencies we found among savannas is the occurrence of distinct tree cohorts. Dominant oaks are typically 80 to 250 years old. Where fire has been excluded, a young mesic understory invariably is present and oak regeneration has ceased.

Studies of old-growth forests indicate that catastrophic disturbances are largely responsible for recruitment (Hough and Forbes 1943, Henry and Swan 1974, Tubbs 1977, Lorimer 1980, Runkle 1982, Nowacki 1988). We have seen similar recruitment of white and red pine in the GLPF (Apfelbaum and Haney 1986).

Invasion of mesic trees and shrubs reduces or prevents recruitment of oaks, even from root grubs, a conclusion shared by others (McCune and

Cottam 1985, Nowacki 1988). Fire has the potential to prevent invasion of a mesic cohort, and can reduce or eliminate a mesic element once established. Older oaks have endured numerous fires as indicated by tree age and recorded fire events as well as by the numerous fire scars on virtually every old savanna oak we have examined.

In the simplest oak woods we have studied, a red and white oak mesic savanna on silt-loam soil in Downer's Grove, Illinois, 2 cohorts of oak were present, one 230 to 250 years old and a second 135 to 150 years old. Size of trees in both cohorts comletely overlapped, and ranged from 13" to 38" dbh. Beneath the oaks was a 25-year-old cohort of black cherry. Intense grazing had been eliminated 25 years prior to our study. The exotic garlic mustard was well established in the fringes of this community.

In the most complex community examined, 4 cohorts of bur oak were present in an excellent example of tallgrass savanna. No understory was present although oak grubs were abundant. Oak cohorts were 230 to 250, 110 to 140, 50 to 90, and <25 years old. Again, tree sizes overlapped. Evidence indicated that fire regularly occurred in this savanna which bordered a railroad in a Chicago suburb.

These data and similar data from other savannas, indicate that oak recruitment is related to periodic events that may occur once in 25 to 100 years. If fire more or less regularly recurs, often every year, or at least once in 10 years, then oak recruitment must be related to a temporary cessation of burning. Although oaks are more resistant than other species, fire consistently top kills young oaks. The absence of fire for 10 to 20 years may be required to recruit oaks. Mesic species that are more susceptible to fire are then eliminated by the next series of fires or the next intense fire.

A dendrochronological study in the Chicago area indicated that wet cycles of 5 to 12 years occurred every 25 to 50 years between 1700 and 1970 (Sheppard and Cook, unpubl.). These wet cycles may be sufficient to reduce or eliminate fire during which recruitment of oaks occurred. Although our data are not sufficient to draw a firm conclusion, wet cycles do appear to roughly correlate to recruitment. Likewise, dry cycles may have resulted in periods of frequent and intense fire that shaped the structure and composition of the savannas.

## Conclusion

Savannas are unstable communities that have evolved along the prairie-forest border where periodic fire maintained their structure and composition. In the absence of fire, savannas are invaded by mesic species and exotics that eliminate the characteristic herb layer and prevent oak regeneration. A dense shrub layer becomes established. The resulting closed communities support a different fauna and fewer species than were found in savannas.

Because savanna species are fire adapted, use of prescribed fire appears to be the best way to preserve savanna in presettlement conditions, although selective cutting and use of controlled grazing and herbicides may also be useful. The ecological instabilities of savannas is not unlike other formations in the Upper Midwest. For example, recruitment of dominant species in old-growth is tied to catastrophic disturbance, fire is essential to maintain the biological diversity in the Great Lakes Pine Forest, and tallgrass prairie is soon invaded by trees in the absence of fire. Fire is an essential management tool for maintaining these communities.

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# 3 Wildlife and Fire in the Upper Midwest

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# Wildlife and Fire in the Upper Midwest

Gerald J. Niemi and John R. Probst

*Abstract:* Fire plays an important role in the perpetuation of forests, prairies, and wetlands in the Upper Midwest. The effects of fire in these habitats have profound implications to wildlife because of the dynamic changes in plant species composition and habitat structure. At the same time, wildlife species may be instrumental in the regeneration of forests, prairies, and wetlands following fire, through enhancement of seed dispersal, seed viability, and the development of soils. Hence, the role that fire plays in altering plant and soil ecosystem structure is closely intertwined with the dynamic processes that take place in the animal communities. These interactions represent complex feedback loops that affect forests, prairies, and wetlands following fire. Many species of wildlife (e.g., Kirtland's warbler [*Dendroica kirtlandii*], sharptailed grouse [*Tympanuchus phasianellus*], yellow rail [*Coturnicops noveboracensis*], black-backed woodpecker [*Picoides tridactylus*], and moose [*Alces alces*], likely depend on fire conditions for their continued existence, and it is prudent to include fire as an active component in the dynamic management of wildlife in the Lake States area. However, the role that fire plays in the continued management of these areas should be scrutinized where humans and important natural resources are located.

The forest fires that raged through Yellowstone National Park in 1988 created a renewed interest and concern about how we deal with fire in resource management. Although the destruction and loss of resources from fire seem immense, it is generally accepted that fires have long been a part of the natural ecology of forest and prairie ecosystems in the Lake States area (e.g., Daubenmire 1936, Curtis 1959, Ahlgren and Ahlgren 1960, Frissel 1973, Heinselman 1973, Wright and Heinselman 1973). Moreover, it is generally accepted that most wildlife species have lived with fire for thousands of years and may even be considered "adapted" to fire (e.g., Kelsall et al. 1977). The role of fire in wetland habitats is less clear because it has been little studied (Weller 1981), but recent studies on fire regimes and climate change indicate that fire must have been frequent in many habitats during dry years (Clark 1988). Hence, fire has become an integral part of many wildlife management practices (Lotan 1979).

Intense crown fires in forests will result in early successional stages of vegetation consisting of open grassy areas and shrublands. In prairies, fires

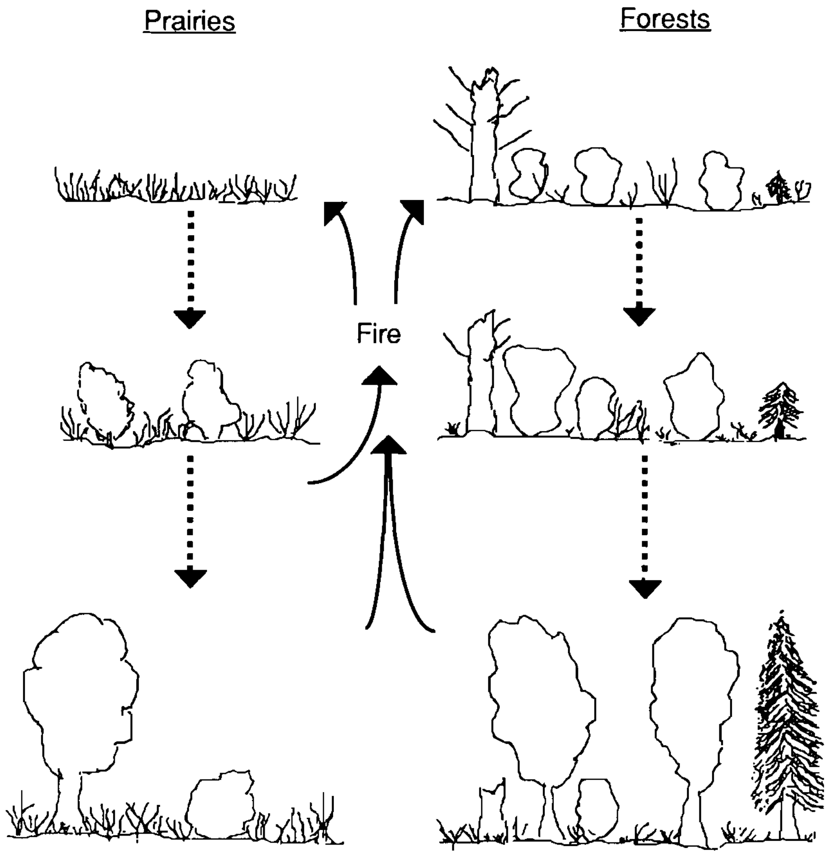


*Fig. 1.* Vegetation development after fire.

maintain open areas by eliminating woody vegetation such as shrubs and trees (Fig. 1). In wetlands, fires burn standing crops of cattails (*Typha* spp.), sedges (*Carex* spp.), and shrubs (Weller 1981) and, if intense enough, can burn well into the moss of peatland habitats (Anderson 1982).

There is sometimes direct mortality to wildlife from fire especially if suitable refugia are not available or if dispersal from the fire is impossible (Bendell 1974). The major effects on wildlife, however, are due to changes that occur in the habitats (Anderson 1982). Species that favor young forests will be positively affected, while those favoring old growth forests will be negatively impacted. Similarly in prairies or wetlands, those species requiring shrubs or trees within their habitats likely will be eliminated, while those favoring grass or sedge dominated habitats will be positively affected. Here we provide an overview of fire and how it affects wildlife in the Upper Midwest area (see also Bendell 1974). By Upper Midwest we refer to the general area consisting of Michigan, Wisconsin, Minnesota, Iowa, Illinois, and Indiana. Rather than focusing entirely on a species-specific approach, we discuss potential feedback loops and interactions between vegetation, wildlife, and fire within these ecosystems. Moreover, given that "fire suppression" is generally the rule for most of the Upper Midwest, it is time to review the role of fire in relation to the species and communities that may need fire in a landscape context. For a more complete review the reader should see Kelsall et al. (1977), Viereck and Schandelmeier (1980), or Wein and MacLean (1983).

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## Fire Effects on Habitat

### Landscape Patterns

Fires create a complex mosaic of burned and unburned patches of habitat with the actual juxtaposition of these areas depending on such factors as the patchiness and intensity of the fire, topography, soil moisture patterns, and weather patterns during the burn. Hence, each species responds to the conditions left by the fire in a manner consistent with its needs and the spatial scale with which those needs are met. The size of the burn is less important to a species with a small home range (e.g., $< 2$ ha) such as a deer mouse (*Peromyscus* spp.) or chestnut-sided warbler (*Dendroica pensylvanica*). In contrast, size and orientation of a fire is more important for wide-ranging species such as moose or hawks that move over several square kilometers of area. In the latter case a small fire would likely have only a minor effect on the species. For instance, the frequency and spatial pattern of fires in coniferous forests can profoundly affect population dynamics of wildlife species that depend on early successional deciduous species for food. Geist (1974) hypothesized that moose populations find refuge in habitats of continuous but small disturbances, but expand into habitats with an abundance of food created by large disturbances such as fire. The ability of a moose to affect recovery of the forest also depends on the size of the burn. Pastor and Naiman (1988) show that browsing by moose in large disturbances does not alter species composition because of the abundance of food regenerated and the lack of seed dispersal to the center of the disturbance. Recovery of small disturbances, in contrast, can be greatly affected by intense moose browsing.

Few studies have considered the effects of wildfire over large landscapes (Erskine 1977, Anderson 1982). The difficulties and costs of conducting such studies have usually prohibited this kind of landscape approach. At a landscape level, the relative effects of forest fire are obviously different from those resulting from logging activity. Where forest fires tend to be large with complex mosaics, logging produces landscape patches that are rectangular or square. How these differences in shapes, scales, and frequency of disturbance between logging and fire affect wildlife are relatively unexplored, as are related ecological processes such as nutrient dynamics.

Several studies on endangered species have indicated the importance of examining habitat requirements for species on a landscape basis (e.g., Noss 1983). Studies of the red-cockaded woodpecker (*Picoides borealis*) in the southeastern United States (Baker 1983) and the spotted owl (*Strix occidentalis* in the northwest (Simberloff 1987) have shown the importance of old growth forests in a landscape perspective. The most prominent example for the Upper Midwest area is the Kirtland's warbler (Probst 1986, 1988), which is typically a fire-dependent species requiring jack pine (*Pinus banksiana*) stands 6 to 23 years old regenerated naturally after fire.

The nature of wildfire has potential implications to habitat fragmentation patterns. Several studies have examined the effects of fragmentation on animals from a landscape perspective in the Upper Midwest area (e.g., Blake and Karr 1984). Land fragmentation is more acute in southern Michigan, Ohio, Indiana, and Illinois, than in the northern portions which have not experienced this intensity of fragmentation. Fragmentation patterns in the southern portion of the Upper Midwest result from agricultural and urban development where woodlots are left as islands in the landscape. In the north, forest habitat patterns are created by fire, roads, and logging activities.

More information is needed to assess the various roles that wildlife play in the regeneration of forests following wildfire and other disturbances in the Upper Midwest area. It is especially important to attempt to understand how small mammals (e.g., Sims and Buckner 1973), moderately sized mammals (e.g., snowshoe hare [*Lepus americanus*], Keith and Surrendi 1971), large mammals (e.g., moose, Pastor et al. 1988) and birds (e.g., Johnson and Adkisson 1985) aid in the regeneration of forests through enhanced seed dispersal. There are many wildlife and plant species that are affected by fire, and many complex interactions among these species currently are not well understood. Furthermore, the role of nutrients and how they are affected by fire varies with season, soil, weather, the nature of the fire, and

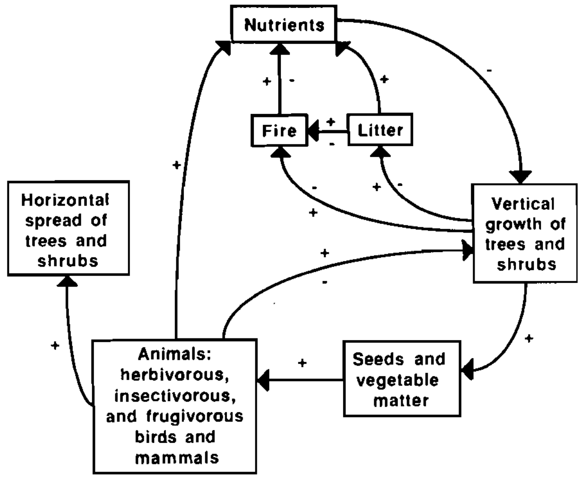


*Fig. 2.* Potential feedback loops in the vertical growth and horizontal spread of forests as affected by fire and wildlife.

a variety of other factors (e.g., Daubenmire 1968, Smith 1978, Bendell 1974). What is needed is the identification of a conceptual framework which will enable us to understand the interrelationships among the components (Fig. 2) and then to test the magnitude of the relationships under a variety of conditions.

## Stand Regeneration, Species Composition, and Succession

*Forested Areas.*—Central hardwood forests are composed chiefly of mixed oaks (*Quercus* spp.), with hickory (*Carya* spp.) as a minor component. Succession results in gradual replacement of oaks by American beech (*Fagus grandifolia*) and sugar maple (*Acer saccharum*) in the eastern part of the region, but fire promotes vigorous oak sprouting and allows invasion by aspen (*Populus tremuloides* and *P. grandidentata*), cherry (*Prunus serotina* and *P. pensylvanica*), red maple (*Acer rubrum*), and more xeric oaks such as black (*Quercus velutina*) and post (*Q. stellata*). The southern portion of the Upper Midwest have many species in common with the Central States, but northern pin oak (*Q. ellipsoidallis*) often replaces post oak in more xeric situations. Forested habitats in southern Minnesota are similar to the mixed mesophytic forests in the Eastern Central Hardwoods and the Northern Hardwoods. Big Woods-type habitat is found in areas favored by fire breaks due to topography and bodies of water (Grimm 1984). Much of the southern portion of the Upper Midwest before settlement was drier forest transitional to adjacent barrens, savannahs, or prairies.

Northern hardwood forests dominate a majority of sites in the northern part of the Upper Midwest, but most of the area is in early succession aspen-birch (*Betula papyrifera*). Further north and on wetter sites aspen-conifer types (especially aspen-fir) or conifer bogs are common. Drier sites are characterized by oak or jack pine barrens and savannahs. The major effect of fire in mesic forests is to favor oaks and pines or to perpetuate aspen-birch. However, wind also has a major influence on northern hardwood composition and structure. In the absence of disturbance and depending on site, early succession broad-leaf trees can be replaced by conifers such as balsam fir (*Abies balsamifera*), white pine (*Pinus strobus*), white spruce (*Picea glauca*), and eastern hemlock (*Tsuga canadensis*), as well as hardwoods such as sugar maple and basswood (*Tilia americana*).

*Open Lands.*—Prairies, savannahs (Nuzzo 1986), and barrens were more common in the southern part of the Upper Midwest during presettlement times, but agriculture, fire control, and tree planting have reduced natural open lands (Tester and Marshall 1963). Oaks tend to invade prairies unless suppressed by drought or fire. Climate and fire frequently are highly variable, so savannahs and prairies share a dynamic spatial relationship. Topographic relief and microsites accentuate differences in tree spatial pattern of grassland-savannah zones. Oak barren communities develop where moisture is sufficient for woody plants to become established, but where fire is frequent enough to prevent forest development. In the absence of fire, oak barrens may be invaded by aspen and cherry, which tend to form scattered clumps of trees. In the Central hardwood states, barrens may have a shrubland physiognomy similar to old fields and Eastern red cedar (*Juniperus virginiana*) is often a dominant tree species.

In the Upper Midwest, dense jack pine barrens are associated with wildfire, but also may form an open shrubland in clearcut forests. Barrens, savannahs, and dry prairies share some common ground plants. Barrens frequently are characterized by low-growing shrubs such as blueberries (*Vaccinium* spp.), prostrate cherries (e.g., *Prunus pumila*), sweet fern (*Comptonia peregrina*), and bearberry (*Arctostaphylos uva-ursa*). Fire promotes ground vegetation diversity by preventing dominance of grasses and sedges and by allowing invasion of forbs and small shrubs.

## Primary and Secondary Productivity

Fire can substantially increase the quantity and quality of plant material available for animal consumption. More specifically, fire releases nutrients held in dead and living plants, increases soil temperature, promotes seed germination, and reduces competition for water and light. These factors allow smaller, younger plants to thrive. A short-term "nutrient pulse" can be especially important on poor-quality soils. Younger plant communities can have higher net productivity than older ones, so more plant production can be channeled into high quality wildlife foods such as berries, seeds, nuts, and herbaceous forage. Furthermore, forage quality is often improved after fire (Hobbs and Spowart 1984). Fire may improve longer-term secondary productivity indirectly by increasing snags for cavity nesters and den trees, and by providing perches for raptors, flycatchers, and avian territorial display. As a result, use of plant and animal resources is increased because the spatial complexity of the habitat increases which allows more diverse use of space by wildlife species.

## Post-fire Species Interactions

*Plant Dispersal.*—Seeds of early-successional plant species are usually disseminated by wind or animals. Larger, winged seeds (e.g., ashes [*Fraxinus spp.*], basswood, and maples) generally do not travel long distances unless transported by animals. Frugivorous birds are particularly effective disperses of seeds found in the fruit of many shrubs and trees. Blue jays (*Cyanocitta cristata*) can disperse beech nuts (Darley-Hill and Johnson 1981, Johnson and Adkisson 1985) and acorns over long distances and may be responsible for speeding forest migration (Johnson and Webb, 1989), especially during periods of climatic change. Seeds from herbs and berries also are dispersed by omnivorous mammals such as black bears (*Ursus americanus*). Small mammals are important dispersers of seeds and spores of fungi which are often symbionts that increase plant productivity (Maser et al. 1978). Squirrels and chipmunks (Sciuridae) help move acorns away from forest edges into clearcuts, burns, and other openings.

*Herbivory and Omnivory.*—Many wildlife species are temporarily eliminated from a large wildlife area. Some species do not return until the forest becomes mature (e.g., some woodpeckers and canopy-foraging birds), but others (e.g., raptors, wild turkey [*Meleagris gallopavo*]) return quickly after fire to scavenge on plants and animals killed or exposed by the fire. Prairie and savannah wildlife, and early-succession species on forested sites, colonize burns as herbaceous vegetation recovers or thrives during the post-burn years. Small mammal herbivores usually do not appear in burns until 2 or 3 years after a fire (Buech et al. 1977). Prairie chickens (*Tympanuchus* spp.) may use newly-burned areas for dancing grounds, and benefit from higher productivity of recently-burned grasslands. Cottontail rabbits (*Sylvilagus floridanus*), snowshoe hare (*Lepus americans*), white-tailed deer

(*Odocoileus virginiana*), and moose respond favorably to new herbaceous growth and woody sprout-growth. Middle stages of forest regeneration (3–15 years) create habitat for omnivores such as black bears, finches, and sparrows.

## Fire Effects on Wildlife

### Deciduous Forest

Broadleaf coppice results from fire in deciduous forests in the Midwest. Deciduous shrublands can also appear after fire in some coniferous or mixed forest types as well. In addition to herbivores and omnivores discussed above, regenerating burns in the Upper Midwest provide abundant habitat for birds such as chestnut-sided warblers, mourning warblers (*Oporornis philadelphia*), song sparrows (*Melospiza melodia*), and white-throated sparrows (*Zonotrichia albicollis*) in northern areas (Niemi 1978, Anderson 1982, Apfelbaum and Haney, 1986) and prairie warblers (*Dendroica discolor*) in the southern oak barrens. Middle stages of forest development tend to have few distinctive species, but share species found in younger and older habitats. However, chestnut-sided warbler and American redstart (*Setophaga ruticila*) are numerically dominant species (Back 1979; Probst, pers. obs.). Aerial foragers such as swallows are found more commonly in regenerating burns and seldomly in mature forests.

Periodic fires help maintain a diversity of stand ages that are important for ruffed grouse (*Bonasa umbellus*) (Gullion 1984). Snags left standing after a fire are used for perches and cavity nesting by American kestrels (*Falco sparverius*), Eastern bluebirds (*Sialia sialis*), and many woodpeckers such as the red-headed woodpecker (*Melanerpes erythrocephalus*) in the southern ranges and the black-backed woodpecker in the northern portions (Niemi 1978, Anderson 1982, Apfelbaum and Haney 1986). Equally important, many snags of fire origin persist for long periods and are used by cavity nesters. These snags represent the only places that cavity nesters can use until the forest matures and often are used by birds in mature forests (e.g., chickadees [*Parus* spp.]). Open country raptors such as red-tailed hawk (*Buteo jamaicensis*) often use areas after burns. Other higher level carnivores (e.g., weasels [*Mustela* spp.]) and omnivores (e.g., black bears) may benefit from greater secondary productivity in burns, but supporting data are scarce.

### Coniferous Forests

The response of wildlife shortly after fire in coniferous forests is similar to that described for deciduous forests. The specific response of wildlife species after fire depends on the conditions in the stand affected by fire and whether the successional pattern of the vegetation proceeds to deciduous or coniferous dominated vegetation. During the first 10–15 years following a fire, the wildlife communities associated with early successional deciduous habitats will be similar to those found in coniferous areas. As the conifer tree species become more prominent in the community, wildlife that use coniferous species will become more common and begin to distinguish themselves from the deciduous community. Characteristic birds found in conifer-dominated forests in the Upper Midwest include the magnolia warbler (*Dendroica magnolia*), yellow-rumped warbler (*Dendroica coronata*), hermit thrush (*Catharus guttata*), blackburnian warbler (*Dendroica fusca*), chipping sparrow (*Spizella passerina*), and dark-eyed junco (*Junco hyemalis*) (Green and Niemi 1977). In the southern part of the Upper Midwest area, conifer forests are not common except near urbanized areas. An exception is the extensive pine habitats in the central Michigan area where the Kirtland's warbler (Probst 1986) is found. Similarly, mammalian communities would differ between deciduous and coniferous forest where red squirrels (*Tamiasciurus hudsonicus*), red-backed voles (*Clethrionomys gapperi*), and moose become more dominant in the coniferous forest zones. The role of small mammals may be especially important for dispersal and regeneration of the conifer community (Maser et al. 1978). Although most effects of fire on wildlife are positive (except for species that require more mature forests), fires that are too frequent and intense can actually reduce the production of grasses, herbs, and shrubs; and hence reduce vegetation available for browsing (Bendell 1974).

### Wetlands

The role of fire in structuring wetland communities is not well understood. One of the more comprehensive studies of the effect of fire on wildlife was conducted by Anderson (1982) in the Seney National Wildlife Refuge in northern Michigan. Many parts of the refuge affected by fire were wetland communities, including bogs. Anderson (1982) indicated that fire changed many of the wetland communities. Changes included substantial burning of the *Sphagnum* itself and reductions in the canopy of forested bogs. In these areas the wildlife community will change from species preferring forested canopies (e.g., boreal chickadee [*Parus borealis*], ruby-crowned kinglet [*Regulus calendula*], and yellow-rumped warbler) to those of open wetlands (e.g., common yellowthroat [*Geothlypis trichas*], song sparrow, and swamp sparrow [*Melospiza georgiana*]).

Additional studies by Niemi and Hanowski (1991) in the Red Lake Peatland of northern Minnesota indicated that many peatland habitats may be dependent on fire for their maintenance. In habitats such as sedge fen, a variety of sensitive and threatened wildlife species like the short-eared owl (*Asio flammeus*), northern harrier (*Circus cyaneus*), yellow rail, and LeConte's Sparrow (*Ammodramus leconteii*) may be dependent upon the periodic burning of these open habitats to suppress shrub development. The clumped distribution of the yellow rail in particular may indicate that this species is dependent on these periodically burned habitats. Population centers for this species are found in the Red Lake peatland area of northern Minnesota (Niemi and Hanowski 1991), the extensive sedge wetlands in central Minnesota near McGregor (Janssen 1987), and in the Seney National Wildlife Refuge in the upper peninsula of Michigan (Bart et al. 1984). The role that fire plays in wetland communities is still largely unknown and its importance likely has been unappreciated in past wetland management activities.

Many peatland habitats, such as black spruce (*Picea mariana*) forests, regenerate slowly (> 100 years) in contrast with upland terrestrial habitats. Wetlands in the northern portion of the Upper Midwest area are predominantly of the peatland-acidic type, and in the southern portion cattail marshes and shrubby wetlands are predominant. In southern areas, fire primarily affects cattails and shrubs. Reductions in this vegetation negatively affect species that use them for nesting such as the red-winged blackbird (*Agelaius phoeniceus*), swamp sparrow, and common yellowthroat. However, burning opens up dense marsh vegetation and has been reported to stimulate the development of seed-bearing plants which are used by many waterfowl species (Vogl 1969, Bendell 1974). In general, fire plays a role in maintaining and regenerating wetland habitats in the Upper Midwest area. The role of fire may be especially important during times of drought when water levels are low or nonexistent (Clark 1988).

## Open Lands

Fire creates and maintains large openings as barrens or prairies throughout most of the Upper Midwest area. Many of the subsequent effects identified are positive and important for large shorebirds (e.g., upland plover [*Bartramia longicauda*] and marbled godwit [*Limosa fedoa*]), upland gamebirds (e.g., sharp-tailed grouse, Bergerud and Gratson 1988), raptors (e.g., short-eared owl and red-tailed hawk), and non-game birds such as Kirtland's warbler, Eastern bluebird, and red-headed woodpecker (Probst 1979, 1986). Most larger or medium-sized mammals use open lands as part of a larger habitat mosaic (Bendell 1974).

As trees and shrub understories in open areas are reduced, species favoring closed forests and shrublands will be negatively affected (e.g., ovenbird

[*Seiurus aurocapillus*], red-eyed vireo [*Vireo olivaceous*], and catbird [*Dumatella carolinensis*]). Furthermore, intense fires that reduce the mat of stems and debris on the surface of grasslands or open forests result in the disappearance of several sparrows (Fringillidae), bobolink (*Dolichonyx oryzivorus*), and voles (*Microtus* spp.) (e.g., Bendell 1974).

## Integrating Fire Management with Wildlife and Timber Management

### Wildfires, Clearcuts, and Prescribed Burns

A "let burn" policy for wildfire is rarely practiced except in areas set aside for permanent preservation, such as wilderness areas or where fuel loads need to be reduced. Resource management for objectives best achieved by fire must be accomplished by well-planned prescribed burn programs. Although fire is critical for management of species such as prairie chickens, black-backed woodpeckers, and Kirtland's warblers, few species are "wildfire obligates." It is often impractical to burn large parcels to provide habitat required by many species that benefit from fire. Thus, it is necessary to maintain some permanent openings without fire and integrate prescribed burning with timber harvesting. Forest regeneration can sometimes be compatible with prescribed burning or even benefit from fire treatment for site preparation. Even where plant species composition may be different, clearcuts and burns often have similar vegetation structure and animal communities. For example, small mammal species found in burns (Buech et al. 1977) are similar to those in clearcuts (Kirkland 1977, Probst and Rakstad 1987). Songbirds found in burns (Niemi 1978) are nearly the same as those listed in aspen clearcuts (Back 1979; Probst, unpubl. data) or in oak clearcuts outside the Midwest (Probst 1979). Thus, early successional wildlife species are often widespread species with general habitat requirements. The most obvious difference between logged areas and burned areas is that many dead trees (snags) will remain in an area after fire, and hence habitat for nesting, perching, and territorial display will remain. Additional complexity in these habitats (partly due to snags) are associated with higher densities of birds (e.g., Niemi and Hanowski 1984). Moreover, the importance of removing the boles from logged areas is still unclear with respect to nutrient cycling and long term sustainability of forest systems.

### Planning and Spatial Considerations

Management for the biogeography and local habitat needs of early succession species requiring large blocks of open lands should integrate planning for permanent and temporary openings. Most wildlife species that prefer permanent openings (e.g., sharp-tailed grouse, upland plover) can use regenerating habitat for 5 to 20 years. Location of permanent openings should be planned within the context of all open habitats. Planning, stand scheduling, and management should involve federal, state, county, and private owners to provide habitat area requirements for targeted species.

Management of land for permanent and temporary openings of larger areas than previously practiced has potential to reduce edge impacts of openings on mature forests and their associated wildlife and plants. Large temporary openings will regenerate into larger stands of mature forest, which can benefit area-sensitive, mature forest plants and animals. The spatial arrangement of these areas in a landscape context and its importance to the long term survival of wildlife and plant biodiversity is essential, but only beginning to be appreciated (Crow 1988).

The strategy outlined above is targeted toward maintaining habitat area requirements of species, but could be interpreted in a way that ignores local habitat quality. Thus, managers should focus efforts on prescribed burning of permanent and temporary openings, where appropriate, to provide wildlife with the benefits of fire such as desired plant species composition, plant and animal productivity, and habitat quality. The establishment of common objectives at local and regional scales for game species, non-game wildlife, plant species, and timber management could serve as a prototype for integrated management of selected habitat types by application of biogeographic principles on a regional scale.

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# 4 Altered Flows and Created Landscapes in the Platte River Headwaters, 1840-1990

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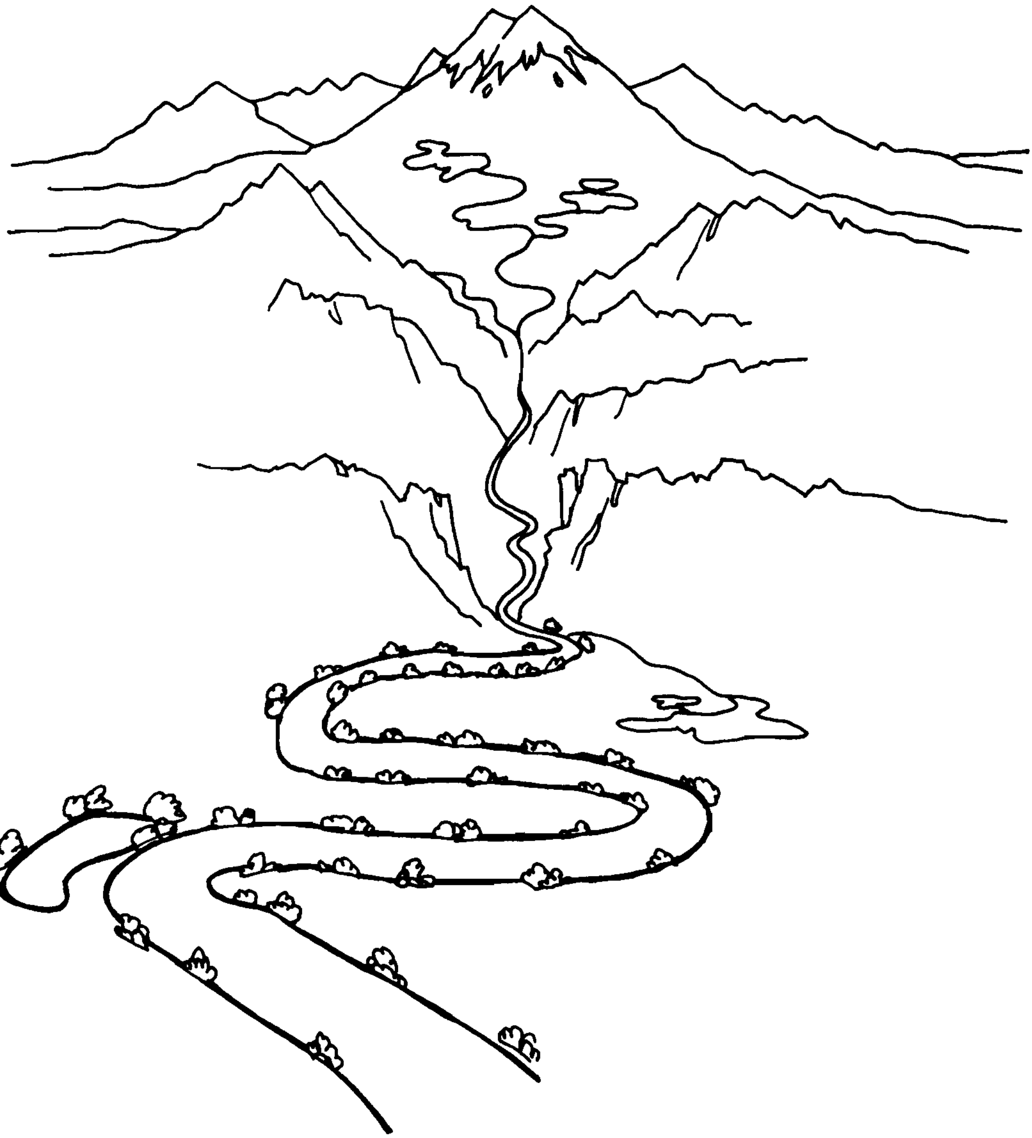

# Altered Flows and Created Landscapes in the Platte River Headwaters, 1840-1990

Fritz L. Knopf and Michael L. Scott

*Abstract:* The North and South Platte Rivers played a major role in development of the West. Historical flow dynamics have been altered dramatically with annual runoff peaks and total discharge severely reduced in the North Platte drainage. The South Platte, in contrast, continues to exhibit natural peak and annual flows. Both rivers now have enhanced low flows. Impoundments in the North Platte and drought during the 1930's in both drainages have contributed to extensive vegetative development in the respective floodplains on the western Great Plains. The deciduous vegetation provides local habitats for more wildlife species than currently occur elsewhere (or historically) in the headwaters. Secondary successional vegetation is colonizing rapidly up the North Platte floodplain, but more slowly in the South Platte floodplain. Exotic plant species, especially Russian-olive (*Elaeagnus angustifolia*), are spreading rapidly in both drainages. Extensive colonization by riparian vegetation has led to the development of very rich vertebrate assemblages along both floodplains. We conclude that (1) the South Platte is a unique river in the arid West because of the continuance of historical peak flows and mean annual channel flows, (2) enhanced low flows (not reduced high or annual flows) have had the greatest single ecological impact upon the Platte River headwaters, and (3) floodplain vegetation dynamics, historically regulated by pulsed flows, are now primarily driven by ecological processes. Conservation of biotic associations along the North and South Platte Rivers is clouded by the complexity of autonomous government authorities with jurisdiction in the headwaters.

Riparian ecosystems, especially along larger rivers, possess 2 unique ecological characteristics. The first characteristic is a pulsed flow—one in which moisture arrives lateral to the surface (i.e., not as local precipitation) and becomes superabundant for short periods (Ewel 1979, Brinson et al. 1981). Such pulses can occur daily in coastal marshes or annually along rivers with snowmelt at distant locations.

A second unique characteristic of riparian ecosystems is their highly linear connectivity across an elevational gradient (Ewel 1979). As flow frequency and magnitude increase, connectivity and biotic diversity decrease. Thus, pulsed flows are the driving ecological force within a floodplain and changes in flow dynamics induce changes in riparian biotic associations along river corridors.

Hydrologic development has historically altered the frequency and magnitude of high flows through impoundment and channelization to prevent overbank flooding, and the volume of low flows by in-channel and off-channel impoundments for water storage. Stabilizing the hydrodynamics in headwater streams drastically alters the characteristic fluvial processes that shaped these systems ecologically (Brinson et al. 1981). We examine how human settlement within the Platte River headwaters drainage has influenced the frequency and magnitude of flooding, and the consequences altered flows have had on native floral and faunal associations along streamsides. We show that the similar biotic character of the 2 rivers in 1990 masks markedly dissimilar development histories in the headwater drainages.

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## Physical Setting

Both the North and South Platte Rivers originate in Colorado (> 4,260 m elevation) with the North Platte flowing through Wyoming before joining the South Platte in western Nebraska (at 858 m elevation) to give rise to the Platte River (Fig. 1). The North Platte drainage is approximately 80,000 $km^2$ with a river length of 1,050 km (Kircher and Karlinger 1983). The South Platte drains an area of about 69,000 $km^2$ and is approximately 720 km long (Bentall 1975).

Climate within the headwaters is highly variable, influenced locally by altitude, topography, and latitude. In general, the climate is semiarid characterized by large fluctuations in temperature and precipitation. Annual precipitation along the Continental Divide averages 1,000 mm and falls primarily as snow. In the mountain foothills and piedmont, precipitation is variable and averages 400–500 mm/year, falling as both snow and seasonal thunderstorms. The High Plains feature large year-to-year variation in precipitation with averages of 300–460 mm/year falling mostly as rain from thunderstorms (Kircher and Karlinger 1983).

## Hydrologic Setting

Flows in both the North and South Platte Rivers originate primarily from snowmelt in the mountains; sediment inputs originate primarily from thunderstorms on the Great Plains tributaries (U.S. Bur. Reclama. 1947). Where

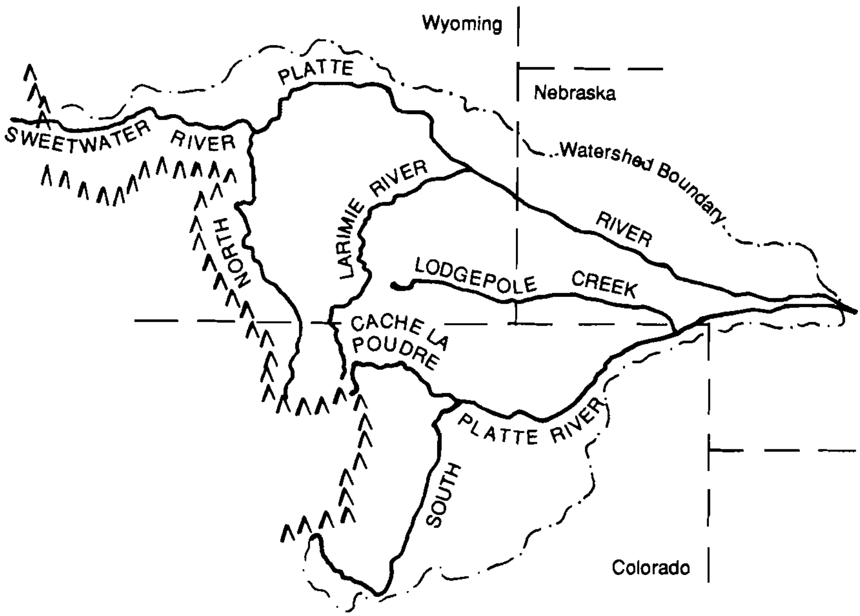


*Fig. 1.* Geographic location of the Platte River headwaters and drainage basin on the western Great Plains. Note the somewhat peripheral encompassing of the drainage by the 2 main rivers, the North Platte and the South Platte.

a river is not confined by bedrock (as in the lower reaches of both the North and South Plattes) annual floods tend to maintain wide, shallow, and active river channels with high sediment loads; such rivers usually are described as "braided." Maintenance of a braided channel is dependent upon water discharge and channel slope (Leopold and Wolman 1957), plus inputs of sediment to maintain equilibrium in channel patterns. Ferguson (1984) proposed empirical thresholds of channel slope (defined by valley slope), discharge, and sediment size for braided streams.

Human impacts on river flows commenced with movement of trappers and then pioneers into the West along the Oregon and Mormon Trails. In order to cross high mountain passes before autumn snows, most travel along the North and South Platte occurred in the spring; thus, early accounts of these rivers describe high flow conditions. These descriptions suggest that both streams were braided and were wide and shallow during high flows (Table 1).

Streamflow in the headwaters of the Platte have been continuously affected since the early 19th century. Changes in surface water hydrology can

*Table 1.* Historical descriptions of hydrology and vegetation of the North and South Platte Rivers.

HYROLOGY

1843: (Frémont 1845) . . . at the confluence of the North and South Plattes, 2 Jul., the southern channel was 450 feet[a] wide, having 18 or 20 inches of water in the deepest places; . . . The northern channel, 2,250 feet wide, was somewhat deeper, having frequently 3 feet of water in the numerous small channels, with a bed of coarse gravel.

1850: (Stansbury 1852) . . . upper ford of South Platte (~ 4 mi. west of Julesburg) is 700 yards wide, 3.5 ft. deep in Jul., . . . 2,045 ft. wide, 18 in. deep on 22 Oct.

1858: (De Smet[b]) . . . The South Fork of the Platte, at the Upper crossing, is 2,045 feet wide. In the month of Jul., its depth is generally about 3 feet; after the junction of the 2 forks, the width is about 3,000 yards (at North Platte, Nebr.). The bottom, throughout the whole length, is sandy.

VEGETATION

1834: (Townsend 1839) . . . starting up South Platte, not a green thing in site; . . . a grove of cottonwoods at Scottsbluff

1842: (Frémont 1845) . . . camped at site of a lone cottonwood at site of present-day town of Julesburg; . . . only a few willows present at mouth of Lodgepole Creek; . . . isolated trees on North Platte River west of main Platte

1849: (Stansbury 1852) . . . green ash present at Ash Hollow between North and South Plattes in Nebr.; . . . no wood on North Platte at Chimney Rock

1850: (Stansbury 1852) . . . timber plentiful 6–26 mil. upstream (South Fork) of North Platte, Nebr.

[a]English measures given to preserve precision in cited publication. Metric conversion factors are: 1 in = 2.54 cm, 1ft = 0.3048 m, 1 yard = 0.9144 m, 1 mile = 1,609.0 km.

[b]As published in Chittenden and Richardson (1905).

be attributed to removal of beaver (*Castor canadensis*) from high mountain wetlands and water development for agricultural, municipal, and industrial uses.

## Beaver Removal

The hydrologic effects of widespread beaver removal in the 1800's was never documented; however, the water impounded behind thousands of beaver dams in the West would have had a tremendous effect on flood and erosion control. Neff (1957) studied the effects of beaver site-abandonment on physical site factors and water storage capacity in high elevation headwater drainages in the Colorado Rockies. As the result of a wide, low-gradient flood plain and stable bedrock, site stability remained high after site-abandonment by the beaver. Subsequent channel erosion was limited to sediments deposited behind the former dams. Local water tables remained high and the drained pond bottom converted rapidly to a meadow of grasses and sedges (*Carex* spp.). In spite of the physical stability of the abandoned site, water storage during low flow conditions was < 18 times that of an adjacent drainage with an active beaver colony. Thus, even in physically or geologically stable locations the cumulative loss of water storage behind abandoned biological dams in high mountain wetlands surely increased peak flows and decreased low flows downstream.

## Irrigation, Municipal, and Industrial Development

Development of water supplies can be viewed as having taken place in 5 stages: (1) ditch construction to irrigate uplands, (2) canal construction to irrigate river terraces, (3) reservoir construction to store runoff for use during low flows, (4) trans-mountain diversions, and (5) groundwater pumping. Each of these developments has influenced the hydrology of the Platte River headwaters; timing and extent vary between the North and South Platte basins.

Between 1880 and 1885, all summer flows on the South Platte were allocated to irrigation (Eschner et al. 1983). In contrast, large scale canal construction on the North Platte (Table 2) began in the 1880's followed by a second period of rapid expansion in the early 1900's with construction of Pathfinder Reservoir. Summer flows in most of the North Platte basin were not completely allocated to users until 1915 (State of Wyoming 1965, Eschner et al. 1983).

The development of reservoir storage has been dramatically different between the North and South Platte basins (Fig. 2). Beginning in the 1880's, water was diverted from the South Platte for storage at off-channel reservoirs and dam construction continued sporadically through the 1930's. Most impoundments since the 1930's have been developed for recreation, flood control, or municipal water supplies. Mainstem reservoirs have not

*Table* 2. Numbers of canals constructed in the Platte River headwaters 1851–1930 (after Eschner et al. 1983).

| | 1851–1860 | 1861–1870 | 1871–1880 | 1881–1890 | 1891–1900 | 1901–1910 | 1911–1920 | 1921–1930 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| South Platte | 28 | 376 | 533 | 364 | 63 | 313 | 141 | 96 | 1,914 |
| North Platte | 0 | 17 | 194 | 1,627 | 725 | 1,391 | 732 | 249 | 4,935 |
| Totals | 28 | 393 | 727 | 1,991 | 788 | 1,704 | 873 | 345 | 6,849 |

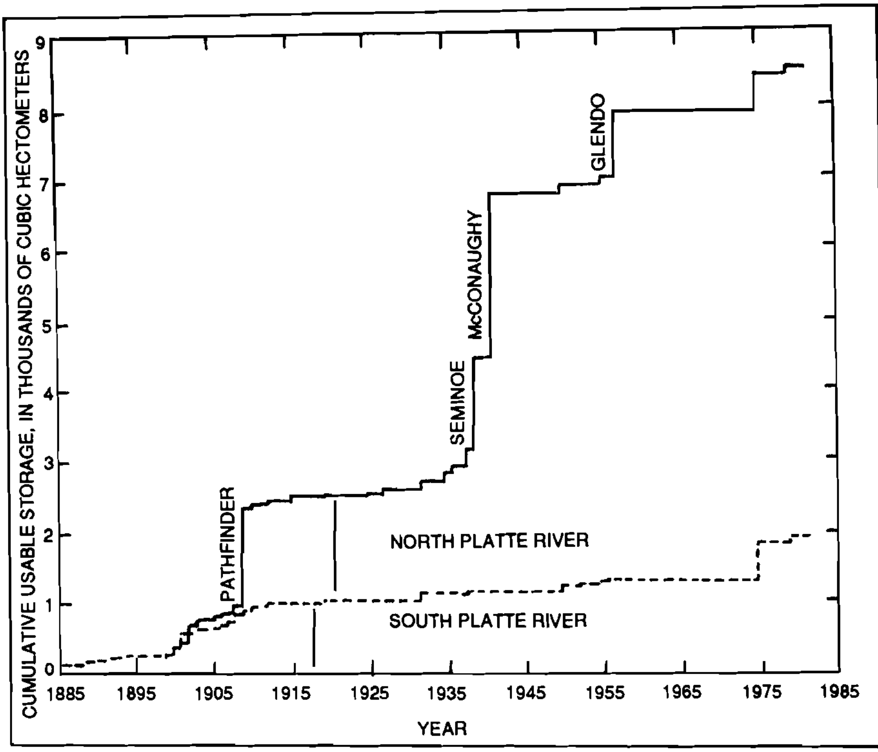


*Fig. 2.* Comparison of cumulative reservoir storage within the North Platte (solid line) and South Platte (dashed line) basins over time (from Eschner et al. 1983).

been constructed on the South Platte below Denver. From the completion of Pathfinder Reservoir in 1909 to Glendo Dam in 1957, many large reservoirs were constructed along the mainstem of the North Platte for irrigation, power generation, flood control, and recreation.

Flows in the South Platte basin have been supplemented by the transwatershed diversion of surface waters from the Colorado and North Platte river basins for irrigation, municipal, and industrial uses (Fig. 3). The earliest diversions began in the 1890's and in 1974 average yearly import to the South Platte basin totaled 460 hectometers$^3$ (Gerlek 1977). Water diversions into the North Platte basin (primarily for municipal supplies) total $<$ 48 hectometers$^3$ (Dep. Inter. 1983).

Groundwater supplies have been actively developed in eastern sections of both the North and South Platte basins. Along the South Platte, groundwater use was limited before the 1930's, but developed rapidly following

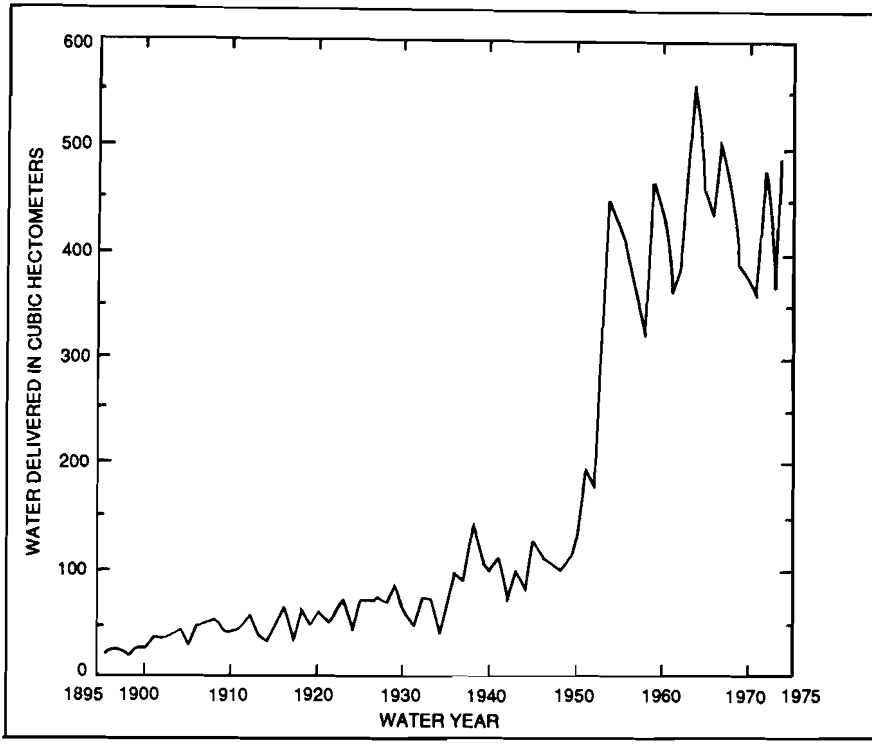


*Fig. 3.* Total yearly imports of water into the South Platte basin since 1895 (from Eschner et al. 1983).

the drought years. In addition to irrigation, which consumes the greatest share, groundwater is now being used by municipalities and industry within both the North and South Platte basins.

## Comparative Hydrology of the Platte Headwaters

Water development activities overlapped temporally, and systematic records of stream flow were limited before the 1930's. Thus, individual effects of the above factors on the surface water hydrologies over the last 100 years are difficult to separate.

Changes in historical streamflow patterns between the North and South Platte basins differ primarily in the way that runoff is stored upstream. Water storage on the North Platte has dramatically altered the annual surface water hydrograph. In contrast, flow alteration on the South Platte has been less extensive and, with regard to the reoccurrence of peak spring floods, the South Platte still exhibits a snowmelt hydrograph. Changes in the surface water hydrographs within the 2 drainages are illustrated in historical trends within annual peak, mean, and mean low flows.

## South Platte River

Reservoir storage on the South Platte has increased 100% since 1915 (Fig. 2); most storage is off-channel. Peak annual flows at Kersey and Julesburg, Colorado have not changed appreciably over the period of record (Fig. 4*a*). However, peak flows have decreased at the City of North Platte, Nebraska. Flows during the 1970's were only half of those recorded from 1910–1919 (Williams 1978). These decreases may reflect additional surface water diversions between Julesburg, Colorado and North Platte, Nebraska (Eschner et al. 1983).

Mean annual discharges on the South Platte also have shown no apparent trends over the period of record (Fig. 4*b*). Mean annual discharges at North Platte, Nebraska show only a slight decrease during the period 1920 through the 1970's. These patterns can be attributed to the diversion of Colorado River surface water into the South Platte basin via trans-Continental Divide aqueducts; such diversions (numbering > 50) have offset surface water development within this basin.

Mean low flows have been relatively stable on the upper South Platte River, but began increasing about 1920 at Julesburg, Colorado and 1940 at North Platte, Nebraska, suggesting that changes in hydrology began in the headwater reaches and progressed downstream (Kircher and Karlinger 1983, Fig. 32).

## North Platte River

When mean daily flows and mean annual flows are reduced with instream impoundment of an alluvial river, average peak discharges (highest flow recorded for the year) are also reduced (Williams and Wolman 1984). Mean peak flows in the North Platte declined progressively with the closure of each of 4 major dams on the mainstem (Fig. 5*a*). Ten-year mean annual flows also decreased significantly during the period 1920 to 1940 (Fig. 5*b*); and currently are half of those reported for 1925 (Williams 1978).

Minimum low flows within a year have also increased in the North Platte, primarily since 1940 (Kircher and Karlinger 1983, Fig. 29). Increases in low flows are typical for alluvial river reaches below mainstem dams (Williams and Wolman 1984).

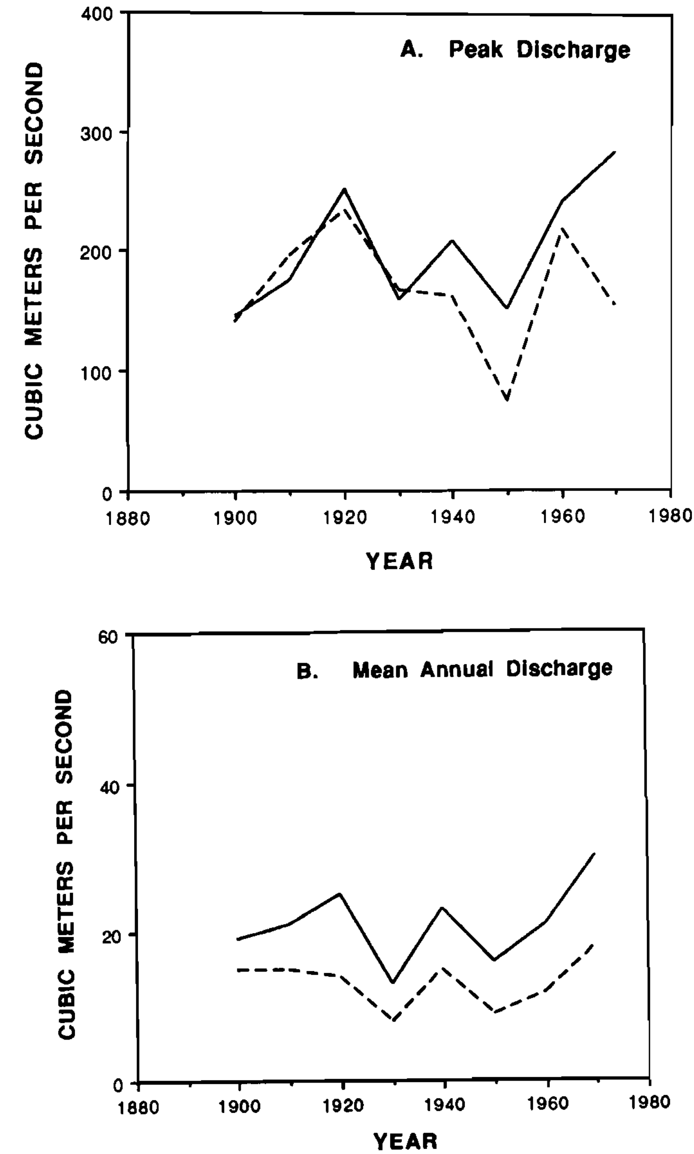


*Fig. 4.* Ten-year averages of A) annual peak discharge (highest flow recorded during the year), and B) mean annual discharge for 2 recording stations on the South Platte River—Julesberg, Colo. (dashed line) and Kersey, Colo. (solid line) (modified from Williams 1978).

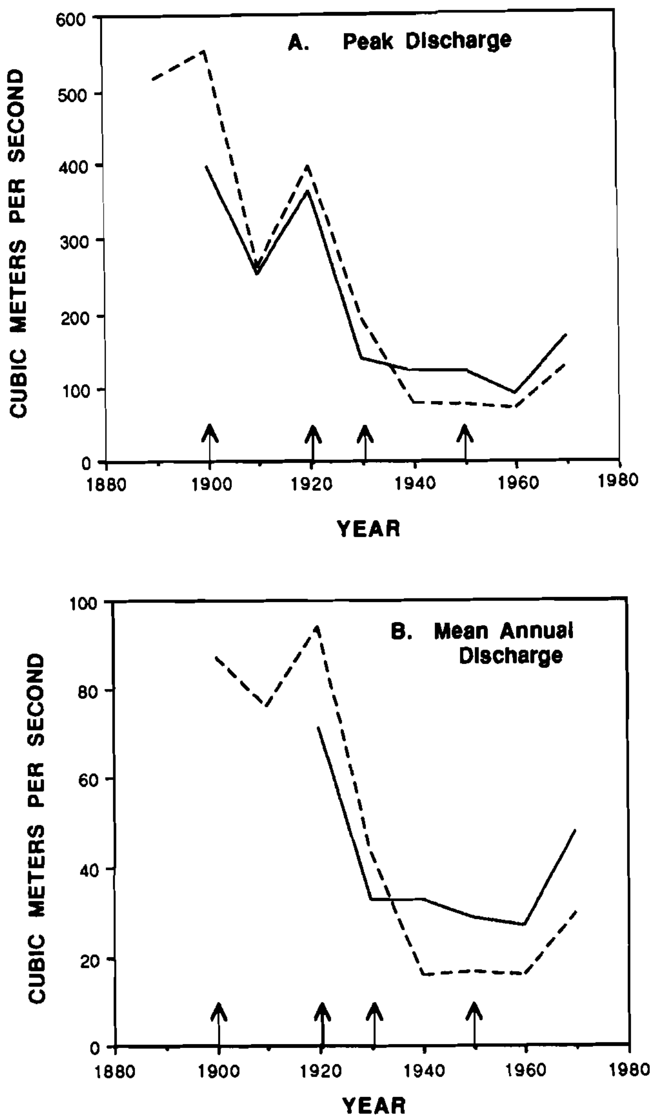


*Fig. 5.* Ten-year averages of A) annual peak discharge, and B) mean annual discharge for 2 recording stations on the North Platte River—North Platte, Nebr. (dashed line) and Bridgeport, Nebr. (solid line). Arrows indicate the period corresponding to the closure of 4 major dams on the North Platte (modified from Williams 1978).

## Vegetative Responses to Altered Flows

The Platte headwaters originally seen by western immigrants were disturbance-mediated landscapes characterized by periodic major flooding which maintained the native riparian association dominated by invading grasses (probably *Spartina* spp.). Woody vegetation was limited along the North and South Platte drainages and occurred as widely scattered stands of cottonwood (*Populus sargentii*) and willows (*Salix* spp.) (Table 1). Hydrologic conditions that maintained a braided river form also controlled the patterns of establishment and growth of woody riparian species. The occurrence of riparian vegetation would have been limited to sites where (1) groundwater was at or near the rooting zone during the growing season, (2) seedlings would not be submerged for extended periods of high flows, and (3) seedlings would not be scoured by high flows in subsequent years (Currier 1982, Skinner 1986). Changes in the surface water hydrographs of the Platte basins have altered river form and conditions for establishment and growth of riparian vegetation.

### South Platte River

River form typically responds to long-term changes in peak flows or mean annual discharges. On the South Platte, however, the floodplain and associated vegetation primarily reflect enhanced low flows, especially through a drought cycle.

With increased crop irrigation in the South Platte basin, irrigation recharge to the river (Parshall 1922) raised local water tables and created a perennial flow in the otherwise intermittent stream (Nadler and Schumm 1981) (Fig. 6). The increased soil moisture contributed to more continuous stands of riparian vegetation along the river, above the mean high water level. Although irrigation began in the 1860's, large-scale geomorphic and vegetative changes did not occur until after the turn of the century. Drought conditions during the 1930's temporarily reduced peak flows which, in conjunction with increased low flows, allowed vegetation to establish below the mean high water level. Estimates of tree ages from the floodplain on the lower South Platte (Sedgwick and Knopf 1989*b*) and North Platte (Currier 1982) support this scenario. With encroachment of vegetation onto the active channel during the drought, channel banks and islands were stabilized. Subsequent deposition of sediments in formerly active channels reduced the historic braided river form to one characterized by a single, or a few, narrow active channels. Woody stands dominated by cottonwood and willow now form a relatively continuous woody riparian corridor along the South Platte

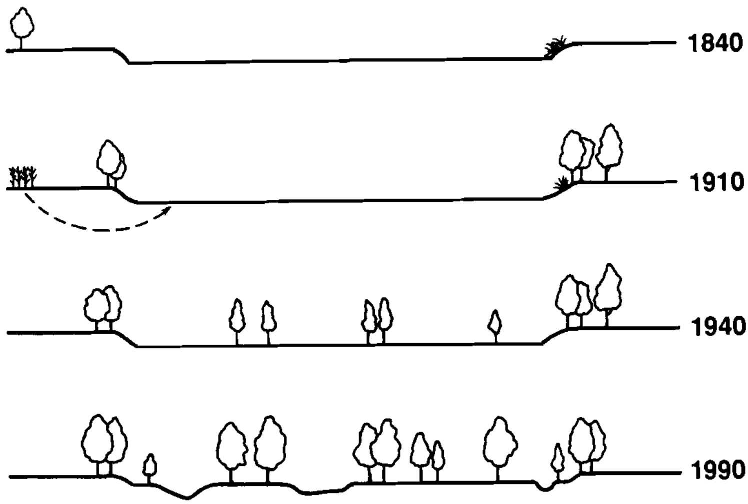


*Fig. 6.* Change in river form for the lower South Platte River, 1840–1990. The historical condition was a wide braided river channel with scattered riparian vegetation primarily at tributary confluences. More continuous riparian vegetation developed with increased irrigation return flows. Reduction in peak flows and drought allowed vegetation to establish below mean high water on the formerly active channel in the 1930's. Contemporary floodplain vegetation on the original active channel has contributed to the filling in of former braided channels through aggradation of materials during high flows and forcing the river to downcut historical sediments to form a few narrow, deeper channels.

floodplain. Lindauer (1983) identified 5 floodplain community types, the most common being open stands of cottonwood. He reported that green ash (*Fraxinus pennsylvanica*) and American elm (*Ulmus americana*) are rare within the floodplain and, in general, vegetation within the drainage appeared to be stable.

## North Platte River

Development of riparian vegetation along the North Platte was similar to that along the South Platte in that low flows were enhanced and peak flows during the 1930's were reduced. The primary difference was that impoundment construction contributed to reductions in mean peak flows and mean annual flows. With reservoir construction on the North Platte, mean annual discharge declined 85% between pre- and post-reservoir periods (Williams 1978). Decreases in peak flows reduced scouring and contributed to encroachment of vegetation onto formerly active channels. As on the

South Platte, cottonwood and willows initially developed as the dominant overstory. In contrast, secondary successional species such as eastern redcedar (*Juniperus virginiana*), Russian-olive, and green ash have been establishing upstream along the North Platte (Currier 1982).

## Ecological Consequences to Wildlife Habitats

Ecological equilibrium is rarely achieved on a local scale and the concept of an ecological climax becomes less valid as the chronological framework lengthens (Sousa 1984). Natural disturbances such as flooding can play a greater role in wildlife community dynamics than biological interactions such as competition and predation (Wiens 1977, Sousa 1984).

Diurnal flood cycles are fundamental to the ecology of coastal estuaries (Teal and Teal 1969) just as catastrophic floods can have both short-term (Knopf and Sedgwick 1987) and long-term (Hunter et al. 1987) consequences to wildlife assemblages. Ironically, major reviews of the role of disturbance in ecological systems (e.g., Pickett and White 1985, Szaro 1980) have ignored flooding as an issue.

Many studies have opportunistically described varied impacts of flooding on small mammal communities (McCarley 1959, Ruffer 1961 and references therein). Within the Platte headwaters, dramatic reductions in populations of mammals that live on the ground surface such as eastern cottontails (*Sylvilagus virginiana*) and muskrats (*Ondatra zibethicus*) were noted following a major cloudburst on the Big Thompson River (Weld County, Colorado) on 3 August 1951 (Beidleman 1954). Population levels of arboreal mammals such as fox squirrels (*Sciurus niger*) and raccoons (*Procyon lotor*) were unaffected by that flood. The effects of flooding on birds show near identical patterns although the impacts on ground-nesting and foraging species were not as immediate (Knopf and Sedgwick 1987).

With extensive colonization by cottonwoods and subsequent establishment of secondary successional woody species, native vertebrate assemblages along the Plattes have responded accordingly. However, these changes represent more than enhancement of local assemblages. The enhanced low, summer flows have been the driving ecological force in the Platte rivers and, coupled with the connectivity of the systems, have enabled dramatic movements among faunal assemblages at the local and regional levels. In a study of avian assemblages across the South Platte River watershed, Knopf (1985) concluded that riparian avifaunas were most unique at the ends of the watershed. Bird assemblages in high elevation, shrub-willow associations along streams surrounded by uplands of spruce (*Aries*)-pine

(*Pinus contorta, P. flexilis*) forests were distinctly different from assemblages in cottonwood savannahs surrounded by an undulating plain of sand sagebrush (*Artemisia filifolia*) and bluestem (*Andropogon* spp.) prairie. Subsequent studies at those same sites (Olson and Knopf 1988) failed to support the significance of riparian ecosystems to small mammal assemblages at lower elevations. Riparian-dependent small mammal species decreased as one progressed down the South Platte drainage and were absent at sites on the Great Plains. All species at the lower elevations were either ecological generalists with broad habitat use patterns or upland species that occurred in the riparian ecosystem in low numbers. Of all individuals within the small mammal community, 95% were deer mice (*Peromyscus maniculatus*), one of the most widespread species. The pattern of decreasing significance of riparian vegetation to vertebrates was directly attributed to the periodic, catastrophic floods following snowmelt; such flooding inundating the entire floodplain. The conclusion that the small mammal assemblages are structured by periodic major disturbance rather than biological processes was supported by the experimental introduction of cattle grazing into the system with seemingly little consequence (Samson et al. 1988).

In view of the historical perspective of the relatively treeless Platte rivers on the western Great Plains it is probable that almost 90% of the contemporary riparian avifauna on the western Great Plains was not present at the turn of the century (Knopf 1986). The evolution of this avifauna has progressed quickly. Population numbers of some bird species typical of mature wetland forests are increasing rapidly at present. Only a single pair of Wood Ducks (*Aix sponsa*) had been reported nesting in Colorado before 1965 (Bailey and Niedrach 1965) but in 1988 Wood Ducks regularly were found breeding along the South Platte floodplain (Knopf, unpubl. data). The Red-bellied Woodpecker (*Centurus carolinus*), a species of Southeastern forests, is now seen annually within the state. Glimpses of very similar changes occurring in native vs. contemporary avifaunas on the North Platte are available in Finch (1989*a,b*).

The vertebrate development included more than birds. Since the 1920's, the least shrew (*Cryptotis parva*) has moved into riparian and irrigated areas along the east base of the Front Range by moving across the South Platte drainage (Armstrong 1972). The fox squirrel (*Sciurus niger*) has spread throughout the upper South Platte drainage due to natural invasion from Nebraska augmented by early stocking at some suburban sites (Hoover and Yeager 1953). Mule deer (*Odiocoileus hemionus*) of montane and riparian areas of the Rocky Mountains intergrade with eastern white-tailed deer (*O. virginiana*) down the South Platte drainage (Armstrong 1972). White-tailed deer, never common, had been extirpated from Colorado by 1952, but their numbers have been building rapidly in the South Platte drainage in recent years. Aerial surveys of the region between Platteville, Colorado and the Nebraska state line in 1989 showed that 78% of the deer population was white-tails (R. Kufeld, pers. commun.). White-tailed deer have moved much further up the North Platte drainage, and are dominant in riparian vegetation on the upper Laramie River drainage near Centennial, Wyoming (F. B. Lindzey, pers. commun.). They are also beginning to appear in North Park, Colorado.

Distribution patterns of species such as the northern cricket frog (*Acris crepitans*), snapping turtle (*Chelydra serpentina*), spiny softshell turtle (*Trionyx spiniferus*), northern water snake (*Nerodia sipedon*), and common garter snake (*Thamnophis sirtalis*) (Hammerson 1982) also suggest range extensions westward into the Platte headwaters in recent times. Only the indigenous ichthyofauna of the South Platte, which was never diverse, has failed to show major changes in species distributions (Propst and Carlson 1986).

## Biotic Assemblages in the Twenty-First Century

Contemporary wildlife associations along the Platte rivers have not stabilized. Changes in the next 50 years likely will be as dynamic and dramatic as those changes since 1900. Projections of future changes in the riparian vertebrate fauna must distinguish between succession toward native vs. altered riparian ecosystems. Succession toward a native condition (though unlikely) can occur only along the South Platte, which currently lacks instream impoundments. The extensive, mature stands of cottonwoods that established during the drought period along the lower South Platte are not being replaced (Sedgwick and Knopf 1989*b*), resulting in a progressive decline in cottonwood coverage and overall height of the overstory canopy. Such decline will impact primarily densities of canopy-nesting and canopy-foraging bird species (Northern Orioles [*Icterus galbula*] and Orchard Orioles (*I. spurius*] especially) which collectively dominate that local avian assemblage (Knopf 1986). With the rapid rate of snag fall in many stands (Knopf, unpubl. data), the rich guild of primary and secondary cavity-nesting species (Sedgwick and Knopf 1986, 1989*a*) will decline appreciably. Species such as the Wood Duck, American Kestrel (*Falco sparverius*), Northern Flicker (*Colaptes auratus*), and White-breasted Nuthatch (*Sitta carolinensis*) will experience the most dramatic density shifts. These species, along with the invading Red-bellied Woodpecker, will gradually disappear along the South Platte, but may continue further up the North Platte with aging of more recently established cottonwood stands.

However, as overstory coverage in the South Platte declines, the river will never progress to the point of redeveloping a broad, sandy floodplain. Agricultural activities will continue to provide irrigation seep-back maintaining elevated low summer flows, although those flows should decline with increased groundwater pumping being used in center-pivot irrigation. In addition, new bridges constructed at highway crossings also will influence future woody assemblages along the river. In contrast to early bridges constructed on elevated pilings, newer bridges exploit extensive solid landfills dissecting the floodplain with girdered spans to allow water passage. Such construction stabilizes channels and forces them to erode progressively deeper because of confinement during high flows and simultaneous accretion of materials on terraces (Nadler and Schumm 1981). Deeper channels will favor more rapid establishment of secondary succession trees in the floodplain.

The future of the South Platte could change rapidly with creation of the proposed Narrows and Two Forks impoundments. Such mainstem impoundments would dramatically reduce the peak flow and annual inundation of floodplains, thus creating a modulated hydroperiod similar to the one that has developed on the North Platte. Projections of future biotic associates of the lower South Platte River would then parallel projections for the North Platte.

Succession toward an increasingly altered riparian ecosystem will continue in the North Platte drainage. Reductions in recruitment of primary successional riparian species, along with increases in the densities of secondary successional species, have been noted downstream of reservoirs on many western rivers. Alterations in the dynamics of forested riparian ecosystems below reservoirs have been attributed to reductions in flood frequency and magnitude, as well as attendant changes in rates of sedimentation and river meandering (Johnson et al. 1976, Bradley and Smith 1986). Similar changes have been noted on the North Platte where native secondary species such as eastern redcedar and green ash are establishing (Currier 1982).

Changes in wildlife assemblages of the headwaters under the altered hydroperiod scenarios are predictable. Vertebrate species composition will emulate changes in forest structure and composition, and secondary forest associates will continue to establish upstream to the foothills. Such progression is certain on the impounded North Platte; only the rate of movement is uncertain. Ultimately, as the forest composition changes the avifauna at Fort Laramie will be similar to the avifauna currently found at Grand Island (Currier et al. 1985). New species (e.g., the Tufted Titmouse [*Parus bicolor*]) currently not present in Colorado and Wyoming also may be expected to breed in those states within future decades.

These conclusions are subject to interference from another ecological force in the Platte drainage: the invasion of exotic plant species and, in particular, Russian-olive. Already projected to be a climax species along the main Platte (Currier 1982) this exotic is spreading rapidly in the headwaters and throughout the western United States (Olson and Knopf 1986). This tree is generally of intermediate height relative to native woody species in riparian vs. upland landscapes and tends to establish along the interface of the 2 native communities (Knopf and Olson 1984). Earlier studies (op. cit.) concluded that Russian-olive enhanced local migratory bird communities by providing breeding habitats for 60% of those species nesting in native riparian vegetation. However, long-term projections for Russian-olive temper enthusiasm about the short-term views. Although the species does not compete well under a cottonwood canopy, it does survive. As cottonwood populations age, Russian-olive is likely to form a dense, lower canopy. The presence of that new canopy will shade the surface of floodplains, thus precluding survival of replacement cottonwoods, especially along the South Platte where native secondary successional species are, as yet, rare. Even in the presence of secondary successional species, Russian-olive may dominate the new canopy. Unfortunately, little is known of the ecology or population biology of this species and future projections are speculative, particularly under conditions of periodic flooding such as along the South Platte.

Displacement of a native cottonwood overstory in the Platte headwaters will result in a loss of habitats for 31% (100% minus 69%) of nongame bird species (Knopf and Olson 1984). Birds lost will include all species within the cavity-nesting guild plus many rarer species typical of native riparian communities. Impacts on wintering bird communities will be greater when cavity-nesting species dominate the assemblage.

## Managing the Platte Headwaters

Managing the ecological complexities of biotic associations along the Platte headwaters represents a major conservation task (Shoemaker 1988). In addition to the various water development practices that have altered historical flow dynamics of the Platte headwaters, future conservation is

*Table 3.* Governmental authorities that manage properties within the Platte River headwaters. Listed authorities are for state and federal agencies that have conservation mandates. The U. S. Army's Rocky Mountain Arsenal, not included here, is rapidly developing a conservation emphasis at time of this writing.

| Agency | Authority |
|---|---|
| Colorado | Division of Wildlife[a] |
| | Division of Parks and Recreation[b] |
| | Colorado State Forest |
| Nebraska | Game and Parks Commission[c] |
| USBLM | Cañon City (Colorado) District |
| | Casper (Wyoming) District |
| | Craig (Colorado) District |
| | Rawlins (Wyoming) District |
| USFS | Pawnee National Grassland, Roosevelt NF[d] |
| | Boulder District, Roosevelt NF |
| | Clear Creek District, Arapaho NF |
| | Douglas District, Medicine Bow NF |
| | Estes-Poudre District, Roosevelt NF |
| | Laramie District, Medicine Bow NF |
| | North Park District, Routt NF |
| | Pike's Peak District, Pike NF |
| | Redfeather District, Roosevelt NF |
| | South Park District, Pike NF |
| | South Platte District, Pike NF |
| VSFWS | Arapaho NWR[e] |
| | Bamforth NWR |
| | Crescent Lake NWR |
| | Hutton Lake NWR |
| | North Platte NWR |
| USNPS | Chimney Rock National HS[f] |
| | Fort Laramie National HS |
| | Rocky Mountain National Park |
| | Scott's Bluff National Monument |
| Wyoming | Game and Fish Department[g] |
| | Recreation Commission[h] |

[a]Includes 46 Wildlife Management Areas, but does not include Access Leases
[b]Includes 14 state parks each with resident managers
[c]Includes 14 state historical sites, recreational, and wildlife management areas
[d]National Forest
[e]National Wildlife Refuge
[f]Historical Site
[g]Includes 6 state Wildlife Management Areas with 1 pending, does not include access leases.
[h]Includes 11 state parks, historical sites, and recreational areas

confounded by the large number of political authorities that conduct land management practices within the Platte headwaters. The quality of connectivity that is fundamental to understanding riparian systems has been ignored in a fractionated approach to natural resource policy and management. Over 100 offices with decision authority currently exist within 4 federal and 6 state agencies in this relatively small watershed (Table 3). The first step toward wise conservation of the Platte headwaters will be to assure that land management activities with hydrological impacts are coordinated among agency authorities across a watershed (Clark 1980, Mantell et al. 1985, Knopf et al. 1988). Such coordination could serve as a model to encourage "basin-wide management" for the Platte watershed (Currier et al. 1985), attracting participation by additional government authorities, private conservation organizations, and users.

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# 5 Impacts of Hydrologic Alteration on Management of Freshwater Wetlands

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# Impacts of Hydrologic Alteration on Management of Freshwater Wetlands

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*Abstract:* Wetlands are dynamic systems that are characterized by daily, seasonal, and long-term fluctuations in water levels. Man's activities in the 48 conterminous states, Hawaii, and the Canadian provinces have severely impacted a vast area of these habitats either by destruction or through modification of natural hydrological functions. Constriction of river channels, and subsequent conversion of floodplain habitats to croplands, change hydrological regimes throughout major river basins and cause a decrease in the productivity of remnant isolated wetlands by stabilizing water levels. In an attempt to counteract the effects of habitat loss and hydrological change, intensive wetland management is widely practiced in North America. Unfortunately, implementation of commonly used manipulations may further stabilize wetlands developed for intensive management. To diminish these detrimental effects, it is essential that we have an understanding of wetland values and functions, as well as knowledge concerning life history strategies of plant and animal foods that supply seasonal requirements for target organisms. Recommendations for desirable development features and guidelines for intensive management to maintain productivity require strategies that replicate natural hydrological regimes.

Freshwater wetlands are among the most productive habitats in the world, with average net primary production reaching 2,500 $g/m^2/yr$ (Whittaker and Likens 1973). The long-term productivity of these habitats are maintained by the perpetual destruction and creation of wetlands within the same general region. Glaciers, floods, fire, and changes in permafrost are common forces important in freshwater wetland formation and maintenance.

Unfortunately, productivity of our national wetland resource has been severely impacted because the natural hydrology that resulted in wetland formation, and to which myriad plants and animals have adapted, has been compromised. Developments such as dams for hydropower and flood control, diversions to speed water flow, levees for flood protection, wetland drainage for commercial districts and agriculture, and filling wetlands for marinas have modified wetlands across the continent (Tables 1 and 2).

*Table 1.* Agricultural developments that modify wetlands

| Development | Modification | Hydrology or water quality |
|---|---|---|
| Rowcrops | Drainage | —Increases speed and volume of runoff, remaining basins receive more water faster<br>—Decreased periodicity of headwater or back-water flooding, but increased intensity<br>—Isolation of individual basins and disruption of wetland complexes<br>—Smaller size of wetland fragments<br>—Disproportionate loss of small ephemeral or seasonal wetlands |
| | Cultivation | —Increase erosion and turbidity<br>—Increase toxins<br>—Seasonal loss of vegetation increases rate and volume of flooding |
| Conservation practices | Terraces and contour farming and riparian buffer strips | —Reduce runoff and erosion<br>—Lessen flow peaks in streams and/or wetlands |

These destructive processes have been so complete within the 48 conterminous states that all watersheds have been degraded to some degree and few wetlands have retained either their natural hydrology or productivity. Because of these modifications in natural hydrological regimes, intensive wetland management is essential in many regions if wetlands are to retain their values and productivity. To be effective, management must be based on an understanding of untampered wetland functions and values in order to emulate natural hydrological conditions that will assure the long-term productivity of the remaining wetlands. A description of the essential components in wetland productivity sets the stage for an understanding of how various wetland developments designed for either wildlife, commercial, or navigational purposes have impacted wetlands. The goal of this paper largely focuses on the abiotic components of hydrology and fire and their role in maintaining viable wetland habitats. The effects of modified hydrology and the need for intensive management to compensate for man's modifications are discussed.

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## Basic Wetland Concepts

Wetlands are transitional habitats between terrestrial and aquatic systems, that serve as a functional sieve (van der Valk 1981, Fredrickson 1982). Abiotic components that influence wetlands include: climate; soils; fire; water quantity, quality, and chemistry; hydroperiod; and hydrological regime (Fig. 1). Biotic components include those within a wetland basin and those that are more peripheral to the system. Diseases, predators, and upland wildlife that occasionally use wetlands are biotic components that have some influence on wetlands. Within the wetland basin, there are com-

*Table* 2. Non-agricultural developments that modify wetlands.

| Development | Modification | Change in hydrology or water quality |
|---|---|---|
| Reservoir | Modify overbank flooding | —Natural peak flows removed, lower downstream flow over longer time period, reduced turbidity and sediment load, inundates riverine wetlands upstream |
| Reservoir with hydropower | Modify overbank flooding | —Natural peak flows removed, lower downstream flow over longer time period, reduced turbidity and sediment load, inundates riverine wetlands upstream<br>—Dramatic daily and seasonal fluctuations may occur |
| Levees | Constriction of river channel<br>Modify overbank flooding | —Intensifies extremes of flooding and drought<br>—Increase turbidity, decrease sedimentation and surface area<br>—Increase flow |
| Channels | Speed flow of water | —Water rises and drops quickly<br>—Increased bank erosion<br>—Increased flow velocity |
| Urbanization and marinas | Drain and filling wetlands | —Isolation of wetlands<br>—Stabilization of water regimes<br>—Increases speed and volume of runoff, remaining wetlands receive more water faster<br>—Industrial and municipal pollutants, nutrient loading, eutrophication |
| Highways/railroads | Modify flow patterns | —Increase and/or decrease water depths<br>—Toxic inputs |

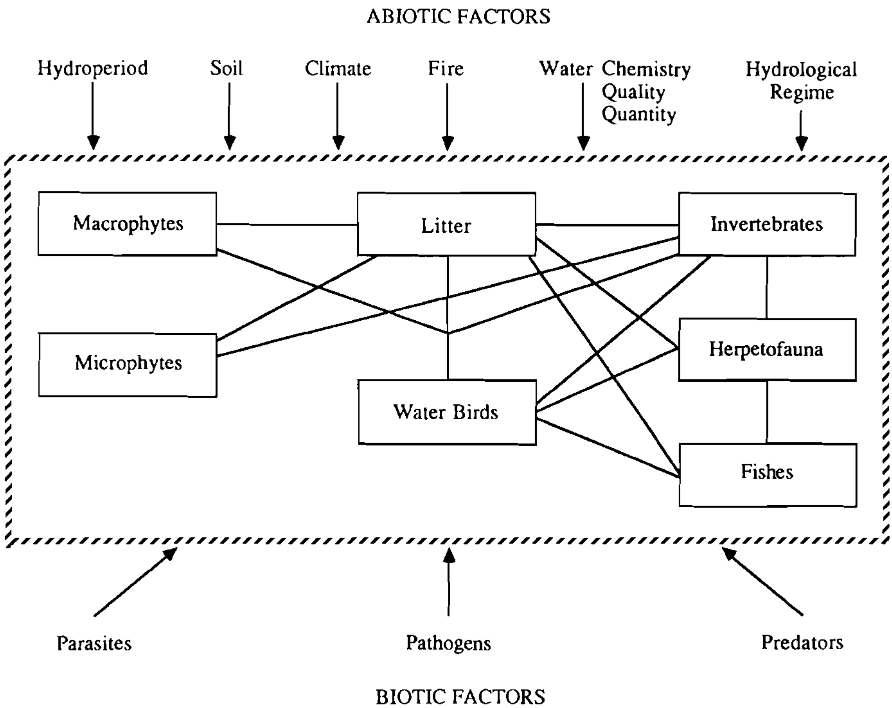


*Fig. 1.* Wetland seive model of the interrelationships among biotic and abiotic factors (after van der Valk 1981, Fredrickson 1982).

plex interactions among microorganisms, one-celled plants, macrophytes, invertebrates, and vertebrates. These biotic components are strongly influenced by abiotic factors, many of which have been severely impacted by man. Man's most dramatic impact has been the modification of the hydrological components that regulate wetland productivity.

## Untampered Wetland Systems

### Innoko River Complex: A Natural System

Examination of a natural, free-flowing river system is instructive in developing an understanding of the subtle effects that modifications have on natural wetland hydrology. The Innoko River system in western Alaska is such an example. A mountain range intercepts weather movements from the Bering Sea, with a resulting precipitation pattern that is highly variable among and within years. The rapid flush of water from the mountainous areas, during snow melt or periods of heavy precipitation, to more level terrain surrounding the Innoko River at lower elevations has produced a vast interconnected wetland system (Fig. 2*a*). Silt deposition along the main channel has formed natural levees that have been stabilized by willows (*Salix* spp). Behind these natural levees are interconnected floodplain lakes that drain into the main river channel through small streams that breach the levees along the main channel. When water is high in the main river channel, the water acts as a natural stoplog structure, controlling the floodplain

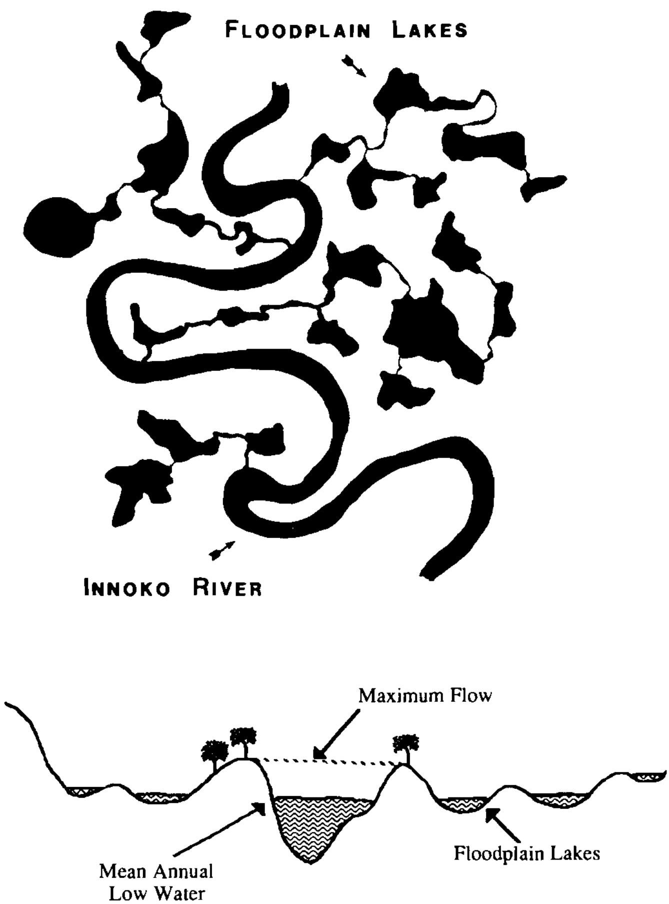


*Fig. 2.* Innoko River system, Alaska showing (a) aerial view of river and floodplain lake drainage pattern and (b) cross-section relationship of water levels in the river and floodplain lakes.

water level and rate of drawdown in the small streams that drain the interconnected lakes (Fig. 2*b*). As water drops gradually in the main channel, a slow drawdown occurs. Lush green browse develops on mudflats and attracts molting white-fronted geese (*Anser albifrons*). Interspersed among the mudflats are sites that are vegetated with robust emergents, such as the sedge (*Carex rostrata*). Higher water temperatures at these latter sites promote a great abundance of invertebrates. As water recedes, these invertebrates are concentrated and made available for waterbird use. Thus, the vast area of wetlands behind the natural levee along the main river channel provides an ideal feeding ground for arctic waterbirds, and supplies key nutritional components for breeding and molting (Myers et al. 1987).

In the case of the Innoko River, an upstream reservoir or other channel modification would compromise the productivity of the system. Retention of water within a reservoir would keep the floodplain lakes at a drawdown stage. Rapid release of water for hydropower would be devastating to the production of diverse food resources because of erratic fluctuations in water levels.

### Managing Pristine Environments

Management of pristine environments should be passive. Emphasis should be placed on investigations or monitoring that results in understanding the dynamic processes of natural production, wetland function, and wildlife use. Unfortunately, resource agencies frequently emphasize intensive management activities within pristine habitats that should be reserved only for the rehabilitation of degraded habitats. As a current example, practiced or planned "habitat improvements" in Alaska include island construction, pothole blasting, hay infusions, fertilization, and impoundment of tidal wetlands. These actions are reasonable solutions to enhance degraded wetlands in some of the 48 contiguous states, but such activities disrupt the natural function of untampered Alaskan and northern Canadian wetlands. Understanding dynamic processes aids biologists in generating appropriate options to proposed perturbations including roads, dams, and oil exploration and transport. Furthermore, an understanding of functions in untampered environments provides clearer guidelines to manage modified environments.

## Modified Wetland Systems

The principal cause of wetland loss in the 48 conterminous states has been conversion to agriculture, accounting for >85% of total losses (Tiner

1984). Recent losses of palustrine wetlands by conversion of forested and herbaceous habitats to agriculture have had significant impacts on wetland wildlife (Frayer et al. 1983). Field expansion, land leveling, and irrigation with ground water have been accelerated in the agricultural areas of much of the Midwest. As fields were leveled, small wetlands were destroyed and more ground water was pumped for irrigation. These practices further stabilized the remaining wetlands and stream systems by facilitating more rapid water drainage from fields and by lowering ground water levels (Table 1). In addition, the capacity to recharge ground water systems was reduced because fewer wetlands remained and near drought conditions often times occurred between periods of peak flow following storm events. As a result, ground water levels dropped, and wetland management has become more difficult and costly. Thus taxpayers spent huge sums of money for cross purposes. Millions of tax dollars or tax-break incentives were used to promote crop production on drained wetlands or on activities that further degraded wetlands. At the same time, millions of tax and hunting license dollars were spent to restore lost or degraded wetlands and to rebuild depleted wildlife populations. The true paradox, however, was that crop subsidies were paid amid continual grain surpluses.

## Alteration of Flooding Regimes

The physical processes that drive the productivity of natural wetlands center around hydrologic events within each watershed. Timing, depth, duration, and frequency of flooding constitute a flooding regime. Changes in any of these factors cause alterations in the hydrologic cycle of wetlands. The 4 general categories of hydrologic alterations include: 1) stabilization, 2) shift in flood timing, 3) increased flooding, and 4) decreased flooding (Klimas 1988).

Stabilization of hydrological regimes usually corresponds to a prolonged inundation of substrates that were periodically exposed. Inundation may involve seasonal, annual, or multi-year flooding that stabilizes ephemeral, seasonal, or semi-permanent waterbodies. Modification of natural flood chronology and periodicity results in shifts in flood timing. Loss of natural floodplain wetlands along large Midwestern rivers has caused increased tributary flows following rainfall. Such floodwaters may inundate forest stands during the growing season and deposit heavy silt loads that cause tree mortality. Before waterway modifications, many of these sites remained seasonally dry except during unusual storm events. Increased flooding may result from changes in the 4 factors of flooding regime. For example, heightened flood peaks in levee-contricted floodplains adjacent to large rivers and increased flooding of semi-permanent glacial wetlands adjacent to agricultural fields with high run-off are common. Although flood control reservoirs, levees and drainage tiles generally result in decreased flooding, severe floods may still occur (Klimas 1988, Reid et al. 1989).

Most wetland management has been partially sensitive to these long-term averages and general flooding patterns. Unfortunately the constraints imposed by development of artificial configurations (i.e., levees, water control structures, water delivery and discharge systems) of many man-made wetlands compromise effective management. These constraints, in combination with a lack of knowledge pertaining to life history requirements of target organisms or their principal foods, generally results in management that emulates the average condition within months or years rather than the dynamic pattern of precipitation and associated flooding that characterizes the short- and long-term fluctuations of natural systems. Thus, stable patterns of hydrology are created across annual periods on many intensively managed areas. Variability in the timing of flooding or dewatering has an important influence on changes in plant species composition and availability of foods for wildlife, but use of this practice is rare in wetland management. Federal managers are regularly reassigned to areas within different biomes, thus they must constantly adapt their management activities to local variations in hydrological and temperature regimes. Types and timing of precipitation and length of growing season varies greatly among latitudes (Fig. 3) even in the Midwest. All are important factors in developing general management scenarios.

## The Misconception of Stable Water

Waterbird response to fluctuating water regimes in the North American prairies is well known because of the well studied relationships between duck populations and drought cycles. In comparison, these relationships are more ambiguous in wetland systems outside the prairie pothole region. Because the goal of many management scenarios is to counteract the effects of seasonal or long-term droughts, a general tendency is to restrict water level fluctuations in managed wetlands. This misconception is based on the fact that most wetland wildlife requires water for most stages in their life cycles. In contrast less is known about the specific requirements of waterbirds and the manipulations that provide the necessary food and cover. Studies that address species biology or management often tend to focus on behavior, bioenergetics, or time-activity budgets but fail to address information on the dynamic nature of habitat conditions. These approaches lead to naive advice concerning the subtle differences in habitat conditions that determine the type and extent of use by wildlife. Furthermore many wildlife management studies are conducted by graduate students, whose short-term

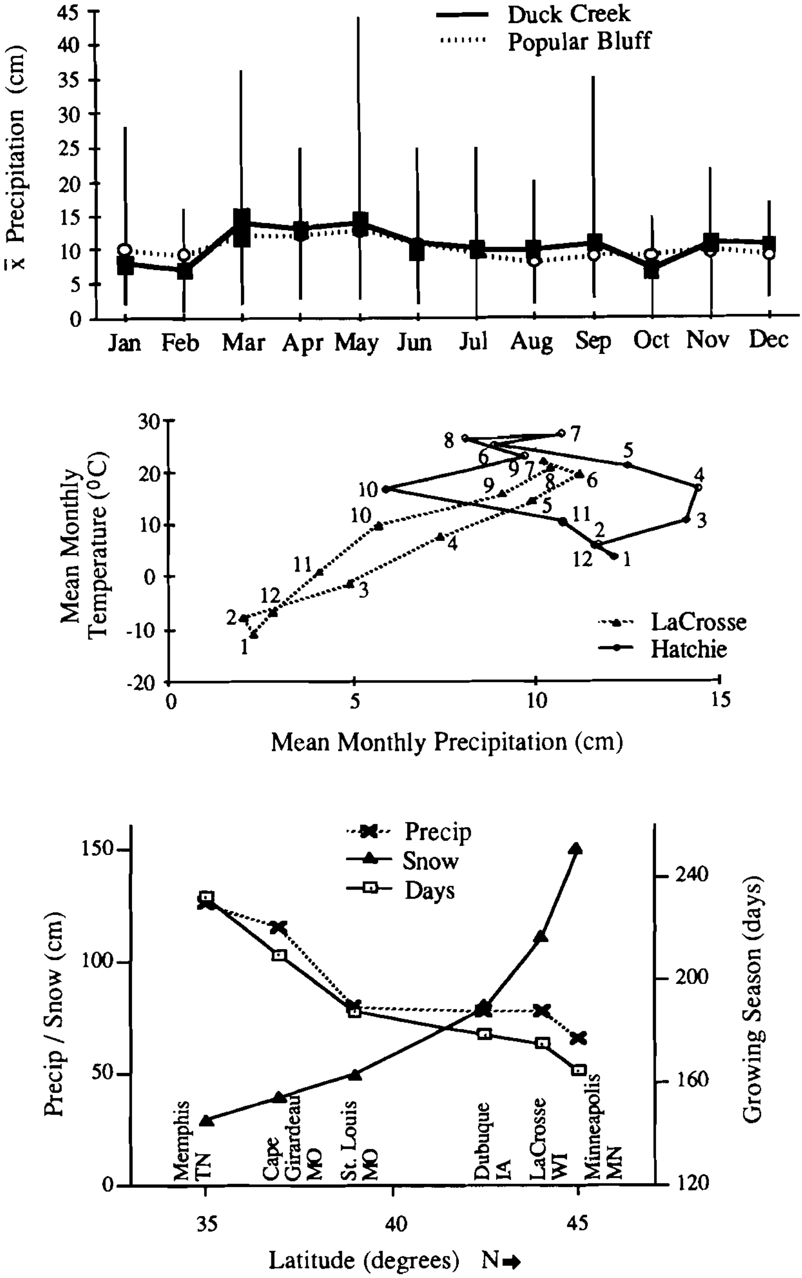


*Fig. 3.* Climatic patterns found in midwestern region of North America. (a) Variations in annual precipitation in southeastern Missouri (Duck Creek Wildlife Area 1960–78). Monthly ranges and averages of rainfall. (b) Climatographs for 2 wetlands (Hatchie National Wildlife Refuge, Tenn., and Upper Mississippi Fish and Wildlife Refuge, LaCrosse, Wisc.) in the Mississippi Flyway that represent conditions across 10° latitude. (c) Length of growing season and amount and form of precipitation across 10° latitude (35–45° N) in the Mississippi Flyway.

studies of 1 or 2 years duration lack continuity over longer time periods and provide only a "brief glance" at the complexities of wetland systems during a short segment of long-term wetland fluctuations or cycles.

This brief glance at wetland conditions often results in incorrect interpretation. Where the capability of intensive wetland management is possible, advice often centers on assuring water during the annual cycle. This practice frequently results in the maintenance of water levels at a set elevation. A more realistic strategy is to identify the wetland types required and to focus on the natural hydrologic regimes that make them productive. All natural basins have seasonal and long-term fluctuations in water levels. Fluctuations within and among seasons and years maintain the productivity as well as the structure and function of wetlands during the long-term cycle. In the real world of management biopolitics, decisions on maintaining dynamic fluctuations must be carefully balanced in order to maintain public support of management programs without habitat degradation. Public support of these more complex programs requires efforts to educate laymen with the basic facts of wetland management.

## Managing Modified Wetland Systems

### Southern Forested Wetlands

Rainfall in southeastern Missouri is highly variable among years and ranges from about 190 cm in the wettest years to only 64 cm in the driest years. Precipitation generally increases from fall into early winter and then is somewhat lower during mid-winter. There is a general tendency for heavy rainfall in April and May with lesser amounts between mid-July and September. The monthly range of precipitation clearly indicates that a major storm event can occur during any month of the year. Precipitation patterns in southeastern Missouri (Fig. 3*a*) result in 3 distinct flooding patterns that influence productivity and determine plant species composition at different sites along a flooding gradient. The gradual increase in precipitation each fall corresponds with a reduction in evapotranspiration caused by lower ambient temperatures and tree scenescence. Surface water begins to collect in small pools, a process called puddling (Heitmeyer et al. 1989). As these pools become larger, they gradually join to form even larger pools until the entire floodplain is inundated, a process termed backwater flooding. About every 6.5 years there is a major storm event when 25 cm or more of rain falls within a 24-hour period and the entire basin may be flooded in a matter of hours. This flash or headwater flooding carries and moves nutrients through the basin and often changes the drainage patterns of small intermittent and permanent streams. During severe flooding, channels of major rivers also change throughout the continuous mosaic of floodplain wetlands.

The area of southern hardwood forests in the Mississippi Alluvial Valley has been reduced from about 10 million ha to <2 million ha (Reinecke et al. 1989). Furthermore about half the remaining forested areas are between levees on major streams where flow velocities are high, water levels rise more quickly and remain higher longer, and depth of flooding is great. The integrity of the forest is further compromised because many tracts outside the levees are distributed as small islands in a vast sea of agriculture. Areas outside levees generally tend to be drier than normal because the depths, duration, and extent of flooding are less than under natural conditions.

These modifications in flooding regimes result in gradual changes in plant species composition. Areas surrounded by levees often exhibit a gradual shift in species composition to plant communities that are more water tolerant (Fredrickson 1979*a* and *b*, Klimas 1990). Trees such as pin oak (Quercus palustris) or nuttall oak (Q. *nuttallii*) are gradually replaced with more water tolerant forms such as overcup oak (Q. *lyrata*), bald cypress (*Taxodium distichum*), and water tupelo (*Nyssa aquatica*). In contrast, pin oak sites that become drier are more likely to be replaced by more xeric species such as hickories (*Carya* spp).

Changes in the vigor and condition of trees in greentree reservoirs are evident throughout the South. These changes likely are related to modifications in the timing, depth, and duration of flooding (Table 3). Normally greentree reservoirs are flooded rapidly in early to mid-fall to provide resources for waterfowl and opportunities to hunters. The timing of early flooding is very different from natural hydrological regimes (Figs. 3 and 4). Water levels in greentree reservoirs are normally held at full pool during the waterfowl hunting season. At the close of the duck season most greentree reservoirs are drained rapidly to protect the trees from flood damage or mortality. Thereafter water levels fluctuate with local precipitation. Tree mortality is common on sites within greentree reservoirs having deep flooding or poor drainage. Leaf chlorosis, branch-tip dieback, limited acorn production, and butt swelling are all indicative of stabilized water regimes among years and seasons (Black 1984). Furthermore stabilized flooding regimes influence nutrient cycling and invertebrate production (Wylie 1985, Batema 1987). The species composition and total biomass of invertebrates changes with the depth and duration of flooding (Batema et al. 1985, Magee 1989). As managed forests deteriorate, wildlife use also diminishes.

*Table 3.* Effects of development and intensive management practices in greentree reservoirs.

| Development | General practice | Hydrological/ biological effects | Enhanced practice |
|---|---|---|---|
| Levees | Levees not on contours | —Wetter conditions inside levees<br>—Shift in tree species dominance<br>—Yields less area available for waterbird foraging<br>—Increased beaver activity causing tree mortality | —Contour levees<br>—Avoid overdevelopment of remnant forests<br>—Beaver control |
| | Rapid early fall flooding for opening of duck season | —Earlier than natural flooding<br>—Deeper flooding than in natural system<br>—Repetitive flooding schedule among years<br>—Modifies nutrient cycling | —Delay flooding until after senescence<br>—Flood gradually<br>—Vary time of flooding among years<br>—Keep dry some years |
| | Maintain stable water levels | —Tree Damage<br>a. Butt swelling<br>b. Reduced acorn production<br>c. Branch tip dieback<br>d. Chlorosis of leaves<br>—Reduced waterfowl use | —Replicate natural flooding regimes<br>a. Change water levels throughout winter<br>b. Never schedule the same depth or duration in consecutive years<br>c. Avoid permanent inundation |
| | Rapid drawdown following duck season | —Export soluble nutrients<br>—Remove potential for using macroinvertebrate resources<br>—Severe ice damage to trees in some years | —Delay drawdown until spring migration begins<br>—Use only slow drawdowns<br>—Vary timing of drawdown among years |
| Water control structures | Screw gates | —Lack ability for precise control<br>—Water level either at capacity or dry | —Replace with stoplog structures |
| Multiple impoundments | All units connected hydrologically | —Lack of independent water level control | —Develop header ditch and drainage system for independent control<br>—Multiple intake and outlet structures |

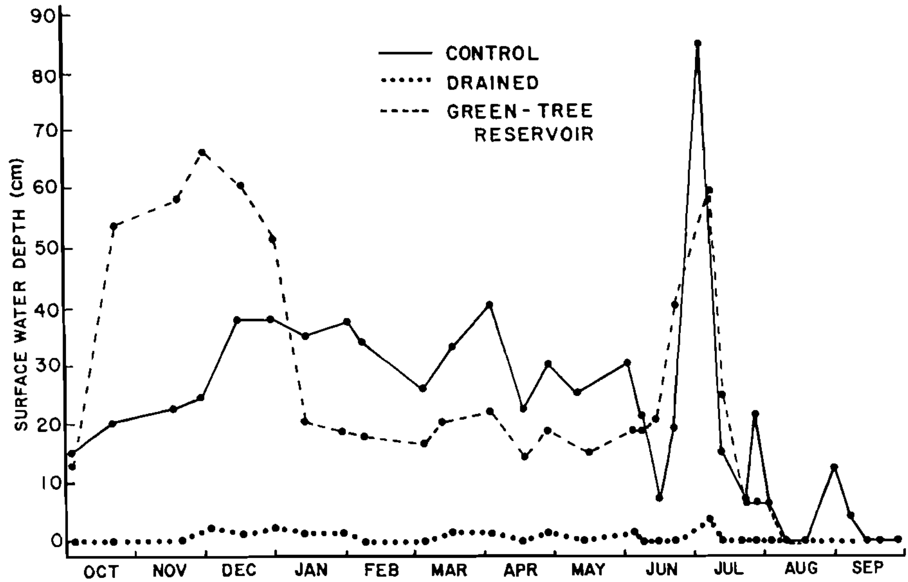


*Fig. 4.* Seasonal water depth in a greentree reservoir (Duck Creek Wildlife Area), a drained site, and a naturally flooded lowland hardwood forest (Mingo National Wildlife Refuge) in southeastern Missouri (after Fredrickson 1979*b*).

## Moist-soil Impoundments

Moist-soil management is an increasingly common practice across the nation as managers attempt to grow native foods for wildlife in restored herbaceous wetlands. Although this management practice has been successful in many areas, the results of this intensive management are not free of adverse effects. Soil disturbance such as plowing or discing is a common moist-soil management practice to enhance the production of annual seeds. Such activities require relatively dry soil conditions that are usually associated with high ambient temperatures in summer. Soil manipulations under these conditions prevent seed germination, decrease organic matter, and facilitate conditions suitable for denitrification. If seed production is desired but drought conditions exist, seasonal irrigation is essential (Kelley 1986). Repetitive yearly management practices, including similar dates for flooding or drawdown, discing, or plowing result in a gradual decrease in the potential for food production (Fredrickson and Taylor 1982).

*Table 4.* Effects of development and intensive management practices on marsh systems.

| Development | General practice | Hydrological/ biological effects | Enhanced practice |
|---|---|---|---|
| Levees | Steep-sided<br>Not on contours<br>Large units | —Burrowing animals cause damage<br>—Flooding depths too deep or too shallow<br>—Difficult to drain or flood | —Levee slopes of 4 to 1 or greater<br>—Contour levees<br>—Multiple units |
| Water control structures | Large expanse structures | —Flood important habitat for other waterfowl<br>—Lack fine control of water levels | —Small structures with good water level features |
| | Screw gates | —Lack precise control<br>—Water level at capacity or dry | —Replace with stoplog structures |
| | Maintain stable water level | —Monocultures develop | —Fluctuate water levels within and among years<br>—Replicate natural fluctuations |
| Multiple impoundments | All units connected hydrologically | —Lack of independent water level control<br>—Potential for drastically increasing soil salinities where evapotransportation is high | —Develop header ditch system for independent control<br>—Multiple intake and outlet structures |

## Glacial Marshes

Some marshes in the prairie pothole region, the arid west, and throughout the East are man-made or man-modified wetlands with developments for intensive management. Unfortunately, many designs prevent managers from replicating natural hydrological regimes (Table 4). Water levels may be too high or are held constant. In other cases basins cannot be drained, and few systems are designed to permit subtle manipulations in water levels (as little as 1 cm) to which wetland plant and animal communities respond. In many cases expensive water delivery systems and control structures are detriments to good management. The most common effect of stabilized water regimes is the development of dense monocultures of robust emergent vegetation. These dense stands destroy the good cover-water interspersion characteristic of the productive hemi-marsh stage (Weller and Fredrickson 1974). Once monocultures are established in a basin with stabilized water regimes, disruptions of the dense stands are difficult.

## Guidelines to Enhance Wetland Productivity

### Water Control Structures

The most important design consideration in developing a wetland is a well conceived water control system. Effective management requires the capability to deliver and discharge water effectively, and to control water depth precisely. This is only possible when water control structures of the proper type and size are placed in the correct location. Many managers are placed at a great disadvantage if water control structures on their areas have been placed incorrectly, have become silt filled, or were the wrong types of structures for the site. In many cases dams simply establish a flow line and water depths are determined at the time of construction (Table 5). Radial gates are essential where high erratic flows pass through wetlands. Screw gates work well for water delivery, but they should never be installed as outlet structures because water levels are difficult to control. On smaller units (i.e., ≤100 ha) the least costly and most effective structure is a stoplog design. Stoplogs of various dimensions provide for a multitude of water level manipulations.

### Replicate Natural Hydrological Regimes and Wetland Complexes

In general, water depths on most management areas are too deep because there are restrictions placed on proper manipulations by the physical

*Table 5.* Characteristics, costs and operational difficulties associated with different types of water control structures.

| Structure | Characteristics | Cost | Operation/ management |
|---|---|---|---|
| Dam | Impounds water<br>Floods habitat<br>Changes downstream hydrology | High | Simple |
| Radial gate | Allows passage of high volume<br>Difficult to control water level | High | Somewhat complex |
| Radial gate with stoplogs | Effective water level control | High | Complex |
| Screw gate | Either open or closed<br>Poor for water level control | Moderate | Complex |
| Small stoplog structure | Effective water level control but volume of water moderate to low | Low | Simple |

configuration or there is a misunderstanding of the desired water depths for most species. Of >150 bird species that use moist-soil impoundments in Missouri, only 23 regularly use water depths >25 cm and, of these, all but 7 generally use waters <25 cm (Fredrickson and Reid 1986). Another 43 species use water ≤25 cm and 26 species use water ≤5 cm. Manipulations that maximize resource availability should coincide with migrant arrival or certain life cycle events of resident species.

In most cases a single wetland cannot provide the resources to satisfy all life history requirements of a species. Thus, different wetland types in close juxtaposition are important to optimize wildlife response (Ryan and Renken 1987, Fredrickson and Heitmeyer 1988, Reid 1989). In the Mississippi Alluvial Valley, wood ducks and mallards tend to concentrate their activities within a 10–30-km radius (Delnicki and Reinecke 1986). In man-made complexes, 5–7 different impoundments allow for the implementation of a slightly different flooding and drawdown strategies that result in the production of diverse food resources (Fredrickson and Taylor 1982; Fredrickson and Reid 1986).

## Soil Disturbance

Periodic soil disturbance must be used in systems lacking the dynamics of natural flooding to maintain early successional vegetation stages. Because man-made systems generally are stable, the availability of multiple impoundments allows timely rehabilitation of impoundments that have become unproductive without losing wildlife values for the entire area. Maximum use of time and management funds are possible when the timing and type of resources required by target wildlife are known. Such information provides the potential to convert resources of limited value to food and cover of high value. For example, impoundments covered with robust plants that do not produce seeds have limited value to most shorebirds. Discing of these plants in late summer initiates the decomposition process. If this plant litter and bare soil is flooded shallowly, invertebrate response is stimulated. The combination of shallow flooding and abundant invertebrates may attract large numbers of shorebirds and early migrant waterfowl. In addition, the soil disturbance and damp conditions result in germination and production of high quality green browse such as blunt spikerush (*Eleocharis obtusa*) (Kelley 1986). Most perennials decrease in abundance because of the discing while the response by seed producing annuals is usually great during the following growing season (Reid et al. 1989). Thus a manipulation during one growing season has the potential to provide benefits during future growing seasons. However, if the timing of discing is scheduled without consideration for the needs of shorebirds and fall migrating waterfowl that use browse, the opportunity to produce high quality habitats for insectivorous shorebirds and grazing waterfowl might be lost.

### Fire

Man has influenced the dynamic nature of wetlands by suppressing fires for >50 years. Fire is an integral component of many natural wetland communities. The historical influence of fire on prairie and boreal forest habitats is obvious. Undoubtedly fire swept by southwesterly winds removed woody growth from prairie habitats, but forest remnants of burr oak (*Quercus macrocarpa*) exist to the north and east of large wetland complexes. Likewise in Alaska's interior boreal forests, fire scarred snags protrude from waterbodies and evidence of fire is abundant in zones of grasses and sedges surrounding many wetlands.

Fire can be an especially valuable tool at remote locations or where extensive physical developments are impractical or too expensive. The northern boreal forest is undoubtedly a system where fire management can play an important role, and its value as a tool in arid or high altitude environments is also great. Fire sets back succession and releases nutrients to promote vegetation growth. Timing and frequency of controlled burns should vary to encourage diverse plant communities.

## Summary

Wetland managers should remember the following points when developing and implementing wetland management plans:

1. Emulate natural hydrology.
2. Use abiotic factors (water and fire) whenever possible to enhance management.
3. Rarely manipulate a unit the same way in consecutive years. Change the: a) time of flooding, b) depth of flooding, and c) duration of flooding.
4. Develop independent water delivery and discharge for each unit.
5. Deliver water to the system at the highest elevation.
6. Discharge water from the system at the lowest elevation.
7. Use stoplogs rather than screw gates as outlet structures.
8. Use contour levees.
9. Rarely flood the majority of a unit deeper than 25 cm (10 in).
10. Always match manipulations with biological events such as molt, migration, or reproduction.
11. Develop and manage wetlands as complexes or mosaics.
12. Control human disturbance.

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# 6 A Dynamic Approach to the Conservation of the Prairie Ecosystem in the Midwest

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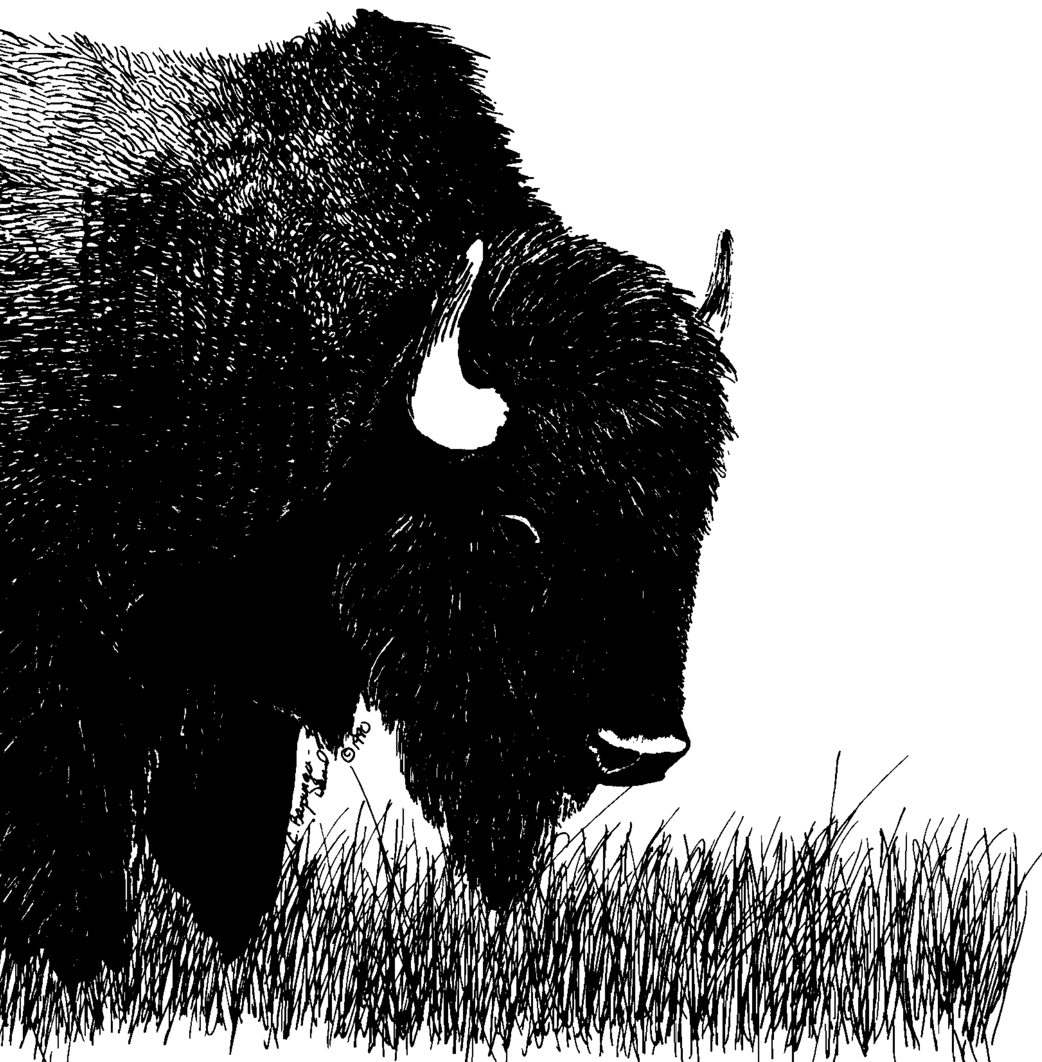

# A Dynamic Approach to the Conservation of the Prairie Ecosystem in the Midwest

Mark R. Ryan

*Abstract:* The prairie ecosystem is portrayed as a 2-dimensional continuum along interrelated gradients of soil moisture, and fire and grazing frequency and intensity. An array of habitat types are shown to comprise the prairie ecosystem. Using birds as an example, it is shown that maintenance of a variety of grassland habitats is required to conserve the biotic diversity of the prairie ecosystem. An ecosystem management approach using Gap Analysis to assess current resource status, principles of landscape ecology to direct acquisition efforts, and regional level management coordination to assure maintenance of habitat diversity is presented. The creation of a regionwide Prairie Ecosystem Recovery Team made up of state, federal, and private representatives is suggested.

Prairie biologists have been pioneers in the use of dynamic approaches to habitat management. There is a long history of the use of disturbance to manipulate vegetation and affect wildlife populations in the grasslands of North America. Higgins (1986) chronicled the use of fire by Great Plains Indians to aid hunting and food gathering. By the early 20th century, prairie ecologists had begun documenting the dynamic nature of native grasslands. Climate, topography, grazing, and fire were identified as causal factors in the development and maintenance of the prairie ecosystem (e.g., Clements 1916, Sauer 1950, Stewart 1951, Buell and Facey 1960, Roe 1970, Wells 1970). By the 1960's, biologists were regularly touting the use of prescribed burning, and to a lesser extent grazing, mowing, and herbicides, to manage prairie habitats and selected resident vertebrates (Tester and Marshall 1961, 1962; Kirsch and Kruse 1973; Kirsch et al. 1978).

Today, fire is ubiquitously used in the management of grasslands. Grazing, long viewed with disdain, particularly by wildlife managers (e.g., Kirsch et al. 1978) is increasingly a part of the management arsenal of prairie biologists. In Missouri, mowing is a commonplace management tool (T. Toney, Missouri Dep. Cons., pers. commun.), and herbicides are occasionally used to control woody invaders (Cannon and Knopf 1981, Doerr and Guthery 1983).

The science and art of prairie management has embraced the concept of grasslands being shaped by dynamic processes. Prairie managers are increasingly open to the use of a suite of disturbance-creating tools to manipulate prairie flora and fauna. Current limitations to successful prairie ecosystem conservation come not from a lack of dynamic management actions, but rather from a non-holistic vision of the ecosystem itself. Dynamic management focused on only some components of the ecosystem can not succeed in conserving the total biodiversity of the prairie.

To achieve true prairie ecosystem conservation a dynamic management approach that establishes state, or preferably, region-wide diversity goals, and assesses progress toward regional objectives is needed. Holistic, dynamic thinking at state and regional administrative levels, especially in developing management plans, is as critical as the creative use of disturbance tools by land managers. In this paper I present a view of the prairie ecosystem as a continuum of habitat types, each contributing to the total diversity of the ecosystem. This prairie continuum model can serve as a conceptual goal for ecosystem conservation. I further suggest the use of Gap Analysis, Geographic Information Systems (GIS), and principles of ecological diversity and landscape ecology in the development of management scenarios.

## A Prairie Ecosystem Model

The goal of prairie ecosystem management should be the conservation of all prairie plant and animal species. The existing piecemeal approach that has characterized prairie management is inadequate to meet this goal. Historic and current efforts have focused on some components of the prairie ecosystem to the exclusion and, at times, detriment of others. Prairie preservation actions that set aside small, remnant grasslands protect many prairie plants, but are ineffectual in conserving all but a handful of prairie animals. Wildlife managers have too often focused their efforts on a subset of prairie fauna: large vertebrates of economic importance. To varying degrees, many prairie conservationists have been guilty of holding too narrow a view of what constitutes the prairie ecosystem. Most management efforts have attempted to create and maintain tall, rank grass habitats. Although this is a vital component of the prairie ecosystem, it is but one of many necessary components.

The first step in conserving the ecosystem is recognition of the array of habitat types that make up the prairie. Topography, soils, fire, and the grazing and trampling actions of herbivores, all in association with climate, have been widely recognized as the natural agents controlling the develop-

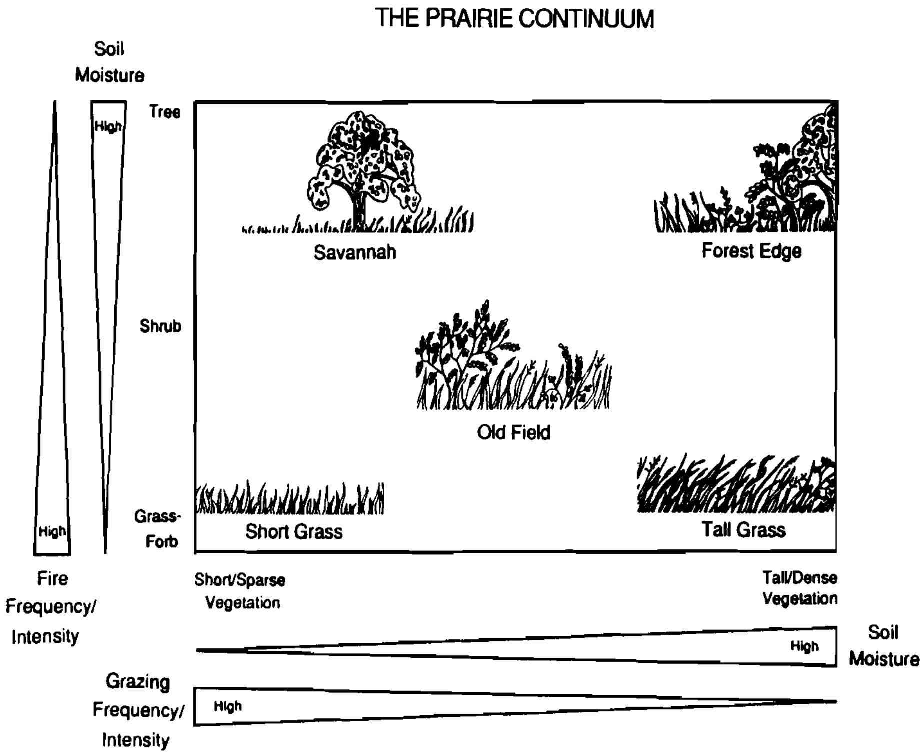


*Fig. 1.* Prairie continuum model.

ment of grasslands. Climate sets geographical limits to grassland formation and combines with the other factors to shape prairie habitats at the local scale.

In an earlier paper I presented a simple model using gradients of soil moisture (a product of climate, topography, and soil type), and fire and grazing frequency and intensity to describe the pristine prairie environment (Ryan 1986). Grassland habitats are portrayed along these interrelated gradients in a 2-dimensional continuum (Fig. 1). Along one axis, soil moisture combines with grazing frequency and intensity to control the height and density of vegetation. On the other axis, fire and soil moisture modify the vegetative communities from grass-forb dominated assemblages through shrub-grass associations to savannah or late succession grassland/forest edge. The resulting continuum can be readily envisioned on the large geographic scale, with short grass prairie in the western Great Plains and tall grass prairie and forest edge in the east. But mosaic habitat patterns occurred on a smaller scale in the pristine prairie ecosystem as well. In the tall grass prairie, dry ridge tops supported sparser, shorter growth forms, herbivores created patterns of vegetation height, and incomplete burns left woody vegetation among the dominant grasses. Different wildlife species evolved adaptations to exploit these varied prairie habitats. Failure to provide an adequate range of prairie habitats will result in failure to preserve the biotic diversity of the pristine prairie.

## Avian Diversity In the Prairie Ecosystem

In the prairie continuum model, species habitat niches may be overlaid as continuous or discontinuous distributions. Using birds, the following example will illustrate the importance of maintaining all habitat components of the prairie ecosystem for the conservation of biodiversity (Table 1).

Species such as Bobolink, Dickcissel, Sedge Wren, American Bittern, and Gadwall typify the tall, dense grass habitat association. Within this zone of the prairie continuum, these species can be further differentiated by habitat preferences. Bobolinks favor lush vegetation with dense ground cover. Sites that burn too frequently may not provide the necessary thick litter layer. Bobolinks also seem to avoid grasslands with too much woody cover, so too infrequent a fire regime may not maintain optimum habitat. Bobolinks also seem to occur at higher densities at sites with a minimal forb component. Dickcissels also prefer rank cover, with their above ground nests supported by tall forbs or woody plants. Fire and grazing pressures that favor forbs and allow low densities of shrubs will create ideal habitat for Dickcissels.

At tall grass sites with a woody component, species such as the Mallard and Henslow's Sparrow are likely to be more abundant. Frequent fires that eliminate woody song perches can locally extirpate Henslow's Sparrow.

At drier sites or those impacted by moderate grazing, moderately tall, dense grass vegetation will predominate and Baird's, Grasshopper, and Savannah Sparrows, as well as Upland Sandpipers are likely to occur. If shrubs are present Sharp-tailed Grouse, Clay-colored and Field Sparrows, and Loggerhead Shrikes may be present.

On sites with poor quality soils, low moisture, or heavy grazing, short, relatively sparse grass cover will result. A very different assemblage of bird species is likely to occur in this habitat. Horned Larks, Chestnut-collared Longspurs, Sprague's Pipits, Killdeer, and Burrowing Owls are adapted to exploit the shorter-grass, prairie habitats. If wetlands are associated with this short, sparse cover, Marbled Godwits and Willets also may occur. With

*Table 1.* Habitat affinities of prairie birds in the Midwest[a]

| Habitat type[b] Bird species | Scientific name |
|---|---|
| Tall-dense grass | |
| Blue-winged Teal[c] | *Anas discors* |
| Gadwall[c] | *Anas strepera* |
| American Bittern[c] | *Botaurus lentiginosus* |
| Northern Harrier | *Circus cynaeus* |
| Greater Prairie-Chicken[d] | *Tympanuchus cupido* |
| LeConte's Sparrow | *Ammodramus leconteii* |
| Bobolink | *Dolichonyx oryzivorus* |
| Eastern Meadowlark[e] | *Sturnella magna* |
| Sedge Wren | *Cistothorus platensis* |
| Dickcissel | *Spiza americana* |
| Tall-dense grass/shrub | |
| Mallard[c] | *Anas platyrhynchos* |
| Northern Bobwhite | *Colinus virginianus* |
| Common Yellowthroat | *Geothlypis trichas* |
| Henslow's Sparrow | *Ammodramus henslowii* |
| Mid-grass | |
| Pintail | *Anas acuta* |
| Upland Sandpiper | *Bartramia longicauda* |
| Baird's Sparrow | *Ammodramus bairdii* |
| Grasshopper Sparrow | *Ammodramus savannarum* |
| Savannah Sparrow | *Passerculus sandwichensis* |
| Mid-grass | |
| Western Meadowlark | *Sturnella neglecta* |
| Wilson's Phalarope | *Phalaropus tricolor* |
| Mid-grass/shrub | |
| Sharp-tailed Grouse | *Tympanuchus phasianellus* |
| Greater Prairie-Chicken | *Tympanuchus cupido* |
| Clay-colored Sparrow | *Spizella pallida* |
| Field Sparrow | *Spizella pusilla* |
| American Tree Sparrow | *Spizella arborea* |
| Loggerhead Shrike | *Lanius ludovicianus* |
| Short-sparse grass | |
| Horned Lark | *Eremophila alpestris* |
| Sprague's Pipit | *Anthus spragueii* |
| Chestnut-collared Longspur | *Calcarius ornatus* |
| Lapland Longspur | *Calcarius lapponicus* |
| McCowan's Longspur | *Calcarius mccownii* |
| Smith's Longspur | *Calcarius pictus* |
| Snow Bunting | *Plectrophenax nivalis* |
| Burrowing Owl | *Athene cunicularia* |

*Table 1. continued*

| Habitat type[b] Bird species | Scientific name |
|---|---|
| Greater Prairie-Chicken | *Tympanuchus cupido* |
| Sharp-tailed Grouse | *Tympanuchus phasianellus* |
| Marbled Godwit | *Limosa fedoa* |
| Short-sparse grass | |
| Killdeer | *Charadrius vociferus* |
| Willet | *Catoptrophorus semipalmatus* |
| Short-sparse grass/shrub | |
| Lark Sparrow | *Chondestes grammacus* |
| Lark Bunting | *Calamospiza melanocorys* |
| Vesper Sparrow | *Pooecetes gramineus* |
| Harris' Sparrow[f] | *Zonotrichia querula* |
| Savannah/short-moderate grass | |
| Western Kingbird | *Tyrannus verticalis* |
| Eastern Kingbird | *Tyrannus tyrannus* |
| Scissor-tailed Flycatcher | *Tyrannus forficatus* |
| Swainson's Hawk | *Buteo swainsoni* |
| Ferruginous Hawk | *Buteo regalis* |
| American Kestrell | *Falco sparverius* |
| American Robin | *Turdus migratorius* |
| Northern Flicker | *Colaptes auratus* |
| Chipping Sparrow | *Spizella passerina* |
| Late succession prairie/forest edge | |
| Eastern Bluebird | *Sialia sialis* |
| Willow Flycatcher | *Empidonax traillii* |
| Least Flycatcher | *Empidonax minimus* |
| Blue-winged Warbler | *Vermivora pinus* |
| Golden-winged Warbler | *Vermivora chrysoptera* |
| Yellow Warbler | *Dendroica petechia* |
| American Goldfinch | *Carduelis tristis* |
| Mourning Dove | *Zenaida macroura* |
| Bell's vireo | *Vireo bellii* |
| Bachmann's sparrow | *Aimophila aestivalis* |

[a]These preliminary habitat affinities assigned from personal observation and from Cody 1974; Johnsgard 1979; Kantrud and Kologiski 1982, 1983; AOU 1983; Skinner et al. 1984.
[b] Based on Prairie Continuum Model (Fig. 1).
[c] Require wetland habitats near preferred grassland habitat type.
[d] Species with different habitat affinities during annual cycle; they are listed more than once.
[e] Broad habitat tolerance; listed under optimal habitat type.
[f] Winter resident.

an increasing shrub component Vesper and Lark Sparrows and Lark Buntings would be more likely to be present.

Some species may use several distinct prairie habitats for different life history needs. For example, Greater Prairie-Chickens in Missouri use short, sparse grass sites for communal breeding displays, nest in taller, lush cover, and use grass-shrub habitat for rearing broods or as thermal roost cover.

Savannah habitats also support a distinct avifauna. Characteristic species of these tree-dotted plains might include Eastern and Western Kingbirds, Scissor-tailed Flycatchers, Swainson's or Ferruginous Hawks, Northern Flickers, etc. (Table 1). At wetter sites with infrequent fire and little or no grazing, late-succession grasslands or forest-edge habitats will predominate. Uncommon or rare species associated with these habitats include Eastern Bluebirds, Golden-winged Warblers, Bell's Vireo, and Bachmann's Sparrow (Table 1).

The creative use of prescribed burning, grazing, mowing, and herbicides at different sites with varying soil moisture conditions can produce the array of habitats needed to support the prairie avifauna. If one or more of the habitat components portrayed in the prairie continuum are missing, a substantial number of bird species will be unlikely to occur or will be present at levels below which their long-term survival will be questionable. Other species groups will be effected similarly.

## Conserving the Prairie Ecosystem

### Resource Status Assessment

With a state or region-wide goal of maintaining prairie diversity, the first step in a conservation strategy will be the assessment of the current status of prairie resources. Scott et al. (1988) proposed the use of Gap Analysis to evaluate the extent to which biological diversity is currently protected. By identifying the number, size, and distribution of prairie communities and associated species under protected ownership/management, "gaps" in the conservation network can be identified (Burley 1988, Scott et al. 1988). After unprotected or inadequately protected habitats or species are identified, specific prairie management actions can be prioritized and initiated. This approach shifts conservation of prairie resources from crisis management of declining species to that of ecosystem conservation. Such an approach can address rare species needs while helping to prevent the future decline of additional species.

Gap analysis can be initiated by using Geographical Information Systems software to develop maps and data bases on prairie resources. Data to be compiled should include location and size of tracts, type of prairie habitat, ownership of units, and principal management or land use. Description of vegetative cover types can be problematic because no universal classification of prairie habitats has been established. At the initial stages, a simple, generalized scheme may be most feasible. Perhaps parameters for the 8 categories listed in Table 1, derived from the prairie continuum model, could serve for the first analysis. Another possibility is the development of remote sensing methods to characterize prairie habitats. Small tracts, ≤133 ha (320 ac), probably could be given a single categorization. Larger, potentially more heterogenous tracts might be assigned >1 cover type. Information on size and if possible shape (quantified by perimeter length or length:area ratio) may be critical data for evaluation of degree of satisfaction of species-specific minimum area needs.

Information regarding tract ownership and management or current land use is necessary to assess the degree of protection. Care must be taken to identify more than simple ownership. Private or state preserves often afford a high level of site protection, but different state and federal agencies manage lands for a variety of purposes. State wildlife areas or parks may be managed with highest priority for resource protection, but state school lands or those belonging to the Department's of Transportation, Agriculture, etc. may not effectively protect prairie resources. Federal ownership, even within an agency can vary substantially in protective status. For example, National Forest grasslands may be designated wilderness or open to lease grazing, oil or mineral development, timber harvest, etc.

Scott et al. (1988) suggested developing vegetation distribution maps at the 1:100,000 scale. This is probably adequate at the regional level, but states may need 1:50,000 or even 1:25,000 for limited prairie areas within their boundaries. Ground-truthing of vegetation categories will be needed in many cases. Existing data bases, (BLM land ownership and management maps, state heritage files, National Wetland Inventory maps, etc.) can be readily accessed for gap analyses.

Once vegetative maps are compiled, prairie species distribution maps and files should be generated. Several midwestern states are currently developing vertebrate species atlases. Other data bases on rare, endemic, and economically or culturally important species (including invertebrates and plants) are available. Information on prairie species can be extracted from these sources and supplemented with data from museum collections, published sources, etc. Data on a wide range of prairie invertebrates may be difficult and costly to compile. Concentrating on rare or endemic species and an ecologically sensitive group such as butterflies (Lepidoptera) may be adequate.

Where possible, regional and state identification of prairie habitat affinities of species should be included in the data bases. A preliminary attempt at a regional classification of prairie bird habitat associations is given in Table 1. More sophisticated, less arbitrary methods than those I used in developing Table 1 are needed.

Once the data are compiled, GIS procedures can be used to generate maps showing protected and unprotected prairie habitats. Species distribution maps can be overlaid on vegetative/protection maps to assess species protection and identify sites for protection action or to set priorities for altering management on protected units. Maps depicting centers of prairie species diversity also may be useful in identifying areas for acquisition.

After information on current resource status is summarized, specific management actions be planned and initiated. Management efforts will include acquisition or easements, land management, monitoring, and in some states, prairie restoration.

## Prairie Acquisition Considerations

Because prairie is basically a 2-dimensional system, habitat diversity is achieved primarily in the horizontal plane. Diversity increases most readily with area. Therefore, an issue affecting all acquisition or easement efforts and some habitat manipulations is that of prairie reserve design. In recent years, many plant and animal species have been suggested to have minimum area requirements. Thus the size, configuration, and juxtaposition of reserves is a critical concern in maintaining prairie biodiversity.

The efficacy of size, shape, and distributional patterns of habitats in conserving species has been much debated. Unfortunately there has been little focus on grasslands (but see Samson 1980, Simberloff and Gotelli 1982). No consensus on ideal reserve design has been reached, but some useful guidelines for prairie conservation may be extracted. The following is my interpretation of the existing data and my judgement on opposing viewpoints.

For similar habitats, large blocks will likely support viable populations of more species than small blocks. Given the paucity of large prairie tracts in public ownership in the Midwest, remaining large tracts ($\geq$265 ha, 640 ac) should be given highest priority for easement or fee-title acquisition. At this time, protection of remnant prairies not in public ownership must be the number one priority in prairie ecosystem conservation in the Midwest.

Much of the controversy over minimum reserve sizes has centered on the trade-offs of single large versus several small tracts. Conflicting viewpoints and, to a lesser degree, evidence abound. In some cases, clusters of small prairie tracts offer excellent potential for maintaining biodiversity. I arbitrarily define clusters of prairie habitats as >2 tracts separated by <1.6 km (1 mi). As data on species-specific needs become available this definition should be adjusted.

Small, isolated prairie remnants will, in most cases, contribute little to ecosystem preservation. Occasionally these prairie gardens may harbor rare or endemic plants and therefore warrant protection. But a conservation strategy based on small, widespread prairie plots cannot be viewed as a realistic approach to preserving ecosystem biodiversity.

Many species, especially vertebrates, will be better served by large tracts or networks of smaller units. For Greater Prairie-Chickens in Missouri, I have recommended acquisition of tracts ≥133 ha (320 ac), especially those closely juxtaposed (<3.2 km, 2 mi) to other blocks, large or small (Burger 1988, Jones 1988). I favor protection of centers of habitats over widespread acquisitions and the protection of smaller tracts that may serve as stepping-stones between clusters. In my view, smaller tracts adjacent to other protected habitats are more desirable than slightly larger but isolated units. Clearly, I would like to see as much total prairie habitat protected as is feasible.

The trade-offs between specific purchases of a large unit and several small ones cannot be decided by ecological theory. Actual decisions must be made from knowledge of species occurring on the prairie patches, the habitat conditions present, habitat potential of the sites when under intense management, options for other acquisitions, the presence of existing preserves nearby, as well as economic and political considerations. The data bases generated through the Gap Analysis should provide much of the needed data.

## Management Coordination

Regardless of how aggressive an acquisition program is, few single prairie tracts remain in the Midwest of a size to allow management for the entire continuum of prairie habitats. The alternative is to manage small units or clusters of tracts as components of the overall prairie mosaic.

Such an approach necessitates, careful statewide, and preferably regional coordination of planning, monitoring, and land management. Whether at the state or regional level, coordination must occur among prairie management agencies and private interests. If management goals are set and actions taken at the local level, or within agency hierarchies, there is an unacceptable risk that some components of the prairie continuum will be underrepresented and the associated species unprotected. Managers may achieve relatively high diversity at the local scale (alpha-diversity; Whittaker 1970:39) by maintaining tall-dense, grass or forest-edge habitats. But if all managers across the region employ the same management efforts many aspects of the prairie ecosystem will be unrepresented and diversity across the gradient of prairie habitats (beta-diversity) will be low.

## Land Management

Acquisition of prairie tracts can provide the spatial resources and the topographic and edaphic features necessary for the maintenance of all aspects of the prairie continuum, but land management will be necessary to sculpt actual habitats. I will not review the management of prairie vegetation via fire, grazing, mowing, herbicides, etc. Numerous research and review papers are available on fire and grazing effects on prairie and associated wildlife (e.g., Ellison 1960, Karasiuk et al. 1977, Graul 1980, Ryder 1980, Bryant et al. 1982, Wright and Bailey 1982, Kantrud and Kologiski 1982, Lemen and Clausen 1984, Ryan 1986). Research efforts on and comprehensive reviews of mowing and herbicide treatments in the management of grassland communities are still needed.

The current literature is valuable in describing approaches to prairie management but it cannot be used as prescriptions for on-site management actions. In listening to prairie managers I am continually impressed by the specificity of response of different grassland tracts to disturbance treatments. Combinations of soils, topography, existing plant community, management history, climatic conditions, timing of treatments, etc. produce unique results spatially and even temporally at the same site. There is no substitute for experienced managers and their creative experimentation with available tools. What is an effective fire prescription to eliminate or control woody invasion at a North Dakota site is likely to be ineffective in Illinois. In some cases, adjoining tracts require different management regimes to effect similar results. Often only long-term trial and error by dedicated managers will provide desired results. If land managers are given the appropriate goals for a tract of prairie, I believe they can produce the needed habitat conditions with current tools.

## A Prairie Ecosystem Recovery Team

To assure prairie ecosystem conservation in the Midwest a dynamic new approach is needed involving the cooperative efforts of state, federal, and private entities in the development of regional goals, management scenarios, and monitoring efforts. I believe that this can be best accomplished by the formulation of a Prairie Ecosystem Recovery Team patterned after endangered species teams established by the U. S. Fish and Wildlife Service. A regional team, composed of representatives of the state agencies with the lead responsibility for prairie protection, federal agencies with major grassland holdings (U. S. Forest Service, National Park Service, and U. S. Fish and Wildlife Service) in the Midwest, and private conservation organizations (The Nature Conservancy and Audubon Society) should be formed. This group would have responsibility for coordinating the current status review (Gap Analysis), the development of a regional prairie management plan, and the establishment of subregional (≥1 state) teams responsible for management coordination. Critics will likely dismiss this idea as unworkable, citing problems with multi-agency decision-making processes, etc. But lesser efforts are not working and are unlikely to work in the future. New approaches are needed to assure ecosystem conservation. Perhaps interagency memoranda-of-understanding can be established to deal with decision-making problems that cut across agency hierarchies. At the initial stage of recovery team development, non-partisan leadership will likely be needed. Perhaps the North Central section of The Wildlife Society could play such a role.

Ecosystem-level management of prairies or other systems is going to require new approaches in planning, monitoring, coordination, and administration. Old management paradigms are difficult to shed, but only new, dynamic efforts are likely to succeed in conserving the biodiversity of midwestern prairies.

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# 7 Forest History and Management in the Northern Midwest

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# Forest History and Management in the Northern Midwest

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*Abstract:* The static forest exists only to a degree, and that in part as a result of attempts by management to achieve certain goals. The forests of Holocene time consisted of species adapted to the prevailing climate that became established, when seed was available and where substrate conditions were favorable. With amelioration of local climate, and with arrival of other species, forest composition and structure changed. Climatic events and associated disturbances played major roles in determining forest composition and structure, and in creating the massive stands that were exploited during the past 2 centuries. As the older forests have been replaced by younger stands, the nature and frequency of disturbance has changed—from infrequent but catastrophic events to more frequent but less severe ones. Clearly forest management has had a major impact on wildlife species and their habitats. Goals and technologies of management are well established but they are subject to modification in ways that could shift some forest ecosystems into a more dynamic, diverse, and even more productive condition. Changes in the size and shape of clearcut blocks, recognition of natural stand rotation periods, and modification of timber stand improvement practices would all be beneficial. Fire has long been recognized as an important tool in producing change, and prescribed fire should be used more frequently in the future. Different mechanical and silvicultural approaches to drastically alter forest floor conditions may also be appropriate. The forest changes continuously and future major changes are to be anticipated as a result of extrinsic factors not presently subject to control, such as acid rain, depletion of the ozone layer, and climatic warming.

Season to season, year to year, and century to century forests change. The rate of change depends on the structure and composition of the forest, climatic events, substrate conditions, and human impacts. Our concern here is to consider how our actions have altered not only the rate but also the direction of change in the forest landscape as we have attempted to achieve societal goals, and how these actions may be modified to benefit all components of the forest system. We cannot completely recreate the immediate presettlement forest environment even if we deemed it desirable; indeed, those particular forests represented a relatively short period in the postglacial history of midwestern vegetation.

Midwestern forests are a complex of many different forest types adapted to a variety of climatic regimes and site conditions that span a range of substrates including coarse sand, glacial till, loess, and muck, each with vastly different physical and chemical makeup. Most midwestern tree species are adapted to disturbance at some time during their life cycle, generally at the time of establishment. Species mixtures vary with the climatic conditions both temporally and geographically. The forests that are the prime concern of this paper are relatively recent, beginning to form $<$10,000 to 15,000 years ago as the last great ice sheet gradually retreated northward uncovering a heterogeneous landscape of outwash plains, moraines, and other features. Davis (1969) noted that "Only 14,000 years ago tundra and spruce-pine woodland covered much of what is now the eastern United States . . ." Tree species that had survived the last advances of the Wisconsinian ice in the Ozarks or Appalachians began their slow migration northward and westward. Fossil pollen preserved in lakes and swamps serves to indicate the rate of that advance. Many climatic fluctuations marked the postglacial period. Today midwestern vegetation continues to respond to the changes in climate as well as in disturbance patterns.

A warmer drier period, between 3500 and 7000 BP (Before Present), had permitted the eastward advance of the grasslands leaving remnants that exist today in most midwestern states as far east as Ohio and Michigan. During this xerothermal period, changes in vegetation were smallest in the north where mixed conifer/hardwood forest persisted throughout most of postglacial time. Cooling followed and the forest, although probably somewhat different in composition, regained much of its earlier extent (e.g., Webb et al. 1983). One of the most recent events affecting midwestern forests was the "Little Ice Age", a period that began in the 1400's and persisted until the mid-1800's. This climatic perturbation had a direct effect on the forests that greeted the European settlers entering the Midwest (Bryson and Murray 1977). The generally cooler climate, attended by greater frontal activity, was erratic with drier, warmer years interspersed with periods that were colder and wetter. There is also evidence suggesting that there were major fires, frequent windthrow, and occasional severe drought. Massive stands of white pine (*Pinus strobus*) and hemlock (*Tsuga canadensis*) became established in the Lake States during that period and the effects of the "Little Ice Age" were noted from Minnesota, Iowa, and Pennsylvania to Iceland and southern Europe (Lutz 1930, Bryson and Murray 1977). Other briefer and less dramatic climatic perturbations produced the conditions that favored the great fires of the recent past (Haines and Sandow 1969).

Another agent of disturbance produced the hemlock decline recorded in New Hampshire and Michigan pollen profiles (Allison et al. 1986). The hemlock decline began rapidly about 5500 BP suggesting, in its resemblance to chestnut blight (*Endothia parasitica*), a wind disseminated pathogen or pest. Hemlock was sparse in the pollen record and did not recover its former abundance until about 3500 BP. Similarly, recent pest epidemics, for example those caused by the larch sawfly (*Pristiphora erichsonii*), the spruce budworm (*Choristoneura fumiferana*), and Dutch elm disease (*Ceratocystis ulmi*), have altered the rate of forest succession and changed both composition and structure over areas of many kilometers.

The tree species that constituted midwestern forest communities came together in part by chance as they spread northward into the glaciated area at different rates. The general direction and rate of movement of different species has been described by several workers including Davis (1981, 1983), Delcourt et al. (1983), and Webb et al. (1983). The resulting forest communities were often ephemeral (Whitehead 1981). Differential species migration is still in progress as species adjust to the influence of climate and soil on their ability to become established and to survive to maturity. Typical boreal forest of spruce and fir is now rare south of the Canadian border and similarly red maple (*Acer rubrum*) is becoming an increasingly important species of successional stages.

Early observers in the northern Midwest described changes taking place in the forest prior to logging, (e.g., Roth 1898) "In almost all parts of the mixed forest of the loam lands, the hardwoods formed the body of the forest and the conifers the admixture. The hardwoods were represented by trees of all sizes, from the sapling or sprout to the mature timber tree. They formed nearly all of the undergrowth and this hardwood forest showed every indication of thrift and permanence. The white pine (red or Norway pine [*Pinus resinosa*] did not grow on these loam lands) and hemlock were represented almost entirely by mature old timber, standing isolated among the hardwoods, or at most growing in groups or small bodies. . . ." Roth also described the effect of the fires that often followed pine logging, that burned, not only in the pine slash, but which also spread into the adjacent hardwood and hemlock stands, and nearby swamps.

The wave of land clearing that accompanied settlement, moved rapidly through the Ohio valley and northward, fragmenting the forests of Ohio, Indiana, southern Michigan, and southern Wisconsin into small, isolated blocks (Curtis 1959, Whitney and Somerlot 1985). Today these blocks, mostly $\leq$20 ha, represent the forest in the agricultural landscape. Such tracts are often samples of static management where some species do not reproduce and species richness declines. Oak reproduction, for example, has been greatly reduced by the absence of fire or other disturbance at the soil surface. Along the contact zone between forest and prairie, the oaks, that had existed largely as grubs or as scattered savanna trees, developed into dense stands when cultivation eliminated fire in the grasslands (Cottam 1949, Grimm 1984, Sharpe et al. 1987).

In the northern Lake States, logging was species selective. White pine was removed first, whether growing in pure stands or found as large stems scattered through the hardwood-pine mixtures. The limiting factor was access to a stream or lake on which the logs could be floated to a mill. Fires followed logging, sometimes the slash was burned intentionally and often successive fires occurred. In the late 1800's, pine became scarce, logging railroads were built, hardwood stands were entered and were generally "swept clean" of any stem that "would make a two-by-four." Hemlock was cut heavily for its bark that was used extensively in the tanning industry.

The burns and the clearcut areas provided abundant opportunity for aspen (*Populus grandidentata* and *P. tremuloides*) and white birch (*Betula papyrifera*) to become established in extensive stands, and for pin, choke, and black cherry (*Prunus pensylvanica, P. virginiana,* and *P. serotina*) to thrive. Oaks, especially pin (*Quercus ellipsoidalis*) and northern red oak (*Q. borealis*), became more evident on the lighter soils, sprouting from stems killed by the fires (Whitney 1987).

During the initial logging era the forests were altered greatly by human activity but continuing biological and successional processes enabled the forest to recover. Since the 1930's, recreational development, increased settlement, logging of second growth, pulp cutting, and forest management activities, including control of wildfire, have affected the direction and rate of change.

The spread of exotic diseases such as white pine blister rust (*Cronartium ribicola*) and of insect outbreaks have had additional impact. For a time white pine was written off as a viable timber tree. As the "Little Ice Age" faded in the mid-1800's, warming began, peaking in the 1930's and 1940's, resulting in good years for agriculture. The temperature decline evident in the middle of this century is apparently being reversed as the greenhouse effect becomes stronger. Most important today are the changes in the nature, severity, and frequency of disturbance. The causes of disturbance have changed appreciably resulting in a decrease in severity and an increase in frequency of those events that modify successional pathways.

As a forest develops following a major disturbance, such as clearcutting or fire, productivity increases as the pioneer species become dominant while an understory of late successional species gradually develops. Likewise, species diversity tends to increase until both productivity and diversity reach maximum values prior to dominance of the shade tolerant species. At that time, both primary productivity and species diversity begin to decline and, in the absence of catastrophic disturbance, the forest approaches a steady state (Loucks 1970; Borman and Likens 1979*a,* 1979*b*). The periodic disturbances to which most native plant communities were subjected at intervals of decades or several centuries served to cycle the system from intolerant pioneer species to shade tolerant species and thus through cycles of low to high and back to lower diversity and low to high and eventually decreasing productivity (Loucks 1970). Forest management is directed toward maintaining high productivity; the usual objective is to maintain high production of the species present and preclude natural succession. The result is often reduced species richness and diversity. In contrast, when succession is allowed to occur and if the terminal (shade tolerant) forest persists long enough, the stand gains in structural complexity, woody material accumulates on the forest floor, openings develop in the canopy, dead snags appear, and plant and animal species richness may increase (Miner 1989).

Successional pathways are diverse, depending on the particular chance of timing of the disturbance relative to the availability of seed, weather conditions at and following seed fall, the species present, the site conditions, and previous history. However, in the past 50 years the controlling factor has often been the forest management method used to maintain a tract in a productive mode. Management approaches have included fire suppression, precommercial and commercial thinning, clearcutting (especially in aspen-perpetuating an aspen monoculture), conversion of hardwoods to pine, timber stand improvement (particularly in northern hardwoods) to eliminate unhealthy and wolf trees and to maintain stands at lower basal areas for increased growth, and shortening of rotations. Clearly, most of these techniques have served a useful purpose, at least in the short run. Even so, virtually all of these forms of management alter the natural course of succession. Other procedures have, at least in part, been instigated by those managing the forest for wildlife. These procedures include predator control, beaver control, single purpose stream management for trout, creation of forest openings, and development of seeded trails and food plots. Many of these latter techniques have benefited the target species while negatively impacting habitat for other species. In the case of the white-tailed deer, a series of moderate winters, favorable browse conditions, supplemental feeding, increased cover from natural and planted conifers, creation of forest openings, and increased edge has resulted in rapid growth of the herd with the potential for browsing to damage or even eliminate rare plants and other favored species.

The remainder of this paper considers specific forest practices and wildlife procedures that preclude normal processes of change and proposes possible modifications of these practices. The discussion deals with management techniques in relation to the broader questions of forest fragmentation, stand structure, and substrate modification.

## Fragmentation

Division of the forest into smaller and smaller units is caused by many factors of which forest management is only one. Fragmentation is often of major concern. Units of adequate size are essential if the land is to undergo the rejuvenating processes resulting from random (or planned) disturbance (Loucks 1970). Edges are created, sometimes obvious ones between sharply different land uses, and sometimes vaguely defined as between adjacent forest stands. Extreme fragmentation is the rule in the Midwestern agricultural landscape where small patches of forest are embedded in cultivated and pasture land and may occupy <10% of the land area. These forest "islands" differ from the matrix in almost every respect. In forested landscapes, fragmentation is more subtle and may be a product of the inherent nature of the terrain, of natural events including wind, fire, or beaver activity, or as a result of human activity including forest management. Residual openings from earlier logging operations may persist for years (Levy 1970). The northern forest is a mosaic of vegetation types and age classes, now with clearcut patches, residential and business areas, roads, snowmobile trails, log landings, and wildlife openings interrupting the continuity of the canopy. Fragmentation is not easy to demonstrate where the matrix is forest and that mosaic was created by natural events and a glacial terrain. The patches that make up the forest may be so small that their size precludes use of certain management practices, such as prescribed fire, or they may not be located so as to provide reasonable association between different habitat components.

Fragmentation has both positive and detrimental effects. Edge is created and habitat for edge species is increased, fire control is simplified, recreation may be benefited, and logging expedited. Edge species such as the white tailed deer (*Odocoileus virginianus*) have been especially favored by the breakup of the forest. Ruffed grouse (*Bonasa umbellus*) populations have benefited although the grouse is not a true edge species (Gullion 1984) but is favored by short rotation aspen (Kubisiak 1985). Increasing edge habitat, once considered vital for wildlife diversity, may greatly reduce the amount of habitat suitable for forest interior species and in addition provide entry into the forest for avian and mammalian nest predators (Temple 1986).

Increased edge is not the only factor involved, patches may become too small to support certain area dependent species.

Causes of fragmentation are diverse and fall in 4 general classes: inherent (intrinsic) factors, extrinsic natural events, those factors related to societal activity, and forest management . . The northern forest is basically heterogeneous, largely a result of the intrinsic nature of the landscape as it was sculptured by the advance and retreat of the glacial ice. Within a short distance one might have steep moraines or drumlins, level ground moraine, or flat outwash plains often pitted with depressions resulting from buried ice blocks and now containing lakes or bogs. Lakes in particular result in a permanent and clearcut edge often with a transitional community blending into the surrounding forest. The textural and hydrological characteristics of the substrate are closely associated with landform and with successional processes (Host et al. 1987, Swanson et al. 1988).

Extrinsic factors of natural origin may also result in drastic impacts on the forest. Catastrophic wind storms, lightning fire, and disease or pest outbreaks have obvious effects (e.g., Roth 1898, Graham 1941, Maissurow 1941, Stearns 1949, Heinselman 1973, Dunn et al. 1983).

Societal considerations are responsible for much forest fragmentation. Support for the growing human populations has required the building of a network of transmission lines, railroads (now largely represented by rights of way converted into snowmobile trails), highways, service centers and shopping centers. Many of the linear openings were developed initially to transport logs from and supplies to the forest during the logging period; activities that continue but that originally had little in common with modern forest management. Logging in the predepression era had little concern for the future.

Forest management and timber extraction also involve activities responsible for continued fragmentation and for maintaining the fragmented condition. Some of these include:

1. Making small clearcuts. This approach greatly increases the amount of edge.

2. Installation of wildlife openings designed to increase edge and provide summer range for deer. In their assessment of openings in northern Wisconsin, McCaffery et al. (1981) noted use of forest openings by small and large mammals, numerous song birds, and both mammalian and avian predators. Placement of these 0.3- to 0.8-ha. openings, in respect to vegetation type, soil type, roads, or other openings, had much to do with whether they were beneficial or detrimental, and to which species. Maintenance of relict openings is a similar activity.

3. Construction of roads, trails, transmission lines, and other linear corridors. These essential networks provide access for a variety of edge species including predators and nest parasites. The corridors and their edges vary in width and orientation as well as in maintenance.

4. Planting conifers, either on sites already open or converted from aspen or other forest types. As the plantations grow they provide contrast in composition and structure to the surrounding forest, and when the plantations mature they will in all probability be clearcut. The result is a recurring and longlived edge. Although plantations interrupt the continuity of the forest, they increase diversity and provide shelter for some overwintering bird and small mammal species, and, when situated adjacent to suitable forage, for deer.

## Community Structure

Vertical structure, stem size, and density influence use by wildlife species, especially birds, e.g. ruffed grouse (Gullion 1984, Kubisiak 1985). Structure is impacted directly by forest management where the objective (except in the case of uneven aged silvicultural systems) is usually maintainance of a simplified structure. Much of the presettlement forest, especially the northern hardwood and the mixed conifer/hardwood types, was stratified into layers including the canopy, the subcanopy trees, saplings, and the seedling and herbaceous layer (Braun 1950, Stearns 1951). Sometimes a supercanopy of scattered large trees, most often of white pine, was present. The initial logging of the later half of the 19th and the early 20th century removed virtually all of the supercanopy stems, the entire canopy, and most of the subcanopy, leaving only sapling and seedling layers. In the northern hardwood type, saplings and advanced seedling regeneration, chiefly of sugar maple (*Acer saccharum*), soon produced a relatively uniform canopy at a lower level. This resulted in a 2-layered stand with the reproduction and ground vegetation heavily shaded. Many northern hardwood stands remain with little structure or species diversity after >50 years; especially since timber stand improvement practices have removed most of the larger residual stems, and most hemlock. Currently, there are plans to increase the hemlock as well as the yellow birch (*Betula lutea*) component. Although management designed to retain a given basal area results in some opening of the canopy, and thus may encourage smaller stems to form a subdominant layer, considerable time is required for the process.

The presettlement pine forests were also often vertically stratified with a somewhat open canopy of large pine, a subdominant layer, sometimes pine but more often of hardwoods, and generally a sapling or shrub layer. This structure was less evident or absent in young stands and in dense old stands where only the canopy and shrub layers were present. Pine plantations are usually managed to eliminate vertical stratification by removing competing hardwoods both in site preparation and during early development. When thinned, suffient canopy remains to preclude invasion by most understory species leaving a low herbaceous layer and some shrubs, and producing a stand with little structural complexity. In plantations established on formerly cultivated fields, frequently even the ground vegetation is lacking.

Patchiness of forest components, both species and age classes, provides horizontal diversity. In unmanaged forests this results from the interplay of site factors, species characteristics and disturbance, e.g., hemlock patches among hardwoods (Lutz 1930). Such small scale patchiness within large areas of continuous forest has both wildlife and silvicultural value.

## Substrate Modification

Substrates are modified continuously in nature. Mounds and pits result from the windthrow of larger trees. Organic matter accumulates ranging from large logs or stumps, to leaves and fine fragments whose rapid decay builds a rich organic horizon. Other alterations result from trampling by large vertebrates to burrowing by small vertebrates and numerous invertebrates. Dead material on the forest floor provides habitat for small mammals, reptiles, and amphibians, as well as insects and other invertebrates. Frequent entry into a forest stand to remove cull trees or thin healthy stems reduces the opportunity for accumulation of wood on the forest floor.

Among the most conspicuous modifications are those produced by beaver (*Castor canadensis*). The building of dams and lodges have been regular activities for millenia and have resulted in creation of ponds that in turn may become alder thickets and later cedar swamps (Johnston and Naiman 1987). The process was described clearly long ago. "Now, while the popular mind readily recognizes that the beaver meadow may be a logical successor to the beaver pond it does not so easily grasp that there are other possibilities, or that the beaver meadow is not necessarily an end result in itself: that it may be but a step in the onward march of events; that it represents but a stage in an orderly process of succession in nature and is due in its turn to be followed by other conditions. Seeds of forest trees will find lodgement and growth in this fertile soil and ultimately the meadow will have been succeeded by the sheltering swamp or the wooded valley, as the case may be . . ." (Johnson 1927). In their study in the Adirondacks, Remillard et al. (1987) conclude that the spot disturbances beaver produce in the forest are followed by "multi-directional and nonlinear patterns of succession." Beaver appear to have had a role in raising the water table for trees on lower slopes, such as hemlock and yellow birch, as well as increasing water storage, reducing siltation down stream, and increasing stream levels of nutrients that may have in turn, benefited fish populations (Bergstrom 1985). Elimination of the timber wolf (*Canis lupus*), and explosive growth of the aspen type following the initial logging, permitted beaver to increase despite continued trapping. Decline of aspen, especially the streamside patches, as well as increase in roading and recreational settlement, have placed beaver in active competition with cabin owners, road builders, and forest managers. The current effort to greatly reduce beaver populations to provide more trout and drier roads may well be counter productive in the long run. The outcome will be less water storage, reduced small scale landscape heterogeneity, and deletion of an important lowland successional pathway.

Site preparation is usually undertaken before conifers are planted. In the process, much of the ground vegetation as well as natural reproduction is lost, reducing competition for the pine seedlings but also lowering vegetative diversity and modifying the soil biota. Where plantations are established on cultivated fields they may remain void of ground vegetation for many years.

## Shifting Goals

The overall goal of timber management is to maximize growth and yield, a secondary goal is the improvement of stem quality in saw timber. These goals normally involve timber stand improvement and reliance on shade intolerant species, or reduction in stand basal area with shade tolerant ones. Avoidance of defect caused by injury or disease and reduction in growth with increasing age are reasons given for shortened rotations. Likewise, wildlife managers have sought ways to increase game abundance through techniques that increase edge habitat and available food resources for target species. In both cases management has often resulted in halting or reversing forest succession. The need today is for a management strategy that provides for a diversity of organisms, plant and animal, using approaches that lead to dynamic forest systems that can undergo periodic rejuvenation.

Various approaches to dynamic management have been suggested and deserve to be reiterated here. In a recent symposium, Tilghman and Evans (1986) provided suggestions useful in forest management for non-game species. Their list included lengthening rotations in stands subject to even-aged management, leaving some large trees to increase structure in uneven-aged stands, keeping some dying and dead trees in developing and mature stands, and holding some areas as "over mature" stands to provide interior habitat. Longer rotations would increase structural complexity and in some cases would stimulate random rejuvenation. Current understanding would add the need to maintain larger stands to provide interior habitat.

Other approaches that might be considered include less intensive site preparation prior to planting, encouragement of fruit producing species, and retention of ground vegetation. Dead trees should be left on the forest floor. Timber stand improvement prescriptions should consider both enhancement of growth and development of vertical structure. Leaving thinned and cull stems on the forest floor would enhance activity of soil organisms. Prescriptions already specify that some cull trees be left standing, the number should be increased. Marking guidelines should be altered to avoid discriminating against particular tree species, e.g. basswood (*Tilia Americana*), beech (*Fagus grandifolia*), hemlock, or ironwood (*Ostrya virginiana*) merely because they are commercially less desirable. Diverse species mixtures may well have long-term silvicultural benefits, in addition to their wildlife values, especially in a period of changing climate. Prescribed fire should be used more frequently—ground fires in autumn could serve to prepare seedbeds for winter-shed seed. It should be noted that most major fires in the Midwest have occurred in autumn. Summer logging and mechanical scarification could also serve to expose mineral soil essential for the establishment of natural reproduction of some species. Where feasible, the level of wildfire control should be reduced to increase heterogeneity and restart the successional process. Likewise, clearcuts should be reduced in number and, where appropriate, increased appreciably in size. Adoption of these and similar techniques, although perhaps less profitable in the short term, will in the long term likely result in a more dynamic forest in which biotic diversity will be increased at all levels and natural processes maintained.

Forests have been, are, and will remain dynamic systems. However, management has altered the rate and direction of natural change and has tended to reduce structural complexity and diversity. Responses to events that impact the forest may lag many years after the events. Diversity in forest composition is especially critical as we look ahead to the probability of major climatic changes. Both forest and wildlife managers must anticipate the possibility of counterintuitive results of their actions and where possible let natural processes operate.

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# 8 Static Management of Forest Ecosystems

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# Static Management of Forest Ecosystems

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*Abstract:* Forest ecosystems did not develop in a static environment. Disturbance factors coupled with the inherent diversity of a region produced a mozaic of vegetation types of different successional stages within the various ecological land types. Today we are managing the forests that have developed after major human influences without adequate regard to natural ecosystem processes. This static approach to forest management has produced problems such as ecosystem alterations, habitat fragmentation, reduction of stand diversity, and loss of important vegetation types. Managers need to consider the vegetative mozaic over larger areas. Multi-factor ecological land classification systems need to be developed, funded, and implemented, as do geographic information systems, to facilitate long-term planning for large areas. Natural methods of forest management, such as use of fire, need to be further developed and used in place of artificial methods such as herbicides. In short, management needs to incorporate a better consideration of the ecological processes that forest ecosystems developed with if we are to meet demands for diverse forest products while maintaining biodiversity and naturally functioning ecosystems.

The flora and fauna of forest ecosystems in the Midwest did not evolve in a static environment. Geological, climatic, and site factors all changed over time and interacted to produce the ecological land types of the region. A corresponding inherent diversity of forest habitat types developed in response to the site and climatic factors. Disturbances further diversified vegetation types by causing induced changes in forest stands. All plant communities in Midwestern forest ecosystems developed with periodic disturbances such as fire, wind, ice, drought, floods, and pathogens. On any given ecological land type, the community response to disturbance followed a fairly predictable, though sometimes complex, sequence of successional change.

The periodicity of natural disturbance at a site varied considerably (Heinselman 1973). Some stands of jack pine (*Pinus banksiana*) or aspen (*Populus* spp.) may have burned at intervals of ≤50 years (Heinselman 1973). Northern hardwood forests, sometimes termed "asbestos forests", undoubtedly had longer disturbance cycles (Bormann and Likens 1979). These forests were influenced primarily by wind and ice affecting individual trees or small groups of trees in old growth stands, creating numerous small openings of earlier successional associations. This matrix of different disturbance factors produced a mozaic of forest stands of varying composition, age, size, and shape. The complete complex of endemic wildlife species evolved with and responded to this pattern of forest vegetation.

Human impacts caused dramatic change in the mozaic of Midwestern forests, as discussed by Stearns (This proc.). The forests of today are the result of past human influences and management practices. This paper explores how current management practices relate to the natural disturbances that shaped the forests, and addresses concerns about the static conditions that can result if ecosystem dynamics are ignored.

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## Current Forest Management

Forest management today typically strives to meet multiple-use objectives by integrating timber production with objectives for wildlife and recreation. Specific forest outputs include cords of pulpwood, board feet of timber, tons of chips, recreation days of hunting or viewing, and maintenance or enhancement of specific populations. Forest stands are usually mapped using classifications based on existing dominant species, stocking densities, and stand age. Thus, a "91-6" code might signify a well-stocked, pole-stage, aspen stand. Management decisions are usually made for blocks of land, often termed compartments, typically several sections in size. Management is based on existing or expected public demands for resources, usually on a 10-year operational plan. Desired outputs from a compartment are based on the existing vegetation and how it can be directly managed or manipulated.

Using these criteria, aspen is usually planned for clearcutting at 40–70 years of age to maximize regeneration from clones (Perala 1977). Northern hardwoods can be managed by selection cuts, shelterwood cuts, or clearcuts (Tubbs 1977, Leak et al. 1987), but the most commonly used method is single tree selection cuts. Red pine (*Pinus resinosa*) is typically managed by clearcutting and planting (Schone et al. 1984). Depending on site conditions, herbicide application is often used to reduce competition to the red pine seedlings. Plantings are usually at high densities and then stands are thinned at around 25 years of age. Many agencies create and manage small wildlife openings distributed throughout forest lands, primarily for game species, which may be maintained through mowing, herbicides, or fire.

These practices are examples of current forest management. While exceptions are common, these serve to illustrate the current approaches or philosophies of management in vogue today.

## Problems with Current Management

Forest management, at the present, is based on production of specific timber products, wildlife populations, or recreation. Because human demands change, planning to meet demands tends to be for short time intervals. Stands are mapped by existing vegetation and managed to yield outputs from the existing vegetation. Aspen is managed to remain aspen, and produce aspen products, typically pulp or chips, and white-tailed deer (*Odocoileus virginianus*) and ruffed grouse (*Bonasa umbellus*). Northern hardwoods are managed to remain northern hardwoods. This approach ignores the ecological complexity and natural dynamics of these forest types. Aspen and northern hardwoods are part of the same successional pathway on some ecological land types. Management based only on existing vegetation ignores the long-term successional changes that can take place in a stand, and the associated successional stages that could occur. For example, aspen occurs on ecological land types supporting a number of possible later successional vegetation types. By clearcutting aspen, we keep it from advancing to later successional stages. While this may be appropriate for many aspen stands, under intensive management, it will preclude the occurrence of stands supporting a transitional successional stage of over-mature aspen and associated invading tolerant species (e.g., northern hardwoods). These stands would produce large numbers of snags, large amounts of dead and downed woody material, and high structural diversity important to many species of wildlife.

Northern hardwood stands are typically managed to remain northern hardwood stands, commonly through the use of single tree selection cuts that favor regeneration of sugar maples (*Acer saccharum*). Few stands are scheduled to advance successionally to an old growth stage. Such old growth stands, characterized by higher numbers of decadent or dying trees, would provide an abundance of large snags, den and wolf trees, dead and downed woody material, and as reported by Franklin (1989), high populations of parasitic and predatory invertebrates compared to earlier successional stages. Resistance to stands advancing to old growth stages is partially due to a common attitude of many natural resource managers that resources not utilized by humans are wasted. Timber left to die and decay is viewed as waste, despite its value as snags for cavity nesting birds and insectivores; its value as downed woody material as cover for many small mammals, reptiles, and amphibians; its contribution to soil fertility, soil microorganisms and detritivore communities; and its potential role as woody structure in streams or rivers. Maser (1988) provided a more long-term perspective of the value of old growth stands.

Little regard has also been shown to the natural disturbance cycles of northern hardwood stands described by Bormann and Likens (1979), which would indicate that group selection cuts may represent a more natural disturbance pattern. Group selection cuts can produce increased plant diversity in stands due to the regeneration of more intolerant or intermediate species (Leak et al. 1987) which may be important in the habitat of a number of wildlife species, although this has not been adequately researched. Runkle (1985) stated that single-tree selection cuts, group selection cuts, and clearcuts are all needed in northern hardwood forests in order to regenerate the original species composition.

Forest management has generally taken a very narrow focus on forests, placing a very high value on the utility of a variety of forest products (Maser 1988). A much lower value has been placed on the complete understanding and consideration of many ecological relationships.

Another problem has resulted from management based on single factor classification systems of existing vegetation. Using such a system, managers are incapable of adequately planning for long-term changes. What will be the invading species in an intolerant stand such as aspen? It could be a large number of species, based on the geological, edaphic, climatic, and ecological factors influencing that stand. Classification systems that ignore these factors will not provide information on invading tolerant species such as northern hardwoods on some sites, and white pine (*Pinus strobus*), or spruce (*Picea* spp.) -fir (*Abies* spp.) on other sites. Multi-factor ecological classification systems would also allow for better quantification of subdominant vegetation, such as soft mast producing species in the understory, which may be important in assessing habitat quality for wildlife species such as black bears (*Ursus americanus*).

Lack of a sufficiently long-term perspective, management of stands in small compartments or areas, and a narrow focus on products of immediate interest have also led to problems with forest fragmentation. Species requiring "interior" areas away from certain types of edges, such as some species of ground-nesting warblers, have shown population declines in many areas (Wilcove 1985, Robinson 1988). In the Midwest, the degree of past human disturbance to forest ecosystems and the patchy distribution of public land ownership further complicate this problem.

A narrow focus on specific products has encouraged the use of more intensive timber management practices such as planting of red pine. This species is now being forced into many ecological land types where it would not occur naturally. Herbicides are often used to alter the naturally occurring species to favor red pine. Genetically improved trees are being planted in other areas to achieve faster growth rates or reduced susceptibility to diseases or parasites. What are the long-term consequences of altering the natural associations of plants, especially on the wildlife that have evolved in response to these natural associations?

Perhaps 2 quotes best summarize the problems I perceive in our current forest management. "Traditional forestry practices such as clearcut, shelterwood, and selection cutting have focused on the regeneration of trees and not the perpetuation of a complex forest ecosystem" (Franklin 1989:42). "Nature designed a forest as an experiment in unpredictability. We are trying to design a regulated forest" (Maser 1988:4).

## Solutions to Static Management

The solution to the problem of the static approach to management prevailing today is to apply an understanding of ecosystem dynamics and a long-term ecological perspective to the management decision process. This is an important goal if we are to be good stewards of all of the resources under our responsibility. It will require managers to be knowledgeable of natural disturbance factors, their timing, and ecological patterns, and to incorporate this knowledge into management plans. This is not to say that we should attempt to return to pristine conditions, but that we need to infuse a better understanding of the ecosystem processes that produced pristine conditions into management plans. It also means that long term successional pathways for each ecological land type need to be documented and available to managers. Many of these are known; however, others need additional research. In addition to this general change in approach or philosophy, a number of more specific solutions can be implemented.

Classification systems based on multi-factor ecological analyses need to be selected and implemented into forest mapping. A number of such classification systems are available, although each may need modifications for specific locations. Funding needs to be allocated to identify appropriate classification systems and produce new maps of appropriate areas. This should be a high priority for all land management agencies.

Management needs to shift from a small-area emphasis to a large-area emphasis. Managers need to first make decisions on a regional basis within a state in terms of forest vegetation patterns and distributions, and then work with stands on a small-area basis. Over a region, a mozaic of forest vegetation needs to be produced, with enough area of each successional stage of each ecological land type maintained to at least provide minimum conditions for viable populations of all endemic species. Geographic information systems (G.I.S.) will provide the capability of planning on a regional basis within a state. Allocating funding for G.I.S. implementation and providing inservice training on its application and use need to be high priorities.

Habitat fragmentation and species-area relationships need to be considered in management plans. More information is needed on edges in forest ecosystems (Reese and Ratti 1988) in order to adequately plan for interior species. Many types of induced and inherent edges occur in Midwestern forests, with little information available on which edges can influence interior dependent species. Mature and old growth stages have been identified as a concern in habitat fragmentation, but in continuous forest tracts, size and distribution of grassy openings may also be a problem for a species dependent on grasslands. Locking up large blocks of land in no-management zones is an over-simplistic approach to this complex problem. Only through management on a large-area basis can this problem be correctly solved.

Old growth stands are lacking in all Midwestern forests. Stands of sufficient size to meet species-area and interior species requirements need to be identified for old growth development and incorporated into regional plans within a state. Another alternative proposed by Franklin (1989), is the use of leave trees. These are trees identified in stands to be managed by selection, shelterwood, or seed tree cuts, that will never be cut. Thus, most of the stand will be harvested in a normal silvicultural fashion, but 20–40 trees/ha would be protected from cutting. This could provide many of the advantages, over time, of old growth stands in terms of large trees, snags, den trees, and dead and downed woody material, while still maintaining active timber production. This would also produce, in these areas, superdominant trees that would provide nesting opportunities for bald eagles (*Haliaeetus leucocephalus*) or other species attracted to this habitat component.

Natural regeneration of stands should be a management goal. Herbicide use results in the alteration of naturally regenerating species. Fire should be used whenever feasible instead of herbicides as a natural management tool. Studies in Michigan (D. Dickmann, Dep. For., Mich. State Univ., pers. commun.) have shown good natural regeneration of red pine in stands containing abundant hardwood competition when these stands were correctly treated with fire. The role of fire in ecological land types that historically were disturbed by fire needs to be more thoroughly evaluated, and in many cases, researched.

In summary, what is needed is not so much a change in many of our methods of forest management as a change in our management approach or philosophy. We need to keep our natural ecosystems in mind as we plan to meet demands for forest production. This means considering the natural disturbances and patterns that our forest ecosystems developed with, and selecting compatible management strategies. Only through this type of approach can we meet demands for forest products while maintaining both biodiversity and natural ecosystem processes.

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# 9 Wilderness and Wildlife Management

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# Wilderness and Wildlife Management

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*Abstract:* Traditional negative attitudes toward wilderness are slowly giving way as the amount of wilderness declines, and ecological knowledge and human appreciation of undeveloped landscapes increases. Wildlife managers, accustomed to manipulating populations and habitats, and husbanding game species, sometimes view wilderness preservation as a threat to what has come to be called "sound management." Some hunters consider wilderness designations as a threat to hunting, but not all hunters agree. Wilderness designation may furnish refuge for such species as grizzly bears (*Ursus arctos horribilis*), wolves (*Canis lupus*), loons (*Gavia* spp.), and whooping cranes (*Grus americana*), and also provide living examples of land health. Because designated wilderness areas at present do not provide a cross section of representative ecosystems, long-term efforts should be directed toward public acquisition of a variety of natural ecosystems with the goal of restoring wilderness conditions for research as well as recreation. Wilderness preservation is consistent with Aldo Leopold's land ethic, which seeks to preserve the integrity, stability, and beauty of the biotic community.

For centuries of traditional western culture wilderness was regarded at best as worthless and at worst dangerous. Wilderness was something to be avoided or to be conquered by the courageous—to be "cleansed" of wild beasts and savages for the benefit of civilization (Allin 1982). But not all cultures have seen wilderness that way. The American Indians and the descendants of some Europeans who came to settle in North America developed a certain fondness for their "uncleansed" surroundings, the prairies, the mountains, marshes, shores, and forests, and they began to regret their passing (Catlin 1832 cited by Allin 1982, Thoreau 1854, Vickery 1989). In wilderness they saw beauty, adventure, fascination, opportunity for solitude, and an unexplainable attraction—like that of staring into a campfire, behavior possibly stemming from the very roots of human origins. The purpose of this paper is to review changing attitudes and policies toward wilderness in North America, to discuss the ecological and scientific values of wilderness preservation, and to consider the role of wildlife biologists in this arena.

In the past quarter century, legislation has been passed by the U. S. Congress to set aside wilderness areas. These include the Wilderness Act of

1964, the Federal Land Policy and Management Act of 1976, the Endangered American Wilderness Act of 1978, and the Alaska Lands Act of 1980. Since the enactment of such legislation, 474 areas have been dedicated, and wildlife biologists have had mixed feelings about the designation of land as wilderness. In such areas access for researchers and hunters is often limited, and consequently so is the opportunity to manipulate vegetation and animal populations.

## Wildlifers, Engineers, and Foresters

In the past decade or so, wildlife professionals and interested news media, particularly television, have done a wonderful job of selling wildlife management to the public. Indeed, our profession has had considerable success in managing deer and small game for hunters, and bringing back a few endangered species such as alligators (*Alligator mississippiensis*), bald eagles (*Haliaeetus leucocephalus*), and ospreys (*Pandion haliaetus*). There is much evidence that the public believes in us and our powers to produce deer and grouse given some land on which to do so. Television shows featuring Jacques Cousteau, the late Marlin Perkins, and others have built public interest and confidence in the scientific aspects of our approach; and we have even begun to believe in our powers ourselves. In fact some of us may wonder how wildlife populations have been able to survive through all these centuries without the assistance of wildlife managers.

Scheffer (1976), however, gently chided wildlife managers as suffering from inbreeding, resembling in that respect the professions of education and medicine. He accused us of favoring our traditional clientele, hunters and fishermen. More recently, Kennedy (1985) in characterizing attitudes of wildlife managers, asserted that wildlifers generally assume that wildlife resources should and can be managed (as business managers, accountants, or foresters do of the resources they manage). Kennedy (Op. Cit.) used as an example, a statement by Lynn Greenwalt, Director of the U. S. Fish and Wildlife Service, (paraphrased here) on wolf control in Alaska (Wildlife Management Institute 1976): Wildlife managers had to make a tough decision to control wolves. When wolf numbers become high, if the situation is left to nature alone, we can predict a decline in wolf populations. Artificially reducing wolf populations will help a depleted caribou (*Rangifer tarandus*) herd rebuild itself ultimately to produce a surplus annual crop that can be harvested by both humans and wolves. If nature is allowed to take its course, the prey herds will probably decline to a very low number before the wolf population drops, but it will eventually drop. The net result would

(a) (b)

*Fig. 1.* (a) A wilderness setting with free-flowing stream and uneven aged forest with rotting trees; (b) The same area (as visualized by an engineer) used to meet the demands of society for electrical energy; (c) The area as visualized by a forester with managed

be fewer prey—and fewer wolves—for a longer period than if wildlife managers are allowed to intervene.

Kennedy (1985) indicated that this statement may represent a prevalent (but by no means unanimous) viewpoint of wildlife professionals. In this viewpoint there is (1) an underlying assumption of professional management prowess, (2) belief in logical scientific thinking and American respect for decision-making toughness, (3) utilitarian value of caribou vs wolves, and (4) impatience with and mistrust of nature's course.

The tenet of a high sustainable yield of harvestable surpluses of animal populations is widely accepted in our profession, a concept shared with traditional foresters and fishery managers. As an example, in Michigan after long neglect by wildlife managers and researchers, the black bear (*Ursus americanus*) has suddenly become a popular and economically important game animal. Biologists are suddenly scrambling to attempt to deter-

(c) (d)

timber (and a token "wildlife tree") to meet the demands of society for wood production; and (d) The area as visualized by a wildlife manager with wildlife flooding, hunting blind, and wildlife plantings, to meet the demands of society for recreational wildlife. (Drawings by Mark R. Homant)

mine its population levels and productivity to manage the hunts for maximum yield.

The view that animals, especially those sought by hunters, might be allowed to die in the woods of natural causes is, according to Kennedy (1985), anathema to traditional wildlife management tenets. Foresters have similarly viewed a dying and decaying tree as a wasted resource.

By some standards, wilderness areas are often messy. There are trees of various ages present, some of inferior commercial quality, and there are rotting logs (Fig. 1*a*). In some eastern climax forests, birds and mammals (particularly game species) are not as plentiful as in earlier successional stages (Whittaker 1976). We say these forests are not "productive", but we also now know that fragmenting forests results in disappearance of many species of warblers, vireos, thrushes, and flycatchers (Robbins 1988).

We, as wildlife managers (e.g., Leopold and Leonard 1966) are at odds with the engineers, whose zeal to practice their skills and improve the world differs greatly from our own views of improvement (Fig. 1*b*). The dam builders say we need to produce energy and to control floods, and regard wildlife needs as subordinate. We likewise suspect that the forester, viewing the forests as a crop of wood fiber, is likewise off base (Fig. 1*c*). We need the jobs and the wood, they say (Ludeman 1985). The requirements for multiple use (including wildlife habitat management) in National Forests, the wildlifers say, are often given only token recognition in the main drive to produce wood. However, recently required planning processes under the National Forest Management Act are beginning to reflect demands of various publics, ranging from preservationists to the wood products industry, at least on national forests.

On the other hand, the wildlife manager can, some of us think, create the perfect environment. We can sow multiflora rose (*Rosa multiflora*), birdsfoot trefoil (*Lotus corniculatus*), lespedeza (*Lespedeza* spp.), Russian olive (*Elaeagnus angustifolia*), my all-time favorite—creeping red fescue (*Festuca rubra*), and numerous other plants imported from the far corners of the earth for the benefit of the wild animals we favor. And we can provide easy public access (Fig. 1*d*). We need the wildlife, the wildlife needs us, and we need the hunter's dollars, we say.

But we are far from having a thorough understanding of how natural systems work. Our manipulations of the environment in the name of "sound management", largely for economically valuable species, perhaps at the expense of less conspicuous, less glamorous species, may one day prove to be short-sighted. Management decisions of our predecessors who advocated predator elimination, shooting male deer only, all-out fire protection, and stocking Coturnix quail (*Coturnix coturnix*) were once regarded as state-of-the-art methods of management. We've learned much since then and will learn much in the future.

## The Conservation vs. Preservation Simplification

Our profession has, for a long time, prided itself on being for conservation and against preservation. The latter, we are told, means saving resources and not using them. The words "locking up resources" are often used by wilderness opponents. Conservation, on the other hand, has meant "the wise use of resources." Wildlifers tend to be use-oriented, but there are 2 catches: What does "use" mean, and who decides what is and isn't "wise"? If the preservationists had thought to include the word "wise" in their definition ("the wise saving or setting aside of certain resources") we'd be confused. Besides, all of us lock up things of most value to us, our automobiles and our houses for example, to prevent stealing and destruction by unscrupulous people.

It is quite possible that the best use or management, as suggested by Hickey (1974) for some lands, is no management at all. The definition of conservation has changed since I learned it in the 1940's. Bennett (1983) now defines it as "the scientifically disciplined and socially equitable utilization and, when indicated, preservation of the earth's natural resources."

Some kinds of wildlife may need unmanaged wilderness. These include mountain lions (*Felis concolor*), loons, and whooping cranes. The winter range of the latter species includes an active shipping canal carrying tons of toxic chemicals with the constant threat of spills. Spruce grouse (*Dendragapus canadensis*), wolves, and grizzly bears are other examples of animals that have not coped well with managed environments. In the Pacific northwest, the spotted owl (*Strix occidentalis*) needs large tracts of old growth forests (Fosburgh 1986).

## Hunters and Wilderness

The traditional alliance of wildlife managers and hunters (Scheffer 1976) has not been entirely of our own making, as financial support of our jobs comes largely from contributions of hunters. Although we have new nongame wildlife programs and a growing public interest in nature, funding for nongame programs is <10% of that for game management (Robinson and Bolen 1989). Furthermore, many of us tend to be suspicious of people who don't hunt, and view them as potential adversaries of hunting, and therefore opponents of what we like to call sound wildlife management—based on regulated harvest. Many wilderness advocates are indeed non-hunters, and certainly many of them are anti-hunters.

Sportsmen note this association and many of them see wilderness preservation as a threat to hunting and fishing. The Michigan United Conservation Clubs (MUCC), a large sportsman-oriented organization of which I am a member, recently opposed legislation designating 11 new wilderness areas in Michigan. Their reason was that such designation would restrict access to hunters, anglers, and campers (Washington 1987). I should note, however, that MUCC on the whole has been a strong advocate of conservation and restoration of nongame species, including wolves and loons). In 1988, despite MUCC's opposition, all 11 Michigan wilderness areas were approved by Congress.

Before their designation, a dispute over these areas was carried out in the pages of the Detroit Free Press between Ann Woidwode, Michigan Chapter of the Sierra Club, and outdoor writer Tom Opre. Opre (1987) presented the following argument that wilderness designation is anti-hunting in disguise (quoting Congressman Larry Craig of Idaho): "Over a period of time we will see a movement by those so-called 'conservation groups' to completely eliminate hunting in the wilderness areas. Not only would this spell doom for American hunters, but it would destroy the sound wildlife management practices that have helped our wildlife populations to thrive and grow." The simplicity of the argument is almost irresistible: Wilderness advocacy = anti-hunting = elimination of hunting = destruction of sound wildlife management practices = loss of thriving and growing wildlife populations.

But there are many types of hunters (Kellert 1978), and many prefer to hunt in unmanaged natural systems. These hunters are likely to join forces with other hunters to protect the privilege of hunting in wilderness areas.

## A Broader View of Wildlife

In contrast to the statement by the Idaho Congressman, I would like to cite the words of Dan Poole (1987), Chairman of the Board, Wildlife Management Institute, an organization largely supported by arms and ammunition manufacturers. I regard this as a visionary and courageous article published in American Forests.

"Today's public is interested in all wildlife, not merely those that have some perceived value to man or pose a threat to him. Today's public knows that any animal, if it is to persist, requires secure habitat in which to find food and shelter and rear its young. In essence, the same basic principles apply to the grizzly and to the ground squirrel, to the elk and the eagle.

"The maturation of the American viewpoint toward wildlife is a kind of reflection of the 'all creatures great and small' outlook portrayed in the writings of an English veterinarian. This viewpoint is becoming a sticking point for public resource agencies because their programs are rooted in resource development and use—timber, livestock, mining, and hunting ... Far too often the objective of only 1 or 2 interests are advanced, with scant regard for the others."

Can wildlife be studied or managed in a wilderness area? Studied, most certainly, managed, yes, to a small extent. There are guidelines published in the Congressional Record, Aug. 9, 1984. Research may be conducted as long as it conforms with the requirement of minimum disturbance necessary to conduct the research. The record also states that angling, hunting, and trapping are legitimate wilderness activities.

## Leopold's Concept of Wilderness

Aldo Leopold, whom we regard as the father of wildlife management, was an advocate of hunting, of manipulation of habitats for wildlife in many areas, and also of preservation of wilderness areas. Leopold (1949) presented 3 reasons for preservation of wilderness: recreation, wildlife, and science. The recreational use of wilderness is the one most commonly advanced by both wilderness advocates and wilderness opponents. Advocates stress the cleansing of the human spirit, the connections of nature, mind, and soul, and the personal value of solitude provided by wilderness (e.g., Thoreau 1854, Vickery 1989). Opponents acknowledge these values but regard the economic worth of exploitable resources such as timber, minerals, and oil as more essential than wilderness to the continued functioning of society. Accusing wilderness advocates of being elitists who claim recreational lands at the expense of livelihoods of working people is a common accusation (Tucker 1982).

The wildlife values of wilderness are illustrated by the dependence of numerous species on undisturbed habitats. Some are simply not adaptable to intensive human intrusions, and wilderness provides large tracts of land and water for such species as common loons (*Gavia immer*), wolves, grizzlies, spotted owls, and whooping cranes.

The scientific value of wilderness is the most neglected argument for wilderness preservation. A science of land-health needs, first of all, a base datum of normality, that is, a picture of how healthy land maintains itself as an organism. Paleontology indicates that wilderness maintained itself for immensely long periods. Component species were rarely lost, nor did they get out of hand; weather and water built soil as fast or faster than it was carried away. Leopold noted that wilderness thus assumes unexpected importance as a laboratory for the study of land-health.

Specifically, what might we learn from wilderness areas scattered throughout the continent? Our present highly extractive agricultural system using monocultures of grain crops, fertilizers, herbicides, and irrigation, may not be sustainable in the long run (Eisenberg 1989). Desertification of some parts of the world are evidence of our past mistakes, and the depletion of the Ogallala aquifer in the western U. S. illustrates that even with modern technology, high yields are not without problems. In Kansas, experiments are proceeding to develop productive harvestable polycultures. In these experiments, a combination of genetically modified plants and combinations of native prairie species are being tested in an attempt to attain crop production with minimal soil and nutrient loss. In such endeavors, one researcher was quoted by Eisenberg (1989) as saying "Wilderness is the standard against which agriculture should be judged."

The McCormick Forest, one of the recently dedicated Michigan wildernesses, includes an area in which there are no weeds. In this mixed northern hardwoods-white pine (*Pinus strobus*) stand we have an opportunity to measure the processes of seed germination, competition, and browsing pressure free from the complicating influence of invading Eurasian plants that are now so prevalent across the North American continent (Fred Metzger, U. S. For. Serv. pers. commun.).

Our present knowledge of wolves has been greatly enhanced by studies on Isle Royale, a wilderness area, where wolves and their prey have been allowed to live and die without our meddling. About 8 years ago, there were 50 wolves and about 600 moose (1 wolf per 30 moose), a seemingly precarious ratio suggesting doom for the moose. In any place other than a wilderness area, such a ratio would have brought on the trappers and aerial gunners. But on Isle Royale wolves and moose were left alone. In the next 5 years wolves did a lot of dying on their own, dropping to 11 wolves, while moose populations began to thrive (R. Peterson, pers. commun.) Without researchers, and a wilderness area in which to work, we would not have this sort of valuable information.

In 1987, wolves were first attempting a comeback in Montana on their own, arriving from adjacent British Columbia, and sometimes roaming outside designated wilderness areas. According to newspaper reports, the Director of the U. S. Fish and Wildlife Service, after listening to opinions of Montana ranchers, concluded he that he had doubts about reestablishing wolves in Montana. The wolf is not, he asserted, "truly an endangered species" (despite its designation as such by his own agency). "There are plenty of wolves in Canada and Alaska," he said, "and maybe that's where they belong."

Such thinking had been uncannily anticipated and opposed nearly 50 years earlier by Aldo Leopold (1949): "There seems to be a tacit assumption that if grizzlies survive in Canada and Alaska, that is good enough. It is not good enough for me. Relegating grizzlies to Alaska is about like relegating happiness to heaven; one may never get there."

## Fire and Wilderness

The question of what to do with fires in wilderness areas is still problematic. The alternatives include (1) total suppression; (2) modified suppression, depending on the initial cause of the fire, danger to humans, structures, historic sites, and nearby commercial forests; (3) prescribed burning; and (4) no interference with fires.

Total suppression is unlikely to be an approved wilderness fire policy. This is because of our increasing knowledge of the history of natural fires, the build-up of dangerously high levels of fuel, consequent "super fires", and the potential damage done by fire-fighting crews, equipment, and chemicals to the natural character of the landscape. Despite some recent political cries to resurrect Smokey and his policies, it is unlikely that he will emerge from his hibernation unchanged. As Williams (1989) optimistically points out, the evaluations of the effects of the Yellowstone fires are being conducted by scientists, and few scientists will advocate total suppression of fire in natural ecosystems.

On the other hand, political realities probably eliminate the fourth alternative of no interference with fires. This leaves us with modified suppression and prescribed burning. With either policy, the simulation of wilderness conditions should be the primary objective. Such simulation depends upon knowledge of the history of fires in a particular area, and whether such fires were caused by lightning, volcanoes, or man. A prescribed burn in a wilderness area is supportable by the argument that aboriginal man was a part of nature for centuries. Certain natural systems have evolved in harmony with man's influence as a fire-builder. Does it matter whether that man was barefoot wearing a deerskin loincloth using a flaming pine stick, or wore Korfam boots, a cotton twill uniform, and a petroleum-fueled flame thrower? Yet there is something that tells us that we need a reasonably accurate picture of patterns of anthropogenic fires to simulate prehistoric patterns.

This leaves us with the problem of selective suppression of fires in wilderness areas—a policy very much like the policy developed for Yellowstone Park and in place at the time of the controversial 1988 fires. As the ashes have cooled, however, the press has given fair coverage to the beneficial aspects of the fires. In its zeal to stress the dramatic and unusual during the fires, the news media focused on flames, smoke, fire fighters, and politicians in helicopters. Now, not as spectacular, but quite unusual to the news media, are results showing that the fires were not totally destructive, but have had a restorative effect on life processes in Yellowstone (Assoc. Press 1989, Bolgiano 1989, Williams 1989).

## An Ecological Wilderness or Natural Area Acquisition System

We have no state, federal, or international policy that provides for the saving of representative ecosystems. Our acquisitions thus far, while admirable, have concentrated upon available and eligible lands primarily for wilderness recreation. Eligibility has been based upon the size of tracts and the amount of recent human disturbance. Perhaps the next step in wilderness preservation should be the acquisition of suitable geographic and climatic sites for restoration of representative ecosystems. Prairies, seashores, fresh water ponds, rain forests, and oak-hickory groves should be allowed to proceed as nature dictates. Private agencies, such as The Nature Conservancy, are already ahead of our governments in this effort. Our thinking on these matters must focus ahead not years or decades, but centuries. A national or international committee should be formed to identify and recommend socially and scientifically acceptable long-term procedures for establishing representative protected areas.

The paradox of wilderness designation looms as a menace to such a plan for acquiring representative ecosystems. The paradox, well known to backpackers, is that once an area is designated and therefore publicized as wilderness, it attracts large numbers of people, who, by their presence, destroy the very wildness that designation was meant to preserve. A separate category, such as "Research Natural Area," now used by some agencies, might be more appropriate. With such a designation, human access might be limited to preserve the integrity of the natural ecosystem.

Wilderness areas may be considered akin to the packages of assorted cultural tidbits that people put into time capsules in the cornerstones of buildings. These capsules assume future generations will be interested in how people once lived. Similarly, wilderness areas serve as living examples of how some parts of the world once were. They will be valued by future generations if they can survive. And they can survive only if we can restrain the growth of the human population and control our seemingly insatiable hunger for materials and energy.

## Wilderness and Leopold's Land Ethic

Leopold (1949) left us with the seeds of a land ethic. These seeds have germinated but show only sporadic signs of growth. In Leopold's land ethic man regards himself not as a conqueror of the land but as a citizen of the land-community. And that ethic requires human behavior to be governed not by short-term economic gain but by a long-term perspective for the value of a functioning ecosystem. Leopold said, "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise." Wilderness preservation is a splendid example of a thing that is right.

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# 10 Institutional and Public Constraints on Dynamic Management of Fish and Wildlife Resources

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# Institutional and Public Constraints on Dynamic Management of Fish and Wildlife Resources[1]

R. Ben Peyton

*Abstract:* State fisheries and wildlife agencies have become strongly dependent on public demand as a basis for financial and political support. Subsequently, much emphasis is placed on managing resource components to provide for current demand. Agencies do not have the desired flexibility to manage resources for long-term socio-ecological goals. Fisheries and wildlife agencies are caught in a period of change where traditional support groups and primary constituents (consumptive users) appear to be declining, and new constituencies (e.g., nonconsumptive users and protectionist groups) have not yet become formally integrated into the management system. A new paradigm is needed which bridges the gaps and combines all users in the management process, rather than replacing one support group with another. Further, efforts to broaden socio-ecological research and management will require special attention to public dimension and ecological training for resource managers, comprehensive planning, and support for interdisciplinary projects. A need also exists to educate the public to recognize future resource management opportunities so they will encourage and support agency efforts to increase planning.

> *"We are in an era of special interest politics. Different groups have varying ideas of how wildlife resources should be managed and utilized, and what priorities they should receive. We find ourselves increasingly the subject of controversy. Either we are being regaled for not pursuing some conservation problem, or criticized for going beyond our authority by addressing environmental issues that 'don't have anything to do with hunting and fishing.' In cases where we attempt to react to daily problems, we are chastised for crisis management. Yet, when we look at the long-term impacts of our decisions, we are accused of being unresponsive to the needs of the people."*
>
> *(Crowe 1983:x)*

It would be easy, and unfair, to overstate the premise that wildlife and related resources are being managed as short-term, static products rather than long-term, dynamic systems. Certainly, state and federal agencies do

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strive to manage resources as complex ecosystems requiring holistic, long-term management goals and techniques. Just as certainly, as Crowe (1983) suggests, they are "damned if they do and damned if they don't." However, it is timely to consider whether state fisheries and wildlife agencies should be increasing their efforts at long-term, holistic management, and if so, what constraints exist.

The dynamic management approach proposed by this symposium is broadened in this paper to include a holistic approach to both ecological and social systems involved (socio-ecological management). Holistic management suggests an ecological approach in which ecosystems become the valued object of management. This does not preclude short-term, or species production management (production management) programs as necessary and desirable agency goals to provide recreational opportunity. Dynamic management also implies an acceptance of ecosystem change. Production management often strives to maintain equilibrium in communities and ecosystems rather than accepting and managing for change. Finally, holistic management also includes social concerns. A deer management program must consider the effects on major agriculture industry as well as ecological criteria when defining optimum deer numbers.

Trends exist which support the need to review the status of long-term, holistic management in state agency programs. Several papers in this symposium have described examples of resources and ecosystems being managed as static rather than dynamic systems. Other wildlife management examples can be cited which rely on "quick fixes" to produce harvestable crops of wildlife. For example, new plant species have been introduced to enhance habitat for a specific purpose without sufficient consideration of the ecological consequences (Olson and Knopf 1986). Fertilizers and pesticides are commonly used to produce high quality food sources for selected species. Other practices have dominated wildlife management to the detriment of some species or ecological communities. Reese and Ratti (1988) have challenged the overuse of edge effect management. Large forested areas of states such as Michigan are maintained in early successional stages in order to produce large harvests of game and forest products associated with these seres, and thus certain transitional seres and their species associations may be underrepresented.

Consideration should also be made of the changing status of wildlife management critics. A few years ago, a colleague gave a guest lecture in a course for non-majors on the principles of fisheries and wildlife management. He delivered a particularly graphic and thorough lesson on using fire, chaining, clear cutting, chopping, and other methods to set back succession and achieve various management goals. Following the lecture, a sociology major stormed up to me and declared she was going to drop the class. She was horrified at such "abuses of our environment" and was disappointed in the Department of Fisheries and Wildlife. In her words, she thought we "were supposed to be the good guys!"

Many elements of environmental movements largely reject the notion that state fisheries and wildlife agencies are the stewards of the environment. Rather, they view these agencies as servants of the consumptive user groups; existing predominately to produce harvestable crops, and causing more negative than positive impacts on environmental quality (Favre and Olsen 1979). Hunters, trappers, and anglers are not viewed as concerned allies, but as competitors for the attention of the management agency and the environmental resource. If nonconsumptive environmental interests are to support state fish and wildlife agencies, agencies must be perceived as engaged in broad, environmental management programs as well as producing recreation opportunities. These nonconsumptive interests must relate to the agencies as readily as the hunters and anglers, who, while they may not agree with all agency decisions, in general believe that the agency represents their interests.

It is the task of state fish and wildlife agencies to consider these and other trends and conditions and to determine whether they must increase the prominence of long-term, holistic management goals in their programs. It is proposed here that any efforts by state agencies to increase socio-ecological management should examine at least 3 related categories of potential opportunities and constraints: the extent and nature of public response, characteristics of professionals, and characteristics of institutions. The basis for most of these constraints lies in the sources of funding for state management agencies and associated politics.

## Public Response

The diversity of public perceptions and responses to management programs represents one major influence in effectively achieving management goals. Response of protectionist and other nonconsumptive interest groups to production management has already been discussed. The response of consumptive users to socio-ecological management is often one of support for such management. Nationally, 75% of consumptive users participate in both consumptive and primary nonconsumptive use of wildlife (Connelly et al. 1985). Hunters and anglers comprise a significant number of the donors to state nongame checkoff programs (Applegate and Trout 1984). A strong concern for environmental quality has been found among consumptive groups (Thomas et al. 1984, Leuschner et al. 1989). Similarly, some preservation-oriented groups appreciate the utilitarian value of managed resources and the role which hunters and anglers have played in preserving environmental quality (Evans 1978). Yet, it must be recognized that increased socio-ecological planning will necessarily shift some agency resources away from production management and may define lower optimum levels of game species populations. In this competitive atmosphere, ecosystem management programs that produce game species at some lower optimum rather than accustomed harvest levels are likely to be challenged by consumptive interest groups.

At least 3 additional factors concerning public response need to be considered: (1) most interest groups lack an adequate knowledge base to evaluate the need for socio-ecological management of resources, (2) socio-ecological management involves quite different and often incompatible value choices for which the public is poorly prepared, and (3) the ability of the public to make rational choices is diminished by the complexity and crisis setting which accompany most issues. These factors will be less critical in those rare instances where everyone agrees with the management goals or where the credibility of the management agency is so strong that the public is willing to trust in the resource manager's evaluation.

## Knowledge Base

Behavioral scientists have well established that while information is often an essential component of decision making, it is by no means the only factor which determines the final decision or behavior of an individual. Nonetheless, it is a critical element in getting support for socio-ecological management of resources. Competing interest groups which become involved in decision making processes must be able to evaluate alternatives and understand the need for more holistic or long-term management. It will be a continuing challenge for management agencies to improve the ability of all groups to participate in present and future socio-ecological management efforts.

The challenge is increased because ecology, the basis for wildlife management, is a young science. Our scientific information is often incomplete (Gill 1985) and creates an element of uncertainty in resource decision making. This confounds the process and makes public participation even more difficult. In other situations, ecology does provide an adequate basis for dynamic management, and an informed public is needed which can evaluate and accept resource needs for socio-ecological management.

## Value Conflicts

Kellert (1976) has provided a model to identify some basic values held toward animals by the public which is useful when generalized to other ecosystem components. Some of these values (e.g., ecologic, utilitarian, moralistic) are specifically involved in many of the conflicts relating to the management choices here. Certainly a range of values are held toward a particular resource attribute by individuals, with higher priorities assigned to some than to others. For example, one may place a strong value on the ecological importance of a wildlife species such as beaver (ecologic value) while at the same time valuing the beaver for its wildness (naturalistic value) and its usefulness in providing furs (utilitarian value). A perspective may also exist that the beaver has certain rights to exist (moralistic value). A concern for the well being of an individual beaver may reflect a humanistic value. In addition to Kellert's (1976) attitude domains, other nonmarket values are informative. Existence value is defined by resource economists as the value placed on knowing that an environmental attribute or entity exists. Combinations of these values may provide a basis for understanding varied public response to management approaches at the ecosystem level. For example, strong ecologic values (not necessarily ecological knowledge) associated with strong moralistic and/or existence values would likely foster a protectionist perspective which would oppose active utilitarian management of wilderness. Groups with strong ecologic and relatively low utilitarian values may prefer diversity of species and community types over management aimed at producing large populations of relatively few species.

An important aspect of this valuing dimension is the extent to which the public understands the values and consequences involved, and the extent to which individuals and groups have clearly decided priorities. For example, to what extent have hunter groups considered the economic values involved in agricultural crop damage caused by maintaining large harvestable populations of wildlife species? To what extent have protectionists, who oppose fire management techniques on the basis of (perceived) animal suffering, considered the ecological value of ecosystems that are being maintained? It is in this process of clarifying values and evaluating consequences that the use of a comprehensive and accurate information base becomes essential.

An equally important aspect of the public value dimension is the extent to which the management agency understands not only the values being expressed by the public, but also the extent to which the value clarification processes have occurred. A clear understanding of the values and priorities

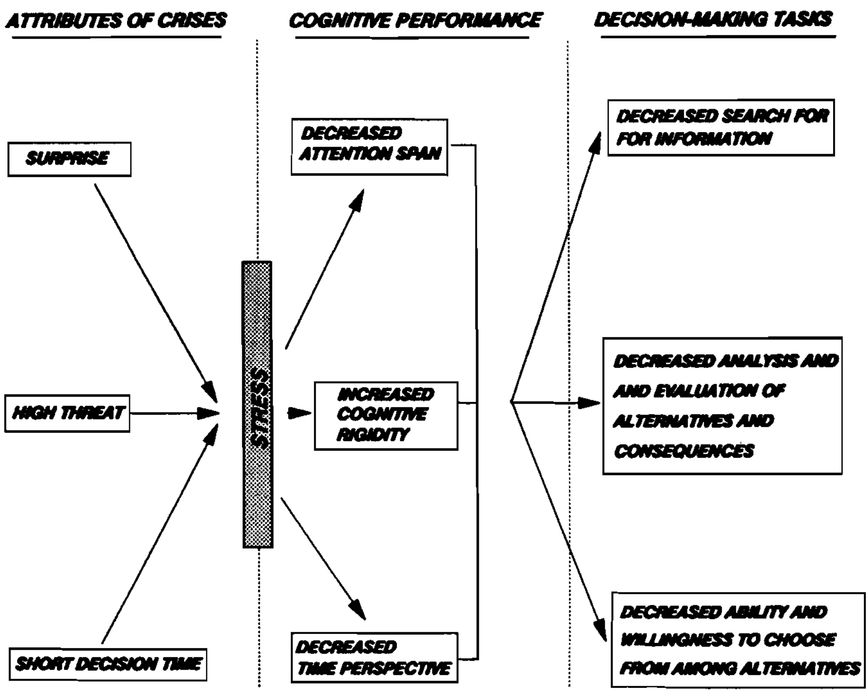


*Fig. 1.* General influence of stress on problem-solving skills in complex situations. (Adapted from Holsti 1978:42)

involved is needed by all interest groups, including the management agency facilitating the decision making process (Peyton and Decker 1987).

## Stress and Issue Resolution

One of the undeniable characteristics of our society is the rapid change which is occurring in many dimensions. Rapid change is often accompanied by increasing conflicts and the need to resolve issues at crisis stages rather than at earlier less stressful stages in an issue's development. The very nature and consequences of these issues makes it difficult for agencies to promote long-term, complex, and holistic management goals.

Individuals experience stress when they are surprised by a situation which they perceive to be threatening and for which they feel they have little time to respond (Holsti 1978). Stress interferes with the very types of behaviors which are necessary to evaluate long-term, complex, and holistic management problems (Fig. 1). Stress causes individuals to concentrate on and protect short-term values and benefits. Stress lowers tolerance for ambiguity and incompletely defined risk and inhibits information-seeking behaviors. These and other results of stress would make it difficult for fish and wildlife agencies to redirect public support for short-term production goals towards ecosystem management goals.

Careful planning and public involvement can help alleviate this problem. However, public involvement programs are not well developed in many state fish and wildlife agencies, and generally tend to be reactive rather than proactive. This encourages management by crisis.

> Seldom are the long-term values of the public at large sought or recognized explicitly at ad hoc so called "public" fishery meetings during times of crisis; instead, actions center on appeasing the demands of vociferous, on-site user groups . . . managers may take an intellectual and political shortcut, spare themselves some verbal abuse from special interests, and assume that more fish, however produced, in the short run is automatically better management—regardless of long-term impacts on stocks or ecosystems, loss of future scientific information, or loss of subsequent management options. (Scarnecchia 1988:2045).

Proactive involvement will be required in most issues to bring about shifts in focus from production to socio-ecological management.

Another limiting factor in increasing socio-ecological management is related to the complexity of the task imposed by its long-term and holistic nature. It is difficult to conceive of all the ecological and social relationships that are involved in a given situation and over time. Weick (1984:40) has reviewed public response to complex social problems and suggests that: "The massive scale on which social problems are conceived often precludes innovative action because the limits of bounded rationality are exceeded . . . People often define social problems in ways that overwhelm their ability to do anything about them." The very nature of socio-ecological management imposes formidable intellectual challenges for the interested public. Not only are the ecosystems and potential relationships incompletely understood, but the problems must be conceptualized over a long time frame. Public responses will range from an avoidance of the problems that seem overwhelming, to a focus on narrow, more comprehensible management goals (e.g., production). Either of these could defeat attempts at socio-ecological management. This places the burden on the agency to administer the process so that continuity and the superordinate management goal(s) do not get lost.

## Professional Managers

Managing resources at the long-term ecosystem level can be an extremely demanding task which requires expertise of many kinds. Goulden (1989) has proposed that future managers need to be skilled in trend forecasting, consensus building, environmental mediation, risk assessments, conflict resolution, understanding sociological interactions, and in creatively applying new technology. As consideration is given to expanding socio-ecological management, agencies should assess their professional resources in at least 3 pertinent areas: (1) expertise in socio-ecological management, (2) attitudes towards broad, socio-ecological management, and (3) skills in communication and social problem solving.

## Expertise in Socio-ecological Management

Gill (1985) and others (e.g., MacNab 1983, McCabe 1985) have discussed the inadequacy of current management science to resolve the complex problems of ecosystem management and have emphasized the need to renew our emphasis on research. Recently, new theories of the order and predictability of systems have challenged our traditional assumptions about managing systems (Gleick 1987). The theory of Chaos may provide new approaches to the difficult task of managing complex ecosystems. Given an incomplete scientific basis to work with and the complexity of the systems they are asked to manage, it is likely that many managers are poorly prepared to implement broad based, long-term ecological management programs. Urich et al. (1986:23) have suggested that a computerized statewide information and planning system is an essential tool to supplement the knowledge base of biologists who "typically maintain expertise in habitat needs of only a few species." Matulich and Adams (1987) have proposed that correctly integrating the socio-economics dimension into biological concerns compounds the task further and presents managers and researchers with even more sophisticated problems requiring multidisciplinary skills and coordination.

Training and experience of many fish and wildlife managers has been oriented towards production management. Even in this area of species/habitat management, fisheries and wildlife biologists working for the U.S. Forest Service felt poorly trained (Kennedy 1986). Some effort is likely needed to supplement the expertise of biologists in both human dimensions and community and ecosystem management in order to increase efforts at socio-ecological management.

## Attitudes Towards Socio-ecological Management

Given the career selection by managers, it is reasonable that most of these professionals hold strong ecological values (Peyton and Langenau 1985) and therefore support in principle the need for community and ecosystem management. However, Kennedy (1985) has argued that many managers conform to a wildlife management subculture which may change those ecological values in ways not accepted by the wildlife management profession nor by traditional support groups. These include a "... utilitarian value of (species)" and an "... impatience and mistrust of Nature's course" which foster a readiness to manipulate ecosystems to produce surpluses of game species, and which may not encourage a socio-ecological approach to management at all appropriate times. If these attitudes exist, they may further limit socio-ecological efforts, especially when held by managers and agencies with strong loyalties for the goals of interest groups which provide their funding.

### Social Problem Solving Skills

There is both an internal and external application of this important dimension. First, managers are susceptible to the limits of rational problem solving reviewed by Holsti (1978) and Weick (1984). The complexities of considering all short- and long-term impacts of management decisions on total social and ecological systems can be overwhelming. Second, managers must package these complex problems so that holistic, long-term goals are maintained, yet manageable objectives and projects can be identified for themselves and the participating public.

Socio-ecological management will also place a greater burden on managers to participate in multidisciplinary projects involving other academic fields, politics, commerce, and industry. Effective coordination and participation will require skills in social problem solving that allow managers to communicate values, knowledge, and expertise across disciplinary and institutional lines. Multidisciplinary projects are also confronted by tendencies to protect professional turf, funding, and traditional procedures. Few of us easily overcome our natural tendencies to enter effectively into such programs.

## Institutional Characteristics

A major constraint to expanding holistic, long-term management lies in the small amount of land which most state agencies have authority to manage. Agency efforts to manage statewide or regional ecosystems will depend on the cooperative relationships of other private and public landowners. This constraint makes even more important, the tasks associated with the planning and public dimension skills already discussed, since the state fish and wildlife agency will increase holistic, long-term management efforts primarily through its role as a coordinating agent.

Another constraint may be the extent to which many state wildlife managers and agency functions have become organized around species and recreational opportunities rather than ecosystem management. Altering this mode may face not only resistance from special interest groups, but from some individuals and agencies as well.

Langenau (1982) has described the processes by which fish and wildlife agencies evolved to their current relationships with the public. He suggests that the growth and activism of special fish and wildlife interest groups during the 1970's was a predictable response of these interests to competition from a variety of government and public forces. By lobbying for self-regulation, these hunter and angler groups were able to not only provide funds for management agencies, but also limited the use of those funds to their special interests (e.g., state waterfowl hunting stamps, public access stamps). While such special purpose funding made agencies independent of government and associated politics, it increased agency dependence on special interest groups and thus a stronger representation of these groups in the agency management process. With this (user-pays) funding system, the use of funds is largely limited to fish and game production management, and is often earmarked specifically for targeted game species programs. In fact, a common source of new revenues for state agencies in recent years have been special-purpose stamps (e.g., waterfowl, trout) (Wildl. Cons. Fund Am. 1987). With this system, agencies have little flexibility to redirect the use of funds to socio-ecological management plans. In effect, the fish and wildlife management agencies—and the resources managed by the agencies—have been "captured" by the consumptive special interest groups.

The tactic which worked so well for consumptive groups, is being courted by protectionist and other nonconsumptive groups. Agency concern over declining numbers of consumptive users (Hamilton 1987) makes this a good time for new groups to develop relationships with state agencies. Some agencies are encouraging methods such as nongame checkoffs and other user-pay systems as means to maintain or expand their funding base. However, this approach may not solve agencies' needs to find flexibility in applying funds since even these funds will be earmarked for special interests. Further, this could eventually increase the control these competitive groups have over the agencies. Wildlife management conflicts can be expected to intensify as new interests seek to establish their own values and controls in this system. This phenomenon will be further exacerbated by the trend of resource managers to be more sensitive to public involvement and thus, seek to identify and provide for preferences of their constituents.

Organization of agencies around special interests (e.g., furbearer, deer program, small game, big game) represents further constraint. For example, a state biologist assigned to manage deer can directly influence habitat only on certain state lands and is largely restricted to managing population through harvest regulations. Even managing habitat for this production goal requires considerable integration with other agency divisions (e.g., forestry), other state and federal agencies, and private landowners. Socio-ecological management is even more constrained by traditional agency structure.

Providing a research basis for complex socio-ecological management tasks will require support of long-term, interdisciplinary research programs. However, agency research programs often are not accepted by managers (Gill 1985). Long-term research on social and ecological systems may be seen as even less acceptable to managers. Additionally, the frequent need to manage disruptive (crisis) issues creates demands for rapid generation of data and further complicates long-term, interdisciplinary research efforts. Research programs often compete with management programs for limited funds, and researchers themselves have little flexibility in applying scarce resources to long-term interdisciplinary projects. Further, the difficulties of coordinating such projects are as limiting in a research context as they are to management activities.

## Responding to Socio-ecological Management Constraints

One response to declining numbers of traditional (consumptive) supporters, has been to increase efforts to recruit more individuals into hunting and fishing activities (Langenau 1982). A further response to increased social disapproval of these consumptive activities has been to place more emphasis on safety and ethics in hunter education programs (Decker and Purdy 1986). While these are both worthwhile efforts that should be continued, they do not reflect the paradigm shift that may be necessary to both expand socio-ecological management approaches and deal with the increasing pressures from formally excluded interest groups.

Agencies should strive to integrate the consumptive and nonconsumptive interests competing for fish, wildlife, and related natural resources. Brown and Decker (1982) have suggested a planning approach for integrating organized publics involved in wildlife issues. Planning methods such as this which identify public value positions, communication networks, and public and agency perceptions of each other, can also contribute to a proactive, rather than reactive issue management mode.

Resource managers not only need mechanisms for determining long range values of society, but also require a science for predicting cause and effects of associated management plans. Research must create a knowledge base for long-term, holistic decision making. The decision to divert some resources from the current emphasis on short-term, problem solving needs of managers cannot be made autonomously by researchers serving an agency if research programs are to be accepted and supported. The request for more long-term research on ecosystems must come from managers and the agency itself. This may be a "chicken or egg" situation, but it is a critical one which must be addressed.

Reorganization of agencies along socio-ecological rather than species or recreation lines may not be possible nor desirable given the current legal and funding constraints. However, the needs may be met by finding mechanisms which insure that management (and research) is better integrated throughout the agency. One such alternative, interdisciplinary management, will require agency encouragement of efforts by individuals, divisions, or other units to cooperatively research or manage systems. Such encouragement may take the form of inservice training programs, increased opportunity for interdisciplinary communication networks, and support of long-term interdisciplinary projects. Agencies must also strengthen formal working relationships with other state and federal agencies. Other governmental institutions such as a department of transportation or county drain commission can place severe restriction on socio-ecological management plans unless they are integrated into the process.

Comprehensive planning efforts can alleviate some of the constraints of socio-ecological management. Integration occurs in comprehensive planning along vertical lines within the agency (Fig. 2). Increased socio-ecological management may require additional and more explicit horizontal integration at the planning stage. The complexities involved will probably require that agencies develop computer assisted, statewide planning processes.

Inherent in any agency response is the need for inservice training of professionals. The need for additional information and skills in ecological analysis and management, communication, interdisciplinary management team activities, planning, and public involvement methods cannot be underestimated. University curricula should also be evaluated to identify needs for revision of preservice training.

One response already initiated by resource agencies is to find new funding mechanisms. In doing so, agencies should strive to broaden their constituents and funding basis in such a way that flexibility is provided to attend to resource management needs that cut across interest lines. One such method being explored in some states is the creation of private foundations which generate funds outside the agency, but support projects conceived

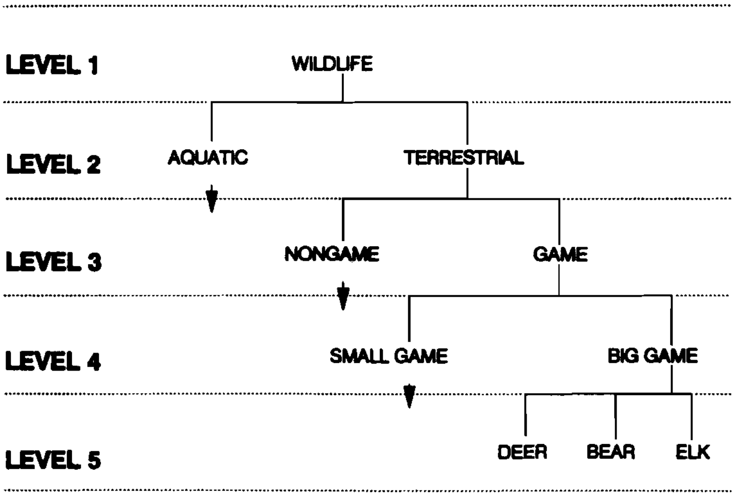


*Fig.* 2. Species management hierarchy. (From Crowe 1983:14)

and initiated by the agency. Another trend has been a growth of general fund support (in all states combined) from 9.4% of agency revenue in 1979 to 14.2% in 1986 (Wildl. Cons. Fund Am. 1987).

It is increasingly popular to refer to "marketing" as a means of broadening the user groups (market) for fish and wildlife resources. Marketing is a strategy which includes collecting data on existing and potential user groups, managing resources to make them more appealing to previously untapped markets, and increasing use by traditional markets. The concept has appeal—and offers some assistance—for management agencies caught in a budget crunch and in the related political battles for support. However, commitment to a marketing approach must be placed in the correct context or it will simply aggravate an already difficult problem. Socio-ecological management could suffer even more if agencies become "captured" by more special interest groups demanding production management. However, if marketing strategies are used to create a demand for socio-ecological management among existing and new markets, the broader goals and missions of resource management can be enhanced.

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# 11 Wildlife Management and Public Sentiment

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# Wildlife Management and Public Sentiment

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*Abstract:* Wildlife management is a complex process involving biological and social factors. Perhaps the most recent element to be considered in management is public sentiment. But managers face a confusing array of attitudes toward wildlife, from indifference to zealotry. A wealth of social research exists to help managers understand public sentiment. Such information is particularly helpful as changes occur in the wildlife knowledge base and in American culture. Managers may avoid much frustration by adopting a realistic perspective of the public's role in fish and wildlife programs. First, resource professionals can dismiss the idea that they should manage for the desires of the "general public." Instead, they can divide the citizenry into specific clienteles with identifiable expectations for wildlife management, much as market researchers do in the private sector to assist in product development and promotion. Second, wildlife professionals should welcome contemporary America's fascination with wildlife as an opportunity to broaden the base of support for wildlife conservation, though not all expressions of public sentiment can be accommodated in wildlife programs.

Fish and wildlife agencies in North America manage living resources. The task is complex, involving biological information, land, fiscal constraints, agency mandates, legislation, political climate, and public sentiment. Not always, however, have all of these been considered in wildlife decisions, particularly public sentiment.

Public interest in wildlife runs from indifference to zealotry. This confusing array of attitudes explains the mixed history of public participation in wildlife management—a history in which citizens have appeared as obstructionists as well as innovators. Social changes in contemporary America are affecting our beliefs, values, and culture, promising to make future attempts to include public sentiment in wildlife management even more challenging.

This review of wildlife management and public involvement first looks at the climate of early interactions between wildlife managers and the public. Then, present and future opportunities for public involvement in wildlife management are considered.

## The Past

Among the older annals of wildlife management are the *Transactions of the North American Wildlife and Natural Resources Conference.* The emerging role of public sentiment in wildlife management can be traced in the Transactions and supplemented by supporting references.

One view of the public's place in wildlife management during the 1930's–1940's was stated in a session at the 1948 North American Conference, "An uninformed public: the management bottleneck" (Hudoba 1948). Introductory remarks by the session vice-chairman amended the title to describe the public as the "conservation bottleneck." Citizens were portrayed as lacking the knowledge to contribute to the visionary conservation efforts of "... scientists, technicians, managers, [and] sportsmen ..." (Hudoba 1948:141–142).

This early reservation expressed by wildlife professionals was understandable. The citizenry was at least partially to blame for the resource abuses that had pushed some wildlife species to the edge of extinction and beyond (Trefethan 1975). Only by educating the citizenry did professionals of that era think that public sentiment could contribute to the efforts of the conservation vanguard. Or, as inscribed around the dome of the Missouri Capitol building in 1917, "As the structure of a government gives force to public opinion, it is essential that public opinion be enlightened accordingly."

The wildlife profession's desire to better educate the public was exemplified by annual inclusion of a "conservation education" session at the North American Conference starting in 1951. Through the 1950's, these sessions highlighted success stories in conservation education, and emphasized that an educated public eventually would become involved and forceful in conservation.

The 1961 opening session of the North American Conference was "People pose the problem" (Romney 1961). The focus was unchecked growth in world population. A second and more subdued theme dealt with the industrial, educational, and economic growth of the 1950's that was producing an affluent America. The public of that decade perhaps was more knowledgeable about conservation than previous generations. But implicit in the tone of the Transactions was a new fear among wildlife professionals that Americans were pursuing prosperity without consideration of the costs to the country's natural resources, including wildlife.

Paradoxically, the social and economic conditions of the 1950's that increased consumerism spawned cultural changes that would forever alter the role of the American citizenry in wildlife management. Greater personal income, more leisure time, and greater mobility in the 1950's resulted in an unprecedented rush by Americans to the outdoors (Outdoor Recreation Resour. Rev. Comm. 1962). The first National Survey of Fishing and Hunting in 1955 (U. S. Dep. Int. 1956) gave startling empirical glimpses of the magnitude of wildlife recreation in America. Many Americans were learning about the outdoors firsthand, and on the threshold of insisting that their sentiments about wildlife be incorporated into management.

Daniel H. Janzen, director of the Fish and Wildlife Service in 1961, made a prophetic statement in the foreword of the 1960 National Survey of Fishing and Hunting. He observed that the data were, "... essential to State and Federal agencies which must manage fish and wildlife populations so as to meet the requirements of our ever-growing human population for sport fishing and hunting" (U. S. Dep. Int. 1961:II). The major implication was subtle, but profound. For decades, biologists had sought to restore wildlife. Citizens, principally sportsmen, did indeed benefit from these efforts. But it seems clear from the way many biologists described their work in Transactions of the 1930's–1950's that they considered wild animals the ultimate beneficiaries of conservation. Biologists displayed a laudable mission zeal, but most were individualists, content to be isolated from public influence. Janzen redirected this focus when he explicitly stated that wild animals were to be managed for the sake of people. His was a clear statement that citizens were the ultimate recipients of fish and wildlife benefits, and in the final analysis, the group whose voice needed expression in management activities.

And starting in the 1960's, the voices of citizen advocates for wildlife and conservation were heard in uncustomary numbers and ways. The number of national wildlife or animal interest groups in the United States had grown slowly from 9 at the turn of the century to 41 in 1950. But in the 1950's, 32 new organizations were established, and in the 1960's, 41 new wildlife or animal welfare groups emerged (Witter 1977). A paper at the 1965 North American Conference was entitled, "Broadening the base of citizen support for conservation" (Gregg 1965). The author listed major conservation achievements in the short period between 1960–65. He concluded, "It's difficult to grasp how quickly the conservation outlook has changed ... in the first half of the 1960's" (Gregg 1965:433). Perhaps the greatest change was the commonness of citizen involvement in conservation controversies compared to previous decades.

This age of enlightenment in citizen participation brought new challenges to wildlife management. Some citizen groups resisted changes proposed by wildlife managers, and others wanted to impose change. Exemplary of resistent publics were the sportsmen's clubs vehemently opposed to implementing a doe season in New Jersey in the late-1950's, fearful that the state's population of white-tailed deer (*Odocoileus virginianus*) was not capable of sustaining doe harvest (Tillett 1963). Sportsmen had a high stake in deer recovery programs that spanned decades. Biologists that had welcomed the financial and political support of sportsmen over the years found that these long-time friends could be obstructionists, slow to accept changing opportunities (Gwin and Lionberger 1981).

Exemplary of citizens wanting to impose change on wildlife management were anti-hunters, a group recognized as a potent force starting in the late 1960's and early 1970's. A paper at the 1973 North American Conference (Klein 1973) critiqued the anti-hunting movement, implying that such sentiment would not simply disappear through better education of the public. Wildlife professionals may have yearned to return to a simpler time when their expertise was unquestioned and their customers did not talk back, but the anti-hunting movement would be just one of many public sentiments with which managers would be forced to deal in the future.

The Transactions of the 1970's–1980's often devoted entire sessions to "human dimensions" in wildlife: urbanites' values for wildlife; interests of nonconsumptive users; motivations for hunting and fishing; anti-hunting, anti-trapping, and anti-management movements; animal welfare and animal rights movements; motives of wildlife rehabilitators; outdoor ethics; public support for endangered species; landowner attitudes; building political coalitions; fee hunting and fishing; whale-watching; and the list goes on. Public sentiment had become an important variable in the complex task of wildlife conservation.

## The Present

Americans' current fascination with wildlife is evidenced by the magnitude of their outdoor participation and membership in private wildlife interest groups. Of Americans 12 years and older, 23.2% are fishermen, 8.4% are hunters, and 61.9% are nonconsumptive recreationists (U. S. Dep. Int. 1988). Proportionally, midwestern involvement exceeds national interest, with angling in the West North Central Census Region totaling 33.1%, hunting 13.9%, and nonconsumptive recreation 68.0% (U. S. Dep. Int. 1988). Gallup Poll studied 16 types of special interest groups in the United States, and found that the most popular was that devoted to "protecting animals", with 1 in 10 Americans contributing to private wildlife organizations (Gallup 1981).

Today's wildlife managers find themselves facing "life in the fishbowl"

(Tipple and Wellman 1989). As if on display and magnified, the performance and techniques of the wildlife profession are often subject to scrutiny by interested citizens. Peering out from the bowl, managers can get a distorted image of public sentiment, seeing some groups as larger than life, and others of lesser importance than is true.

One group whose stature has been misunderstood in the present rush to enhance participatory democracy in wildlife management is the "general public." Biologists attempting to broaden their clientele beyond sportsmen to include the general public have had great difficulty determining what this group wants from wildlife management. The reason is simple. Just as the "general public" can be defined as "everyone", so too can "general public" be defined as "no one in particular." Managing wildlife for everyone is a noble idea and has rhetorical appeal, but the image of managing wildlife for no one in particular crystallizes the impossibility of managing for the general public.

Presently, 2 mutually important challenges face wildlife managers seeking to understand and capitalize on public sentiment. The first is to divide the general public into specific clienteles with identifiable expectations for wildlife management, much as market researchers do in the private sector to assist in product development and promotion. A wealth of social research has been conducted over the last 2 decades to help managers clarify public sentiment and segment the market for fish and wildlife recreation (Manfredo 1989). Usually, these studies do not provide answers to ways that wildlife managers can broaden the appeal of their services. Rather, clues are discovered about public expectations for wildlife management (Witter and Sheriff 1983, 1987).

Second, having compiled clues about public sentiment for wildlife, professionals can weave many of these public desires into comprehensive plans, coalescing the political and financial support of diverse clienteles. By providing something for almost everyone, wildlife professionals will increase the number of stakeholders in fish and wildlife conservation (Roberts and King 1989).

Increasing the number of stakeholders does not imply that public sentiment should dictate how wildlife programs are accomplished (Shaw 1980). Professionals trained in biology and wildlife techniques are best able to determine strategies for specific management objectives. But the essence of program development is the assignment of priorities, which should include weighing public sentiment for wildlife programs.

One of the most innovative uses of public sentiment to increase the number of stakeholders in contemporary wildlife conservation is that of the

1976 citizen referendum in Missouri (Brohn 1977). Through the early years of the 1970's, a strategic plan called "Design for Conservation" was written by the Missouri Department of Conservation, and included objectives for increasing recreational lands, nongame programs, services to urbanites, conservation education, assistance to landowners, as well as offering additional services appealing to sportsmen. The plan contained at least a few elements appealing to each of many different publics, including fishermen, hunters, bird-watchers, college students, hikers, urban dwellers, ruralists, educators, campers, and others. The funding for the plan was to be a 0.125% sales tax that had to be approved by the citizenry. The issue carried in the November election, 1976. The tax has since generated nearly $500 million for enhanced programs of fish, forest, and wildlife management (A. J. Brand, Mo. Dep. of Conserv., unpubl. data).

Precipitating change in wildlife management is not without some risk. Innovation is spurred by strong opinion, and opinions often diverge, with potential for conflict (Morgan 1989). This is particularly so in issues of wildlife conservation that involve an array of public expectations. A lack of agreement among resource professionals about certain conservation practices further complicates matters. Management of old growth forests, clear-cutting, waterfowl harvest regulations, minerals development, grazing, furbearer management, commercialization of wildlife, and animal welfare are but a few topics that evoke divergent opinions in the profession and the public. But innovation demands risk taking. A dying organization is characterized as one in which new ideas are "endangered species" (Morgan 1989). Just as biologists of the 1950's took risks in initiating harvests following decades of restoration and protection of wildlife, so too can contemporary managers take risks in broadening the base of stakeholders in wildlife management.

## The Future

American culture is changing. Some of these changes are profound and undoubtedly will affect wildlife management and the role of public sentiment in conservation. We can speculate about the effects of cultural changes on public values for wildlife by asking, "What are Americans learning, what are they sharing, and how much does their behavior pervade society"?

Four cultural factors and their possible effects on hunting are discussed: urbanization, recreation, family, and affluence. These cultural vignettes emphasize the importance of broadening the base of wildlife management beyond hunters.

## Urbanization

The number of Americans residing in metropolitan areas has grown from 56.1% in 1950 to 76.6% in 1986 (U. S. Census Bur. 1987). Most Americans share a lifestyle in which the urban/suburban complex offers housing, employment, services, and recreation—practically every need within the metro area and surrounding suburbs.

Associated with the urban lifestyle, however, is isolation from sources of natural or biological production. Urbanites are growing increasingly dependent on a remote group of ruralists for food and housing, and more and more isolated from the biological bases of animal and plant husbandry. Curiously, they appear to be growing unaware that they are the ultimate drivers and consumers in the food and fiber production cycle. And in the most curious twist, some of these consumers are criticizing husbandry methods, while enjoying the products.

At risk for wildlife management is that an increasingly urbanized population will see no need or rationale for harvest of wildlife. In their minds, wildlife simply "exists", making the production and removal of animal surpluses unnecessary and undesirable. With such reasoning, hunting becomes a vestige of early American culture—perhaps an anachronism.

## Recreation

Americans find enjoyment in a wide range of recreational pursuits. In a recent Gallup Poll on participation in 50 selected sports, hunting ranked fifteenth, just behind volleyball. Hunting did not place in the top 5 recreational pursuits of men (Gallup 1989), though practically all hunters are male (U. S. Dep. Int. 1988). Hunting participation edged downward among Americans 12 years and older, from 10.0% in 1955 to 8.4% in 1985 (U. S. Dep. Int. 1988). Even in the midwest, this downward trend is noticeable, from 16.7% involvement in the West North Central Census Region in 1955, to 13.9% in 1985 (U. S. Dep. Int. 1988). The nation is experiencing a growing anxiety over firearms, crime, and random killings (Baker 1989), and the public finds the violent imagery of hunting disturbing (Kellert 1980). The virtual lack of any syndicated television programming devoted to hunting exemplifies the idea that hunting generally is not a spectator sport.

In contrast, the Gallup Poll found fishing ranked second among 50 sports, was the most popular activity of men, and the fifth-most popular sport among women (Gallup 1989). Fishing participation among Americans 12 and older grew from 17.6% of the population in 1955 to 23.2% in 1985 (U. S. Dep. Int. 1988). In the West North Central Census Region, angling participation increased from 25.5% in 1955 to 33.1% in 1985 (U. S. Dep. Int. 1988). An increase in television programs on angling also reveals the popularity and market potential of this activity (Pulliam 1987).

The implication of these public preferences is not that wildlife biologists should desert hunting as a management strategy. Hunters, in fact, are among the most committed outdoor enthusiasts, evidenced by the substantial number of participants calling hunting their "absolute favorite" outdoor pursuit (U. S. Dept. Int. 1986). Hunter expenditures totaling $10.1 billion in 1985 further evidence participant commitment (U. S. Dep. Int. 1988).

Americans' diverse recreational preferences should produce a heightened sensitivity in the wildlife profession that hunting must be recognized as but one of many viable uses of wildlife, rather than the primary use. The fishing data provide clues to ways that the appeal of hunting might be broadened. If hunting is ever to capture an audience beyond its current fraternity, then managers must be on the alert for any opportunity to accentuate the positive social benefits and eliminate or reduce negative impressions.

## Family

Social research has identified the significance of the father in communicating hunting values to children (Applegate and Otto 1982). In 1970, 10.8% of American children resided in households in which the mother was the only parent present (U. S. Census Bur. 1987). By 1986, this number had nearly doubled, to 21.0%. As more American households are headed by mothers, the implication for transmission of the hunting tradition is obvious.

## Affluence

The gross national product of the United States dwarfs that of any nation. Per capita expenditures on health, education, defense, and communication, plus low inflation and high purchasing power of the U. S. dollar, identify the United States as offering the highest standard of living worldwide (U. S. Census Bur. 1987).

I speculate that the health and wealth of the U. S. has produced several recent generations of Americans, especially in the middle to upper income categories, so removed from the struggles of daily existence (and so isolated from the sources of food and fiber production), that they have developed or accepted an egalitarian standard that extends to animals. The philosophy might be stated, "We—humans and other animals—are biologically equal, and all deserving of an increasingly high quality of life".

Support for this speculation is the dramatic increase in the number of animal rights organizations in the United States, many of which appeared since 1980, and many located in urban centers of the east and west coasts (T. Bujakowski, Fur Retailers Inf. Counc., unpubl. data). More than 200 animal rights groups exist, some claiming paid memberships in the hundreds of thousands and considerable financial assets. The animal rights movement appears more extreme and militant than the long-tenured concern for animal welfare in the United States. Animal welfare activists have been organized in this nation since at least 1850 (Witter 1977), providing critical but measured commentary on wildlife issues (Schmidt 1989), and leadership in domestic animal care and shelters.

One animal rights leader stated her opinion of animals in laboratory research: "A rat is a pig is a dog is a boy. They're all mammals. . . . Even painless research [on animals] is fascism, supremacism . . ." (McCabe 1986:115). This same activist stated: "We believe that animals don't belong to human beings. The world is not just a supermarket for us" (Newman 1989:135). This "new age" or Utopian thinking common among animal rightists has similarities with Eastern religions portraying all life forms as equal and evolving toward physical and spiritual perfection (Ross 1952). Indeed, this philosophy appears tantamount to a quasi-religious stance in opposition to the traditional Western concept of resource stewardship—wise use of living resources by Man (Whisker 1983).

The extent to which the animal rights movement threatens wildlife management and harvest concepts is subject to debate. One viewpoint is that wildlife professionals should not overreact to the movement because of its limited appeal to most Americans (Kellert 1989). Another stance is that of the International Association of Fish and Wildlife Agencies, which recently asked the Organization of Wildlife Planners to assist them in preparing a strategic plan for dealing with the animal rights issue (H. Libby, Org. of Wildl. Planners, 1989, pers. commun.). Whatever the threat, wildlife agencies likely will never turn these animal rightists into stakeholders in contemporary wildlife conservation. Most forms of public sentiment can be accommodated to some extent in agency programs, but not all.

## Concluding Remarks

Public sentiment can be among the most innovative forces in wildlife conservation, and among the most obstructive and threatening. This review of the past, present, and future roles of public sentiment in wildlife issues has explored a range of influences accompanying citizen involvement in wildlife conservation.

Managing our nation's natural resources is a difficult task that will not grow easier. But by learning from the past, taking action in the present, and attempting to anticipate and influence the future, perhaps wildlife managers will be able to use public sentiment in a powerfully constructive fashion to the benefit of our country's wildlife.

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# 12 Management of Dynamic Ecosystems: Concluding Remarks

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# Management of Dynamic Ecosystems: Concluding Remarks

Robert C. Szaro

*Abstract:* Change, and its implications for land management, has been the dominant theme of this proceeding. Ecosystems by their very nature are in a constant state of flux, always shifting and changing from one condition to the next, and a true steady state probably never exists. Reproductive strategies and other ecological characteristics of many ecosystems are strikingly adjusted to disturbance regimes resulting from catastrophes such as fire, insect outbreaks, and flooding. Change per se is not necessarily something to be avoided. It ultimately may be the underlying motivating factor in management decisions. We may wish to alter vegetation structure or composition to emphasize rarer or endangered species. Old management paradigms are difficult to shed, but only new, dynamic efforts are likely to succeed in conserving the biodiversity of all our ecosystems. Ecosystem-level management is going to require new approaches in planning, monitoring, coordination, and administration. We are being challenged by shifts in public attitudes toward management of public as well as private lands for uses other than commodity production. A new paradigm is needed, one that balances all uses in the management process and looks beyond the immediate benefits. This does not mean all things must occur in all areas, but that all things must be cared for at some appropriate geographic scale. There will be trade-offs. Commodity production may decline in the short-term, but in the long-term will result in gains in sustained productivity while maintaining biodiversity with its complete range of ecological processes.

Change, and its implications for land management has been the dominant theme of this proceedings. Historically, the quest for stability and preventing change in areas where productivity was maintained by dynamic events has led to the declining quality and quantity of many of our most desired habitats (Hart, this proc.; Frederickson and Reid, this proc.). Much prior management of wildlife habitats viewed systems as being immutable, with the philosophy that all that was necessary was to put a fence around an area and it will be saved forever. However, this is simply not the case. Ecosystems by their very nature are in a constant state of flux, always shifting and changing from one condition to the next. A true steady state probably never exists (Heede 1985). This is a constant challenge to land managers for so many factors that impact ecosystem dynamics are beyond our control. Long-term shifts in climatic patterns, whether naturally occurring or caused by man-related activities, are in the news constantly. But we would be naive to assume that all change can be affected by our activities, and that all we have to do is modify those activities to produce any desired result. Paleobotanical records of the eastern United States indicate major northward range extensions of many southern tree species and the more northward movement of others (Davis 1981, 1983; Stearns, this proc.).

Often we are asked to manage a site as if it were an island unto itself, and ignore the surrounding land use patterns and their potential impacts on the systems that we are trying to manage. We must move from the idea of "content" management and view all management activities from a "context" perspective. By this I mean it is important that any management decisions about a given area also be coordinated with those of the surrounding areas.

The dynamics of many communities present a complex set of interacting variables affected by both time and environment (Fredrickson and Reid, this proc.; Ryan, this proc.). Superimposed on the equilibrium fluctuating between the physical environment and plant species is the animal species component, which utilizes these habitats as breeding and wintering habitat, migratory corridors, and areas for brief stopovers. Faced with large species complexes and the patchy nature of many systems, land managers frequently look for indicators of habitat health and condition. Mobile species such as birds can have broad elevational and habitat ranges while more sedentary species such as small mammals, reptiles, and amphibians are much more limited. Further complicating any management plans are the intricacies of land ownership patterns, as many of these same areas are prime sites for human occupancy and use.

## The Role of Disturbance in Ecosystem Dynamics

Disturbance plays an integral role in establishment and development of ecosystems (Haney and Apefelbaum, this proc.; Niemi and Probst, this proc.). It occurs frequently enough in many systems to allow the coexistence of species with varying degrees of competitive ability (Pickett 1980). Typical disturbances, both naturally occurring and man-related, include flooding, inundation, scouring, drought, grazing, recreation, timber harvest, dam construction, fire, outbreaks of pathogens, and revegetation. At any given point in time, it might appear that an ecosystem is in balance. But these periods of standstill in the disturbance process, called dynamic equilibrium, actually alternate with periods of change (Heede 1985). Changes resulting from periodic, abrupt, and/or catastrophic environmental factors, lead to displacement, replacement, and succession with species composition being a function of a disturbance regime (White 1979).

Frequent disruption of the community and creation of open sites often results in species mixtures that are fleeting in time and frequently do not repeat in space (White 1979). Succession is a diverse process, and is based on climatic conditions, invasion, initial floristic composition, life span, tolerance, and levels of disturbance differing in frequency, predictability, and magnitude (Pickett 1980; Stearns, this proc.). The lack of continued recruitment of important canopy species indicates that over time, as existing adult trees age and die, these systems can experience large structural and floristic shifts. This is true of many systems including riparian ecosystems, which often are characterized by being remarkably distinct and highly integrated intermittent pockets within other communities, and in midwest oak savannas where upon exclusion of fire, a younger mesic understory occurs and oak regeneration ceases (Haney and Apfelbaum, this proc.).

Reproductive strategies and other ecological characteristics of many ecosystems are strikingly adjusted to disturbance regimes resulting from catastrophes such as fire, insect outbreaks, and flooding (White 1979, Runkle 1982). Niemi and Probst (this proc.) stressed that fire creates a mosaic of burned and unburned patches with the resulting spatial differences between these patches greatly affecting landscape fragmentation patterns and the responses of wildlife species. Oak savannas are but one example of an unstable community that has evolved along the prairie-forest border where periodic fire maintains its structure and composition (Haney and Apfelbaum, this proc.). Ryan (this proc.) also emphasized the important role of fire as well as herbivory in the development of midwestern prairies ecosystems. In riparian ecosystems, pulsed flows coupled with their highly linear nature across an elevational gradient is the driving ecological force within floodplains (Knopf and Scott, this proc.). Shifting patterns of vegetation, in which species of varying colonizing ability, and tolerance to flooding and shade locate along disturbance-created gradients, result from stream migration, erosion, and deposition (White 1979).

Change per se is not necessarily something to be avoided. It ultimately may be the underlying motivating factor in management decisions. We may wish to alter vegetation structure or composition to emphasize rarer or endangered species. Knopf and Scott (this proc.) showed how changes in hydrologic flows along the Platte River drainage provided local habitats that resulted in greater wildlife diversities than occurred historically in the headwaters of this system or currently occur elsewhere. In fact, it is probable that almost 90% of the contemporary riparian avifauna on the western Great Plains has arrived since the turn of the century (Knopf 1986).

## Future Directions in Ecosystem Management

Usually, land managers are called upon to evaluate the health of a biological system by assessing its' degradation from any of a variety of man-caused impacts (Karr 1987). Documenting the relationships between vertebrates and physical or biotic features of their habitat is important in preserving adequate numbers of individuals or species (Rotenberry 1985). Projections of future changes must distinguish between succession towards native vs. altered ecosystems (Fredrickson and Reid, this proc.; Knopf and Scott, this proc.). Determining these relationships and the potential effects of changing or modifying important habitat parameters are the key to our understanding and assessment of proposed management actions. If used properly, biological data can effectively assist the land manager in assessing potential impacts of proposed habitat management activities and in identifying management opportunities for wildlife species (Verner and Boss 1980). Yet, much ecological work has been plagued by oversimplification. Care should be exercised to take advantage of all available floristic information in order to better understand and manage ecological systems (Szaro 1989, 1990). Even if we sometimes make the wrong choices, it is better to try than to simply throw up our hands and say we don't have the data. Unfortunately, our ability to monitor trends in the abundance of animals, in response to management practices, is short of the technical development needed to do the job properly and efficiently (Verner 1986). The establishment of consistent, repeatable relationships between an animal and components of its habitat permits the prediction of species abundance as a function of those components (Rotenberry 1985). Analysis should be based on such things as interspersion of habitat types, the presence or absence of special habitats, specific requirements of species for water, space, and cover, and a host of other factors beyond broad habitat needs that enter into determining habitat suitability for a particular species (Verner and Boss 1980).

Future conservation of not only the Platte River drainage but of all ecosystem management will be confounded by the potentially large number of political authorities that conduct land management practices on watershed, basin, or even landscape scales (Knopf and Scott, this proc.). Management of larger parcels for permanent and temporary openings has the potential to reduce edge impacts and allow for the regeneration of larger stands of mature forest which can benefit area-sensitive species (Niemi and Probst, this proc.). Haufler (this proc.) expressed his concern for forest "interior" species and that many questions still remained unanswered, particularly what qualifies as a large block of forest. Ryan (this proc.) suggested that for prairie ecosystems 640 acres would qualify as a large block. The juxtaposition of habitat patches within a landscape context and its importance to the maintenance of wildlife diversity is essential, but only beginning to be appreciated (Crow 1988). Unfortunately, many management practices used today ignore the natural dynamics of ecosystems, and the corresponding influence that ecosystem dynamics has on wildlife populations (Haufler, this proc.). Managers need to be open-minded about the use of a suite of disturbance-creating tools to manipulate flora and fauna, particularly in systems that have evolved under a disturbance regime (Ryan, this proc.).

Old management paradigms are difficult to shed, but only new, dynamic efforts are likely to succeed in conserving the biodiversity of midwestern prairies and other systems (Ryan, this proc.). There is an urgent need to manage on a landscape scale (Haufler, this proc.; Knopf and Scott, this proc.; Niemi and Probst, this proc.). Ecosystem-level management of ecological systems is going to require new approaches in planning, monitoring, coordination, and administration (Ryan, this proc.). We are being challenged by shifts in public attitudes towards management of public as well as private lands for uses other than commodity production growth forests and other special communities, wildlife and fisheries habitat, wilderness, air and water quality, and a variety of nonconsumptive recreational uses. A new paradigm is needed, one that balances all uses in the management process and looks beyond immediate benefits (Peyton, this proc.).

Today, more than ever, we need to be concerned about maintaining global biodiversity and what better place to start than here in the United States. Conserving biodiversity involves restoring, protecting, conserving, or enhancing the variety of life, so that the abundances and distributions of species and communities provide for continued existence and normal ecological functioning, including adaptation and extinction. This does not mean all things must occur in all areas, but that all things must be cared for at some appropriate geographic scale. Stearns (this proc.) underscored the fact that forest management is oftentimes directed toward maintaining high productivity of fiber producing species and thus often precludes continued natural succession. The result is reduced species richness and diversity accompanied by increased fragmentation. The greatest challenge is not developing strategies on how to set aside as much area as possible in preserves but how to effectively manage areas that provide a variety of uses. In order to accomplish this, we need to better understand the functions and processes of populations and ecosystems, and to make prudent decisions on how to maintain and enhance their productivity for all values and uses. Dynamic ecosystem management, using an integrative ecosystem approach to land management on a broader landscape scale, will play an important role in our efforts.

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