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Proceedings IV: Issues and Technology in the Management of Impacted Wildlife

February 6-8, 1989
Glenwood Springs, Colorado

1989 Steering Committee

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Issues and Technology in the Management of Impacted Wildlife

Proceedings of a National Symposium
Glenwood Springs, Colorado
February 6–8, 1989

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Library of Congress Catalogue Number 89-051028
ISBN 0-916055-04-3

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FOREWORD

The Fourth Biennial Wildlife Symposium was held at the historic Hotel Colorado in Glenwood Springs, Colorado, from February 6-8, 1989. In spite of some very cold weather, the attendees came from many parts of the United States and Canada. As in previous years, they represented government, industry, academic and professional organizations, including nonprofits.

Thorne Ecological Institute, with the co-sponsorship of several members of industry and other fine groups, is most pleased to present these Symposia every two years. They draw together biologists, wildlife managers and administrators who have had much firsthand experience with mitigation of impacts due to energy, mining and other economic development. Managers and planners always contribute their excellent perspectives to the overall process.

One of the exciting additions to this year's Symposium was the Panel on Fire Management and Wildlife, with a great deal of information and discussion on the 1988 fires in Yellowstone National Park. A video of this panel may be obtained by writing to Thorne Ecological Institute. We also have reprints of the text as published in these Proceedings.

There are many people and organizations who contributed their time and resources to the planning and execution of Symposium IV. The Steering Committee and Editors spent many hours and did a wonderful job, with dedication and sincere interest. They deserve special thanks. In the Thorne office, Susan Foster, Deborah Long and Linda Whitham, whom many of you met at the Symposium, attended to countless details. Rush Services of Boulder, CO, did their usual great job preparing camera-ready pages for printing. Continental Graphics of Broomfield, CO, did the excellent publishing of the Proceedings. Once again, my friend Scott Morrison did the illustration for the cover, a pen and ink of a bighorn ram.

The Symposium was a great success, as it has been in the past. The Trustees of Thorne Ecological Institute and the members of the Steering Committee are honored to present this book and hope that it will be of value to our many friends and others in the fields of wildlife management, ecology and biology. We continue to learn and, thanks to your comments and criticisms, hope to make further improvements in the future.

Thank you for your interest and good efforts.

Dr. Oakleigh Thorne, II
President
Thorne Ecological Institute

SESSION I:

TRENDS AND NEW DIRECTIONS

CONSERVATION OF BIOLOGICAL DIVERSITY IN THE WEST

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Abstract: Loss of biological diversity is receiving much attention in the United States and other countries. New legislation has been introduced in the United States to encourage conservation of biological diversity, and new initiatives and programs are being developed. Conservation of biological diversity is not a new program or movement but rather a unification of many apparently unrelated efforts. These include not only traditional threatened and endangered wildlife programs, but also programs for land rehabilitation, mitigation of development, wetlands and riparian conservation, urban ecology, and many others. Conservation of biological diversity thus represents an evolutionary broadening of the conservation movement from concern with a few rare (mostly vertebrate) species or habitats to concern for all species and all habitats and the processes that support them. Increased attention to conservation of biological diversity may help to strengthen the conservation movement by focusing attention on the common goal of sustainable biological systems, which are the foundation for human prosperity. The western United States offers a unique opportunity to develop an exemplary program for conservation of biological diversity for three reasons: (1) the relatively recent (less than 200 years) population of the West has resulted in low loss of biological diversity to date; (2) a high percentage of the land base is still in public ownership; and (3) there is arguably a higher awareness of the importance of biological diversity in the West compared to other parts of the world or country. However, there are also major impediments to such a program including the many commercial pressures in the West, the weak position of the West in national politics, and the traditional laissez-faire attitude toward land-use controls. Conservation of biological diversity will also require some new and different ways of conducting business for those in the conservation field. In particular, it will require strategic planning at the biome or regional level and a degree of interagency/public cooperation far exceeding the current norm.

INTRODUCTION

"Biological diversity" or "biodiversity" is rapidly becoming a household word and a major cause for citizen and scientist concern. In this paper I (1) explain the current interest and activities related to conservation of biological diversity; (2) introduce current concepts of biological diversity; (3) review the evolution of concern for loss of biological diversity; (4) describe examples of current efforts in conservation of biological diversity; and (5) speculate on the future of biological diversity in the West.

Loss of biological diversity is becoming a major cause for concern in the United States and other countries. The Earth's biological diversity is being rapidly reduced at a rate without precedent (Wilson 1988); furthermore, the extent of biological diversity is neither inventoried nor measured (Wilson 1985).

This concern has led to several major efforts at the national level. The Office of Technology Assessment (OTA) has reported on a major study of "Technologies to Maintain Biological Diversity" (U.S. Congress, Office of Technology Assessment 1987). This report summarizes the general problem, both nationally and internationally, and discusses options for addressing the problems. Findings and options relating to domestic policy (Table 1) include such actions as "Establish a national biological diversity act," and "Direct National Science Foundation to establish a conservation biology program." These findings and options were used to develop legislation. In 1988 a "National Biological Diversity Conservation and Environmental Research Act" was introduced in the House of Representatives. A companion bill was introduced in the Senate last fall.

Outside of government, parallel activities have been taking place. Programs for conserving biological diversity have been largely focused on endangered species for the last 20 years. However, some individuals and groups have been pushing approaches that are focused on biotic communities, landscapes, or ecosystems. The private sector has played a major role in this effort, most notably The Nature Conservancy.

A similar enlightenment has been occurring with the academic community. Numerous conferences and symposia on topics relevant to conserving biological diversity were held in the late 1970s and 1980s, resulting in numerous books and an emerging discipline termed "conservation biology" (Temple et al. 1988). A Society for Conservation Biology was founded in 1986 and publication of its journal *Conservation Biology* was commenced in 1987 (Soule 1987).

Much of the recent concern about biological diversity is derived from concern over loss of tropical ecosystems and to a lesser extent concern over worldwide desertification. However, loss of ancient forests and desertification continues to be a problem in the United States. Thus, there is a strong sentiment among conservation biologists that this country should get its own house in order in terms of conserving biological diversity if it is to hope to provide international leadership.

WHAT IS BIOLOGICAL DIVERSITY?

Various agencies, organizations and texts have defined biodiversity for their purposes. The Office of Technology Assessment developed the following definition:

> "Biological Diversity refers to the variety and variability among living organisms and the ecological complexes in which they occur. Diversity can be defined as the number of different items and their relative frequency. Thus, the term encompasses different ecosystems, species, genes, and their

Table 1. Domestic policy issues for congressional action related to biological diversity maintenance. Excerpted from "Technologies for Conserving Biological Diversity" (Office of Technology Assessment 1987).

Issues	Finding	Options
Strengthen national commitment	Adopt a comprehensive approach to maintaining biological diversity	Establish a national biological diversity act Prepare a national conservation strategy Amend appropriate legislation of Federal agencies
	Increase public awareness of biological diversity issues	Establish a national conservation education act Amend the International Security and Development Cooperation Act
Increase ability to maintain biological diversity	Improve research, technology development and application	Direct National Science Foundation to establish a conservation biology program Establish a national endowment for biological diversity
	Fill gaps and inadequacies in existing programs	Provide sufficient funding for existing maintenance programs Improve link between onsite and offsite programs Establish new programs to fill specific gaps in current efforts
Enhance knowledge base	Improve data collection, maintenance, and use	Establish a clearinghouse for biological data Enhance existing natural heritage network of conservation data centers

relative abundance." (U.S. Congress, Office of Technology Assessment 1987).

Thus conserving biological diversity includes much more than endangered species recovery. The OTA definition has been criticized for not explicitly considering both form and process. Therefore a Bureau of Land Management (BLM) advisory group developed the following definition of "biodiversity."

> "Biodiversity is the aggregate of species assemblages (communities), individual species, and genetic variation within species and the processes by which these components interact within and among themselves; for purposes of classification, biodiversity can be divided into three levels; (1) community diversity (habitat, ecosystem), (2) species diversity, and (3) genetic diversity within a species; all three levels change through time."

This definition more explicitly recognizes ecological processes, such as succession, fire, etc., as well as evolutionary change. Thus conserving biological diversity requires maintaining ecological processes and maintaining the capability of genes, organisms, and communities to evolve over time.

EVOLUTION OF CONCERN FOR BIOLOGICAL DIVERSITY

The recent flurry of concern over biological diversity has caused varied reactions among biologists and conservationists. Some have wholeheartedly embraced the effort as something they have supported all along, or as Jack Thomas has quipped "I was a conservation biologist when conservation biology wasn't cool." (Thomas and Salwasser 1988). Others, often with similar feelings of always having been there, have dismissed conservation biology as the latest fad, parading a new buzzword for an old discipline.

Conservation biology is more than just a new buzzword or fad; rather, it is a natural evolution and broadening of a conservation movement that dates back to the 18th century in this country, and much earlier in Europe and some other parts of the world. Some of the earliest conservation efforts in this country were focused on protection of game species; early colonial and state game protection laws date back to the 1700s and were mainly focused on large (huntable) mammals and birds. This limited focus has been expanded over the years to include all vertebrates, invertebrates, plants, and ultimately all organisms (Figure 1). One can anticipate that such a broadening will eventually be expanded

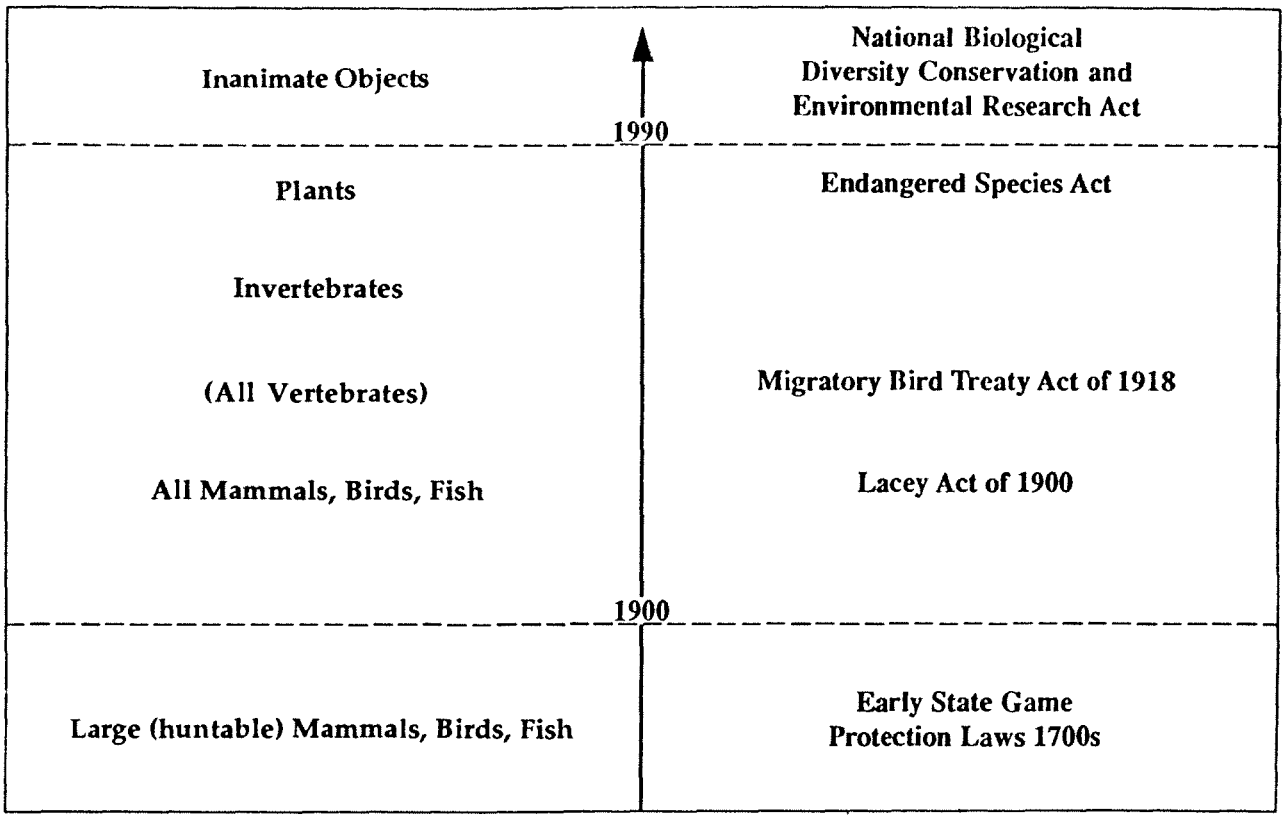


Figure 1. Evolution of concern for organisms in the United States.

to include inanimate objects. Indeed, the concept is inherent in the deep ecology literature. Devall and Sessions (1985:71) in expounding principles of deep ecology have written:

> The term "life" is used here in a more comprehensive nontechnical way to refer also to what biologists classify as "nonliving": rivers (watersheds), landscapes, ecosystems. For supporters of deep ecology, slogans such as "Let the river live" illustrate this broader usage so common in most cultures."

Thus the recognition of the need to preserve inanimate objects is in a sense a return to an older more holistic view of nature that is being rediscovered in academic and governmental circles, but has never been lost in many cultures. This holistic concern for "living systems" is perhaps best illustrated by considering the evolution of concern for various types of ecosystems.

Concern for ecosystems in this country has undergone a similar evolution to that of concern for species. Since the late 1800s concern for particular landscapes or ecosystems has been reflected in protective legislation (Figure 2) beginning with the Forest Reserve Act of 1891 that established the first national forests. The purposes of these forests were clarified by a later act in 1897 to explicitly include "protection of the forests." Over the next hundred years concern for particular types of land or landscapes, including grazing lands, wildlife sanctuaries, wilderness, rivers, and coastal areas, has resulted in a series of protective national legislation (Figure 2). Legislation such as the National Biological Diversity Conservation and Environmental Research Act may be viewed as a natural extension of this pattern of concern to include all landscapes and all ecosystems.

The history of conservation concerns and legislation for both species (Figure 1) and ecosystems (Figure 2) is a clear record of reaction to scarcity or to real and perceived threats. The original game laws were a reaction to declining numbers of game species. Similarly, the original forest reserve legislation was a reaction to the rapid decimation of public and private forest lands.

The recent concern and proposed legislation follows in this tradition. The loss of species and the ecosystems of which they are a part is proceeding at an unprecedented rate. The threats to life are more imminent, insidious, and global than in the past; thus a more holistic concern and response has developed.

An underlying theme of this concern is that biological diversity is the very foundation for sustainable systems, and that sustainable systems are the foundation for sustainable societies (Jacobs 1986; Maser 1988).

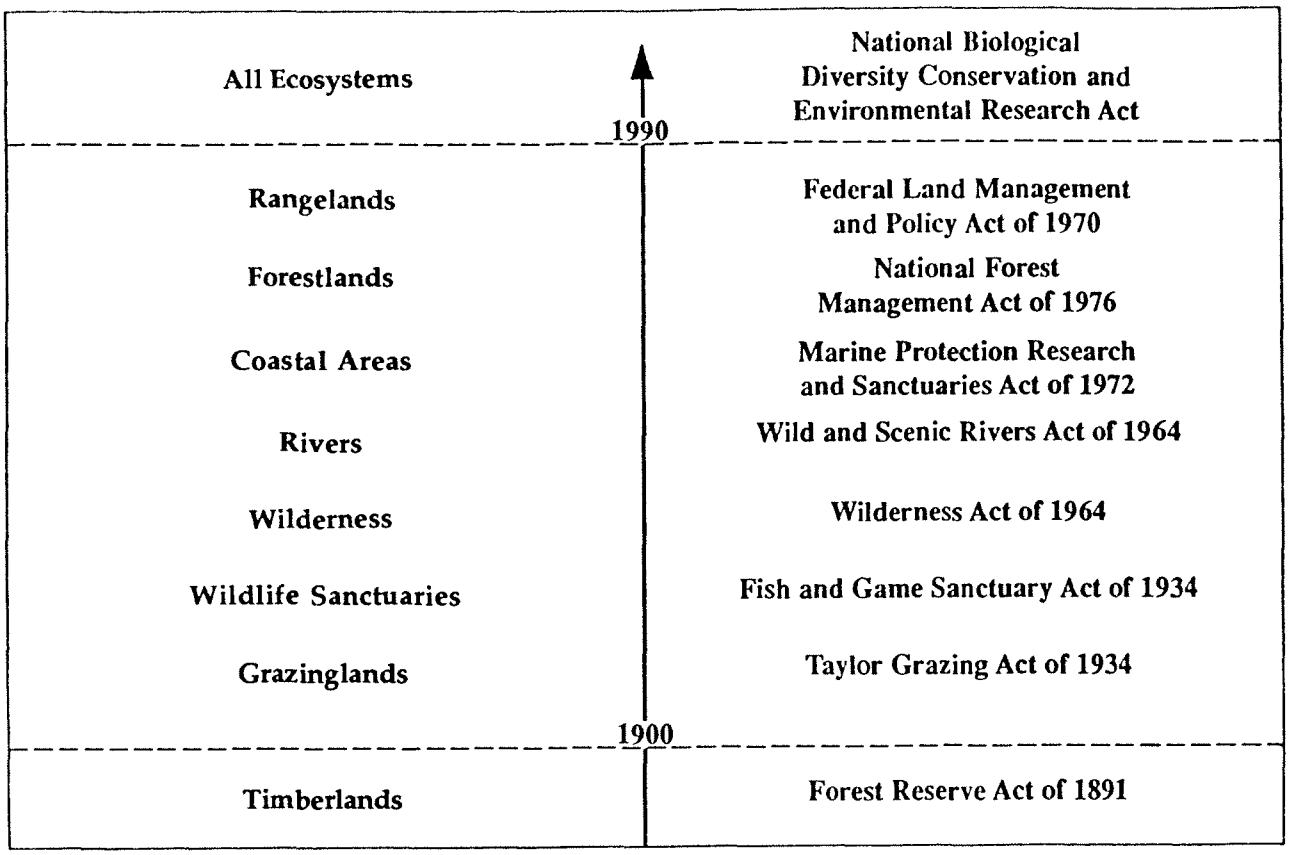


Figure 2. Evolution of concern for ecosystems in the United States.

EXAMPLES OF NEW APPROACHES

Conservation biology is largely a synthetic discipline built upon the techniques of more traditional natural resource disciplines. However, it also will require new approaches and techniques. In particular, whereas traditional conservation focused upon species, conservation biology will require biologists and managers to broaden this approach to consider both a larger scale (ecosystem) and a smaller scale (genetic variation within species) for purposes of planning, research, and management. The new approaches can be illustrated by examining some current examples that incorporate such approaches.

Ecosystem Conservation— Wilderness as Benchmark Areas

At the ecosystem level, wilderness designation has been advocated as one method for preserving "benchmark areas" that are representative samples of major terrestrial ecosystems in the United States (Davis 1988). Both the U.S. Forest Service and the BLM have adopted a hybrid classification system developed from merging Bailey's ecoregion concept (Bailey 1976) and potential natural vegetation (Kuchler 1966). BLM is using ecosystem representation as a criterion in its wilderness studies, and areas currently identified as wilderness study areas (WSAs) can significantly add to ecosystem representation in the wilderness system (Table 2).

Wilderness designation is a prerogative of Congress, and actual designation is still uncertain. However, by adopting a common system of classification of areas, a national perspective on preserving relatively undisturbed and representative ecosystems can be obtained and evaluated.

This example emphasizes the role that certain relatively undisturbed areas such as wilderness, national parks, and other preserves can play in providing benchmark areas. This is a traditional approach to conservation, yet it should not be construed as the main thrust of conservation biology. Although preserves and benchmark areas will continue to be important, the era of creation of vast new acreages in preserves is about over, and emphasis must shift to other lands (Salwasser 1987; Thomas and Salwasser 1988).

Furthermore, most existing preserve boundaries were determined by political, not biological, considerations and are inadequate to support viable populations of the organisms they were designated to conserve (Newmark 1985; Schonewald-Cox and Bayless 1986). Thus much of the attention of conservation biology must shift to those areas managed for other purposes in addition to conservation objectives of which public lands will play a major role (Thomas and Salwasser 1988). The

Table 2. Wilderness designation and biological diversity.

	Number of Bailey-Kuchler Ecosystems in Wilderness (10 Western States)[1]	
Bureau of Land Management (WSAs)	111	(80%)
U.S. Forest Service Wilderness	74	(53%)
National Park Service Wilderness	22	(15%)
U.S. Fish and Wildlife Service	5	(3%)

[1]The total number of Bailey-Kuchler Types is 138.

next example suggests how preserves and adjacent public and private lands can be managed together for purposes that include conserving biological diversity as well as other uses.

Ecosystem Management—The Greater Yellowstone Ecosystem

Yellowstone National Park was the first National Park in the country and has remained the "flagship" park in the National Park System. Yet studies in the 1970s of particular species such as elk and grizzly bears suggested that these populations ranged over a much wider range than the park. For example, Craighead (1979) reported that grizzly bears used about 5 million acres of which only 2.2 million were in the park. He concluded that grizzly bear conservation required coordinated management throughout this greater ecosystem.

Recognition of problems such as these led to the development of a coordinated effort at management for what has been termed the "Greater Yellowstone Ecosystem" by various agencies and organizations (Clark and Zaunbrecher 1987). This effort has resulted in the formation of the Greater Yellowstone Coalition, formed in 1983 with a membership of more than 40 organizations and many individuals. The coalition has publicized the threats to biological diversity in the region and the need for coordinated management.

Although, this effort is a long ways from solving the many threats to the Greater Yellowstone Ecosystem, it is a pioneering effort and will probably serve as a model for similar efforts elsewhere. Clark and Zaunbrecher (1987) concluded:

> the ecosystem concept in natural resource policy, administration and management will continue to grow in the Greater Yellowstone region and elsewhere, largely because of its value biologically and because it is being demanded by an increasingly ecologically aware citizenry. Furthermore, human cultures and economies, if they are to be sustainable for more than the short-term, must integrate themselves into a healthy ecosystem.

ECOSYSTEM REHABILITATION—WESTERN RIPARIAN AREAS

Restoration ecology will continue to play an important role in conservation of biological diversity. Indeed, these symposia are largely devoted to mitigation and restoration of impacts to wildlife habitat. In the future, one may expect some new or renewed emphasis on restoration of whole communities or ecosystems.

Recent work on riparian ecosystems in the West perhaps best exemplifies this type of landscape rehabilitation. Riparian areas in the West are among the most productive and important ecosystems in the West (Crouse 1987). However, they have also been some of the most deteriorated systems due to forestry practices, overutilization by livestock, and other detrimental management practices.

Yet, with proper management, some spectacular examples of riparian recovery have been documented (Prichard and Upham 1986; Smith 1986), although many riparian areas continue to deteriorate (United States General Accounting Office 1988). The development and evolution of concern, knowledge, and management of riparian systems has provided some useful lessons for other ecosystems. In particular, this evolution has been characterized by (1) increased awareness of riparian zones as complex systems of both physical and biological components (Van Haveren and Jackson 1966), (2) recognition of the need for multi-disciplinary approach to rehabilitation, and (3) recognition of the need for participation of a variety of interested parties in planning and developing solutions (Elmore and Beschta 1987). Typically, an initial concern by a fishery biologist for a depleted trout population has led to team efforts of biologists, hydrologists, and range conservationists working to rehabilitate a stream. Also typically, the stream was managed by a mix of state and federal agencies and private landowners, all of whom need to be participants in planned rehabilitation for it to be successful.

Habitat Fragmentation, Viable Populations, and Genetics—Desert Bighorn Sheep

Desert bighorn sheep have been one of the last North American ungulate groups to recover from the low population numbers of the late 1800s (Cooperrider 1985). Although most populations of desert bighorn are not considered endangered, two subspecies are listed as threatened on state and endangered species lists in California and New Mexico. Furthermore, desert bighorn habitat is highly fragmented. Habitat fragmentation can lead to extirpation of local populations and eventual extinction (Wilcove 1987). Furthermore, recent development in the Southwest such as highways and canals has tended to increase the isolation of fragmented habitat and populations. (Cooperrider 1985).

In response to a congressional mandate, BLM has developed and is implementing a rangewide plan for managing habitat to allow recovery of desert bighorn sheep.

Over 80 percent of desert bighorn habitat is on federal lands, the vast majority of which is managed by BLM; therefore BLM can play a critical role in facilitating recovery (Cooperrider 1986). Nevertheless, BLM has a limited range of responsibilities, with the state wildlife agencies continuing to exercise their authority over population management.

The attempt to develop a strategy for rangewide recovery has raised many questions. How much genetic variation is present between and among subspecies and populations of desert bighorn? What is a minimum viable population size? How large must a population or a transplant be to avoid inbreeding depression? What is the relationship between genetics, population size, and susceptibility to disease? How can rangewide strategies for a species like this one be developed when populations are found in six different states on lands managed by a multitude of private and public landowners? These are questions that all must be answered to provide for the long-term conservation of both desert bighorn populations and the genetic variation now present in these populations.

The above examples illustrate some of the new approaches and considerations that will be more common in the future as concern for and commitment to conservation of biological diversity becomes more prevalent. Several common denominators can be observed in these examples, particularly (1) recognition of the complexity of ecosystems and ecosystem processes; (2) recognition of the need for planning and management at the ecosystem level or on a larger geographic scale (Noss 1983); (3) the need to utilize a variety of disciplines in studying and solving problems; and (4) the need for unprecedented levels of coordination and cooperation between and among public and private agencies and other interested parties.

THE FUTURE OF CONSERVATION OF BIOLOGICAL DIVERSITY IN THE WEST

The western United States offers an unique opportunity for conserving biological diversity for several reasons.

First, the major impacts to biological diversity in the West have come within the last 200 years with the settlement and industrialization by people from eastern U.S. and Europe. Although this settlement has had an impact on biological diversity, it is slight compared to parts of the world such as the Mediterranean where deforestation and desertification have been taking place for thousands of years (Lowdermilk 1953).

Secondly, a substantial land base is still in public ownership. Public land ownership in the 11 western states ranges from 30 percent in Montana and 31 percent in Washington to over 85 percent in Nevada. This compares to an average of 32 percent nationally. If public lands in the West can be managed with a coequal objective of conserving biological diversity then the opportunities for conserving biological diversity are substantially better than in areas where private land is predominant.

Finally, there is arguably a higher awareness of the need to conserve biological diversity. Certainly this is a difficult contention to measure or verify. However, such crude measures as average level of education indicate that westerners are generally more highly educated. This may or may not be well correlated with concern for the environment. It is possible that the relatively high percentage of extant wildlands in the West has made westerners more sensitive to biological diversity. Indeed the attraction of these wildlands and their biological values has been what attracted many people to the West originally. It is perhaps not coincidental that some of the major centers for conservation biology (University of California at Davis and San Diego, Montana State University, and Stanford University) are in the West.

The prognosis for conservation of biological diversity in the West is not all positive. Major impediments to such an effort include the many commercial pressures in the West, the weak position of the West in national politics, and the traditional laissez-faire attitude toward land-use controls in the West. Furthermore, factors such as awareness and public land ownership are not necessarily prerequisites to good land stewardship. Savory (1986) has pointed out in comparing Africa with Texas that factors such as level of education and percentage of private land are poorly correlated with degree of desertification.

SUMMARY

Concern for conservation of biological diversity is becoming a major national and international concern. This concern is in response to unprecedented loss of biological diversity in the world and is thus a natural extension and broadening of earlier conservation movements. Pioneering efforts in conservation biology in the West build upon existing disciplinary techniques but also require new approaches. The western United States has an opportunity to conserve a much higher proportion of its biological diversity than most other parts of the nation or world. However, it will require a concerned and committed public and will also require some new and different ways of conducting business. In particular, it will require strategic planning at the regional or ecosystem level, and a degree of interagency/public cooperation far exceeding the current norm.

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WILDLIFE'S STATUS IN OUR ENVIRONMENT: AN APPEAL FOR MONITORING AND STANDARDIZATION

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Abstract. Our predecessors in North America describe environment by four elements: earth, wind, rain and fire. In our sweeping technological advances, we have yet to find better descriptors. Recasting these environmental descriptors in current scientific lexicon they are soil (geology and topography), weather (meteorology and climatology), water (surface and ground hydrology), and energy (flora and fauna). Rather than emphasizing inanimate manifestations of energy such as fire, this interpretation concentrates on the biological manifestations, the earth's source of fire. Ecology, then, is the four elements in equal quadrants of a circle. We know, theorize, and operate with each element as a separate entity now and will achieve ecological understanding when we know how an element interacts with another through time and space. To achieve this level of environmental knowledge requires monitoring that is long-term, wide-spread and standardized.

Based on examples gathered over 14 years in the Intermountain West, terrestrial wildlife populations, as a subset of the fauna, provide a varied source of information on the environment's status. Some avifauna respond immediately to change in soil, weather or water. Small mammals respond at a slower rate and their population changes reflect the magnitude of what the avifauna suggested. Reptiles on the other hand are exceptionally stable terrestrial inhabitants in terms of species composition and population despite significant changes in weather. Methodology used consistently over the past 14 years provides a basis for standardizing wildlife study. Most important is the need for wildlifers to be in the field, collecting a database that justifies wildlife's status as an equal partner in managing our environment.

Key words: Wildlife, monitoring, standardization.

For the past 25 years, I've tried to find my place in biology. I began by comparing anatomies as a pre-dental student. Casting a dental career aside, I had the choice between graduate school in anatomy, continuing to work for USGS in ground water analysis or returning to an action-packed career at the mortuary. As fortune would have it, I was hired by U.S. Fish and Wildlife Service to physiologically and behaviorally help rid the world, of bird, bat, and rat pests. After another six years of scaling biology's rugged cliffs and wondering if I'd get my next merit raise, I returned to school to pursue an elusive doctorate in Wildlife Biology. My problem was to behaviorally control a pest bird's food consumption by making it associate a memorable illness (read: vomiting and partial tranquilization) with a certain food and teaching another naive starling to do the same (Grant 1989a). It worked, but after eight years and being one of the only graduate students with tenure, who cared.

As it happened, halfway through my studenthood I landed a part-time job monitoring terrestrial vertebrates at Utah's Oil Shale Tracts. I liked population monitoring and the timing was right, so I went into business for myself as a population biologist. It was a dream come true, which, perhaps, explains my persistence in my current nonprofit avocation.

What I really wanted to be was an ecologist, one knowledgeable in the structure and function of the world. Anatomy started me on the structural road; with physiology, FWS, animal behavior, and graduate school, I continued down that path, which always implied function. All that was left to do was to use my recently acquired license to speak in learned tones and apply these vast stores of knowledge in the real world, specifically, to the population dynamics of more than 200 different kinds of wildlife.

All thoughts, well, most thoughts, of being an ecologist have been put on hold. As I met and worked with hydrologists, geologists, meteorologists, range and soil scientists, archaeologists, other wildlifers, and, yes, even engineers and botanists, I was humbled, and awakened at least and at last. I am not an ecologist, and probably never will be because of my interpretation of the definition of ecology: the study of the individual organism in its biotic and abiotic environment. This is not original though I cannot remember the author.

Ecology as originally defined by Ernst Haeckel in 1869 is the total relations of the animal to both its organic and its inorganic environment. This definition has been refined numerous times (read: restricted, once for each ecology text) because it has been considered too broad. This means that 100 years later none of us are ecologists if we have to know what Haeckel required. We biologists have restricted the meaning of ecology based on that with which we feel comfortable: genetics, evolution, physiology and behavior.

Hence, "ecology is the scientific study of the interactions that determine the distribution and abundance of organisms" (Krebs 1972, p. 4). If we stay with Elton's (1927) definition as "scientific natural history," or Andrewartha and Birch's (1954) definition of ecology as "the scientific study of the distribution and abundance of organisms," we keep a complex subject simple. Since simplicity is seldom in vogue, we spend our time dissecting, injecting, rejecting, inspecting and generally spinning around in one place concerning ourselves with interactions that for some reason are insoluble in the field

and do not conform to direct observation.

The British, across the big water to the East, take a different view in their treatment of ecology. Ecology is literally the science or study of the place or dwelling (Berry 1987), or as Tansley (1987) defines it, field biology. To be an ecologist, one must know taxonomy, morphology, histology, physiology, and genetics on the biotic side, and climatology, meteorology, geology, physiography, and soil science on the abiotic side. "Ecology is essentialy a 'field subject.'. . . Progress cannot be made in it without constant observation (and frequent experiments) in the field, though some of the ecological problems so met have to be attacked in the experimental garden or the laboratory, or both." (Tansley 1987, p. 11). Field biology in Great Britain directs the physiologists, genecticists, histologists, morphologists, and taxonomists, which, with malice and forethought, is not the case in the United States! Nor is biology the only home for ecology. In terms of scope, geology/geography and agriculture are also appropriate bedfellows.

Our ancestors best defined ecology by its four basic elements: earth, wind, rain and fire (Figure 1). Earth is our soil and rock with its geologic and geographic attributes. Wind is our atmosphere, its meteorology and climatology. Rain is our water, its hydrology on the surface and in the ground. Fire is heat and heat is essential to life as we know it. Then, I call the fourth element flora and fauna. I realize the sun's heat is life sustaining, but it is out of our control for at least the next year, maybe longer. Our flora and fauna, however, are within our sphere of knowledge and are our source of heat within and without. Essentially, we are tomorrow's oil and gas, though the latter state seems to transcend time. Although our ancestors don't deserve high marks as conservationists, they did not have hazardous waste, acid rain, or pollution in their lexicon, nor our technological ability to identify and correct our mistakes.

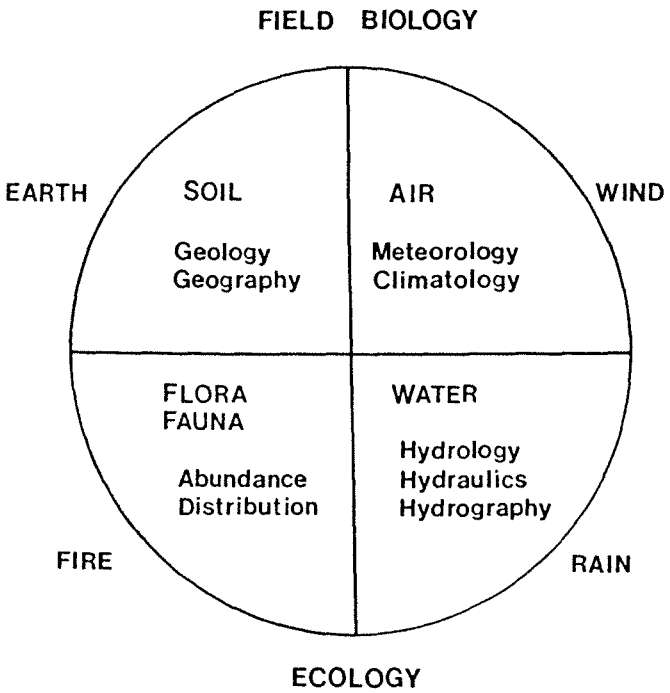


Figure 1. Ecology and its four basic elements.

What we lack is the biological ability to deal with our current state; and rather than attack our biological problems with biological solutions, we establish a plethora of abiotic standards to tell us if we are biologically OK. Our biological input is big on distribution (location) and almost completely lacking in any clue concerning abundance.

We shut our eyes to the outliers, data that doesn't fit our models, and force biology into a pretty little system that tells us all we need to know without sending biologists into the field to determine what really is going on. Not only do we rely almost completely on our laboratory data, we insist that field methodologies be indirect. We know, as field biologists, that data from direct methods, such as actually seeing and counting individuals, is not a pretty sight. Ugly or not, we need to revamp our priorities and put biologists in the field.

If we continue on our present course and avoid the field, we will never know the joys of freezing in the winter, being plagued by gnats, mosquitoes and ticks in the spring and summer, chased by hornets, badgers and bears, robbed by woodrats, scared scatless by rattlesnakes, and rudely awakened by a flicker drumming on a dead snag. We biologists who vainly seek to be ecologists must measure as many abiotic as biotic parameters as we can while in the field if we are to advance past first or second grade in ecology.

Our advancement in wildlife biology has changed little over time. Cronemiller and Fischer (1946:349) wrote..."As far back as the time when aboriginal man learned to count by tallying things on the fingers of one hand, he has probably been counting big game animals. As a science, the determination of wild animal populations has gotten little beyond the point where we can count up to multiples of the fingers on both hands." Gill (1976) states that he is "convinced there are no valid estimates of numbers of free-ranging mule deer on any large portion of western deer range. . . . The figures are not estimates but . . . guesses devoid of reliable, quantified substantiation." Wolfe (1976) states, "In summary, we find that despite the staggering resources and effort expended annually, real accuracy and precision in the enumeration of mule deer population trends remain elusive." Amen.

To obtain reliable, quantified substantiation of animal distribution and abundance requires field work. And meaningful field work requires a standard methodology. I am here to extol the use of transects, live-trapping, and mist-netting. I use line transects for reptiles, birds and mammals (might work for amphibians, but see Bury 1983), live-trapping for rodents, and mist-netting for bats (Grant 1986)

Table 1. Comparison of avian residency status for Utah's Oil Shale Tracts (Ua/Ub) from 1975–1981, and the same species for the Cottonwood Wash Oil Shale Area, for the Oil Shale Area (OSA) (Olsen 1973) and for the Uinta Basin (Behle 1981).

		NUMBER OF SPECIES		
Residency Status	Ua/Ub	Cottonwood Wash	OSA	Uinta Basin
Permanent Resident (R)	18	8	33	53
Summer Resident (S)	64	12	44	71
Winter Resident (w)	13	1	5	8
Migrant (m)	37	3	1	16
Transient (t)	14	18	–	–
Accidental (a)	2	–	–	–
Total	148	42	83	148

STATUS SIMILARITY

NUMBER OF SPECIES

		Uinta Basin (Behle 1981)					OSA (Olsen 1973)				
Residency Status	Ua/Ub	R	S	w	m	Total	R	S	w	m	Total
R	**18**	**18**	–	–	–	18	**13**	2	–	–	15
S	**64**	16	**47**	–	1	64	9	**35**	–	–	44
w	**13**	6	–	**6**	1	13	2	–	**3**	–	5
m	**37**	3	19	1	**14**	37	1	7	2	**1**	11
t	**14**	10	3	1	–	14	8	–	–	–	8
a	**2**	–	2	–	–	2	–	–	–	–	0
Total	148	53	71	8	16	148	33	44	5	1	83

and birds (Karr 1979). Some adaptations to the line transect method I use are road transects for bald eagles and for big game once data positively correlates with line transects; river transects for migratory and resident waterfowl, shore birds, raptors, and beaver; and ground and/or helicopter transects for locating raptor nest sites and determining nest success. There are no special tricks to using transects, though compulsive tendencies help. The data are useful in their simplest form, i.e., number per kilometer; and transects provide a way to compare grassland, shrubland, and woodland with a canopy not exceeding 30 m in height. A canopy above 30 m requires variable circle methodology (Reynolds et al. 1980) in the canopy and on the ground, using Knopf et al. (1988) as a guideline.

Live-trapping rodents provides, along with transect results, data needed to measure the status of resident wildlife. I use a large 12x12 grid for density estimates (number per hectare), a 5x5 grid or a 1x25 linear array for estimating abundance (number per 100 trap nights), and both for species composition, richness, and diversity (Steele et al. 1984). The large grid is best for accurate annual abundance and distribution estimates in August or September. The small grid or linear array are means of estimating seasonal abundance and distribution.

The reasons I tout these techniques are the results gathered in the past 14 years from oil shale and coal mines in Utah, Colorado and New Mexico. My findings solve no great mysteries but are empiric evidence natural history is not a waste of time. Some examples relevent to what we gain from time in the field, are temporal and spatial substantiation of the distribution and abundance of some supposedly well-known wildlife.

Over time, seasonal and annual samplings are essential in establishing an accurate residency status. Regional and sometimes site-specific surveys are misleading. For instance, in the Uinta Basin (Behle 1981) and in the Oil Shale Area (Olsen 1973), of which Ua/Ub is a part, the differences in residency status are significant (Table 1). The importance of residency status is critical in interpreting an area's health and welfare. Migrants, transients, summer and winter residents are either highly mobile or on the move, whereas permanent residents are the most important indicators, the foundation of an area's condition. Where changes in part-time residents and visitors suggest symptoms of current and future environmental health and aid in diagnosis as well as prognosis, permanent residents indicate the magnitude of change and the direction to stability.

Three feeding guilds of passerine birds are excellent examples of changes in part-time residents at Ua/Ub. In all four habitats granivores and omnivores reflect current environmental conditions: at a peak during a desert bloom in 1975, decreasing during the 1977 drought, and in a long recovery period through 1984 (Figures 2 and 3). Insectivores on the other hand, were seemingly little affected by the bloom or drought. However, on closer examination ground-

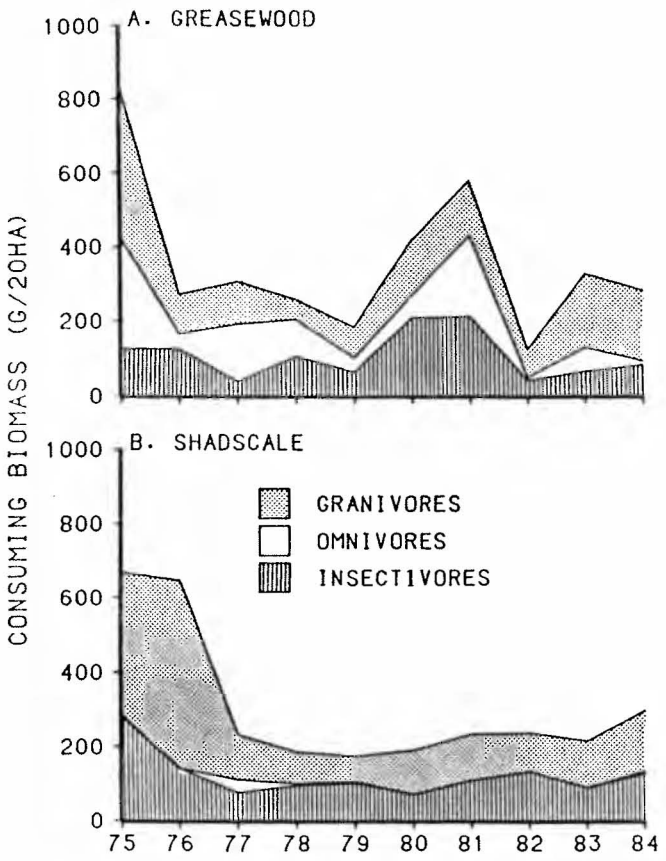


Figure 2. Consuming biomass (species density x species live weight$^{0.633}$) of three avian feeding guilds in desert shrub vegetation in Utah's Uinta Basin, 1975–1984.

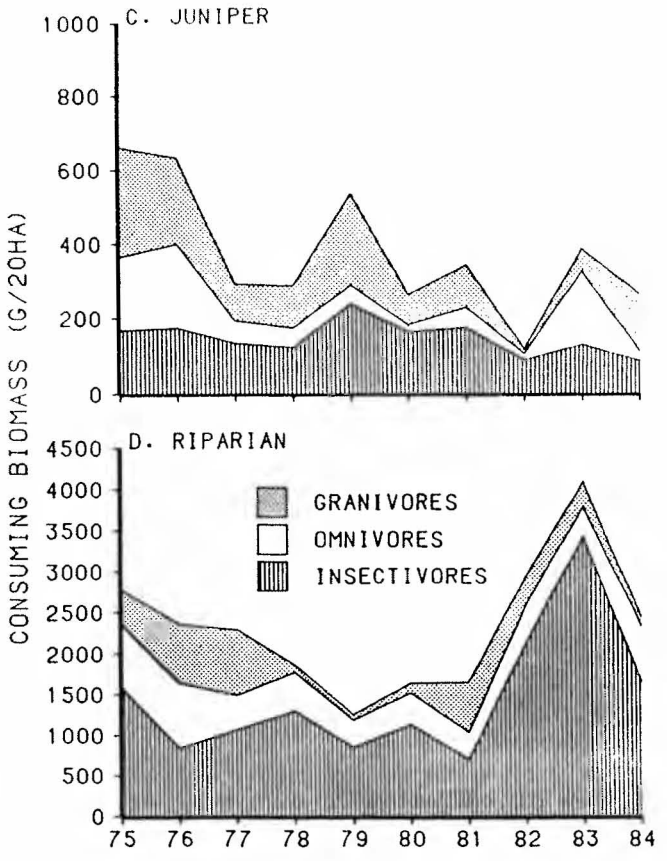


Figure 3. Consuming biomass (species density x species live weight$^{0.633}$) of three avian feeding guilds in desert woodland vegetation in Utah's Uinta Basin, 1975–1984.

gleaning insectivores (wrens, thrashers, thrushs, starlings and meadowlarks) in desert shrub communities respond to bloom and drought and to other factors that remain a mystery (Figure 4). In woodland habitats, ground gleaners are not the dominant contingent of insectivores but share the stage with foliage gleaners (parids, gnatcatchers, vireos and warblers), air cruisers (nighthawks, swifts and swallows), and air hawkers (flycatchers) (Figure 5), guilds that also do not seem to follow any measured parameters. Part of the solution in monitoring insectivores is, like the carnivores, monitoring their prey base.

Using bird data, specifically the June summer residents, as indicators of conditions becomes confusing. Some species such as desert-adapted granivores, sage sparrows (*Amphispiza belli*) and black-throated sparrow (*Amphispiza bilineata*), increase during droughts and decrease during periods of high productivity. Other species within guilds are extirpated for a season or a year or more, such as Brewer's sparrow (*Spizella breweri*), house wren (*Troglodytes aedon*) or Virginia's warbler (*Vermivora virginiae*). To make these birds and their guilds a useful tool requires regional monitoring to determine if a loss or gain in a species or guild is in fact a loss or gain. For example, during 1979-1981 while working at the Edna Mine near Oak Creek, Colorado, Brewer's sparrows were numerous while few occurred at Ua/Ub. We can determine population expansions or retractions or no change at all, but we need more points of reference.

Once we establish regional monitoring we may also be able to dispel concerns over raptor populations. The species that occur at Ua/Ub are permanent residents when prey are available and profitable. The populations of the larger raptors appear nomadic, taking advantage of different areas from year to year. After montane voles (*Microtus montanus*) invade riparian woodland and reach 6-10 individuals/ha, northern harriers (*Circus cyaneus*) occur at an 11 year peak density along the river. The next year both voles and harriers are absent (Grant et al. 1989). Territories, thought to control population numbers, are plastic and nest density is dependent on prey base in golden eagles (*Aquila chrysaetos*). Red-tailed hawk (*Buteo jamaicensis*) abundance is dependent on cottontail abundance; yet no matter what the nesting density, territory size is the same from year to year.

The permanent, less mobile residents of Ua/Ub are the small mammals and reptiles. Among most rodents the

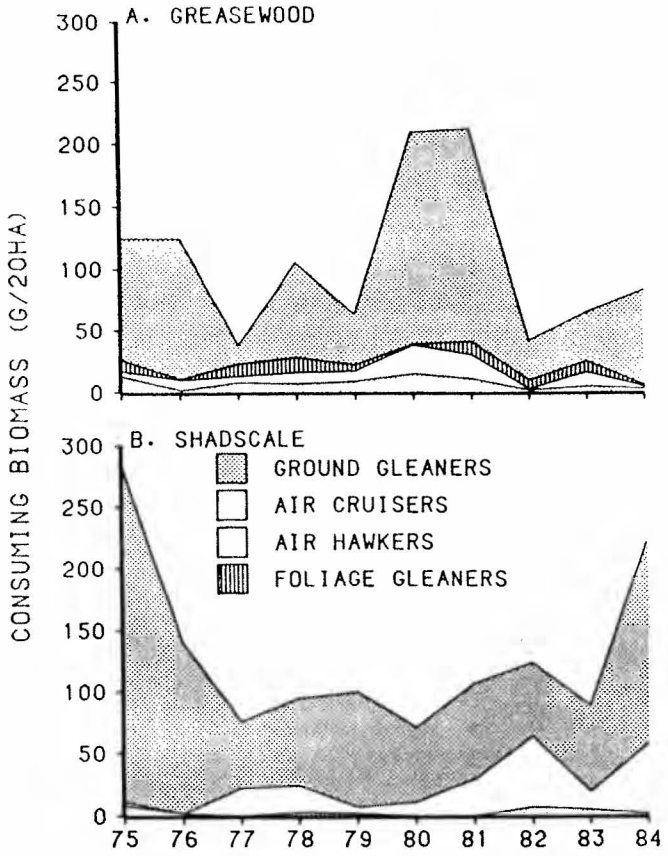


Figure 4. Consuming biomass of insectivorous birds in desert shrub vegetation in Utah's Uinta Basin, 1975–1984.

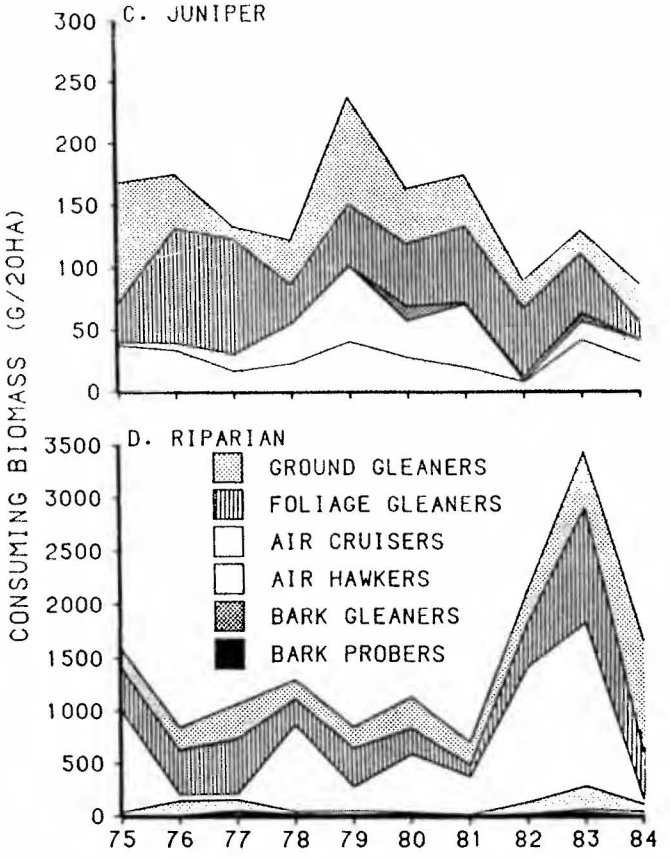


Figure 5. Consuming biomass of insectivorous birds in desert woodland vegetation in Utah's Uinta Basin, 1975–1984.

effects of bloom, drought, and bloom become evident (Grant 1986). Some species, such as white-tailed antelope squirrel (*Ammospermophilus leucurus*) and desert woodrat (*Neotoma lepida*) became extinct in desert shrub habitat in 1977 and did not reinvade through 1984. Deer mice (*Peromyscus maniculatus*) were seasonally extinct in shadscale and juniper habitats with a slow recovery through 1984. However, in riparian woodland the recovery surpassed previous population densities. Ord's kangaroo rat (*Dipodomys ordii*) populations do not respond to bloom or drought but some factor in 1980 led to a rapid increase in desert shrub, invasion of woodlands then a rapid decrease.

Densities of ommnivores and herbiverous rodents at Ua/Ub are closely tied to floral productivity. The former group, comprising most of the species, and the herbiverous woodrats respond one year after changes in annual plant biomass (g/m^2) and stem growth on sagebrush (*Artemisia tridentata*) as an indicator of perennial shrub production ($p<0.01$, $n=8$, $r=0.97$; and $r=0.99$, respectively). These predictable responses appear to be most reliable in desert shrub habitats, less so in desert woodland, and no relation in riparian woodland. The presence of perennial water in a desert environment changes the responses of both birds and some rodents to environmental changes. The birds are sheltered from harsher desert conditions, and the few rodent species are favored in desert riparian woodland (Grant 1986).

Another mammal worth monitoring, especially for predicting raptor densities (Grant et al. 1989), is the cottontail (*Sylvilagus audubonii*). My belief in cyclic populations remains skeptical, but the cottontails are beginning to change my mind (Figure 6). A six to eight year cycle seems to be the case in the Uinta Basin. The reason to monitor these animals is that lagomorph cycles seem to be out of sync from region to region, one population crashing as another builds; and the length of time a poplation increase persists is variable.

What influences the reptiles, particularly the lizards, is bare ground. Sagebrush (*Sceloperus gracious*) and side-blotched lizards (*Uta stansburiana*) react negatively to increased grass and forb growth, whereas the eastern fence (*Sceloporus undulatus*) and tree lizards (*Urosaurus ornata*) react positively (Grant 1986). The latter forage on vertical surfaces, the former on horizontal. Although insect prey increased with grass and forb production (Spangler, S. unpublished data), the two ground lizards declined due to vegetation architecture. Although reptile abundance varied

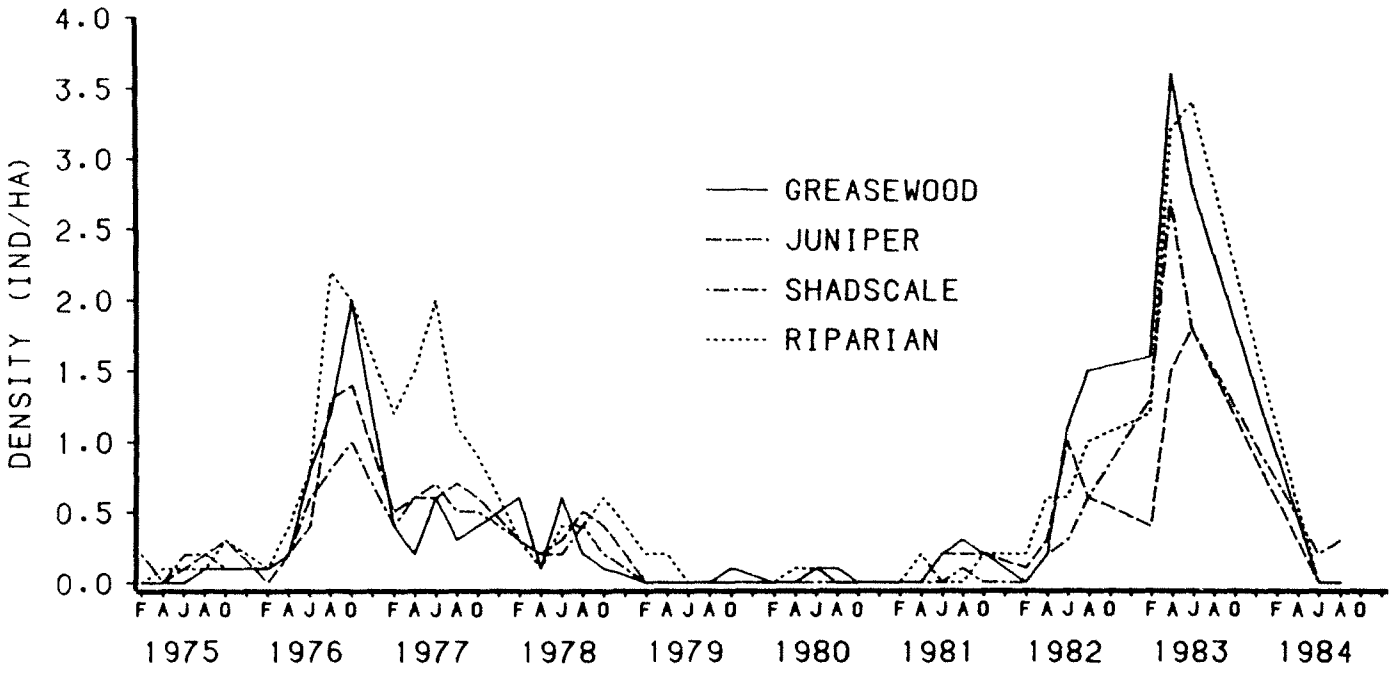


Figure 6. Desert cottontail density in four vegetation types in Utah's Uinta Basin, 1975–1984.

over the years, year-to-year changes are not evident. Among the vertebrate classes reptiles are the most consistent in habitat preference, species composition and species richness. Notably, percent bare ground from vegetation cover estimates adequately predicted lizard abundance in the four vegetation types at Ua/Ub ($p<0.05$, $n=9$, $r=0.88$).

Spatially, monitoring distinguishes habitat preferences (statistically significant in most cases) for most species. Adding new species and measuring the frequency and duration of extinctions is another plus. Morphologically, a ruler and a set of Pesola scales adds needed information to the taxonomic database. Experience in the field also leads one to question some supposed distinguishing characteristics between species.

We can rewrite the books concerning population and wildlife biology. All it takes is putting the chiefs in the field and leaving the Indians in the office. We can compare mule deer populations from point to point and set harvest levels that conform to reality. Using our big game as a source of lean meat, we can do a better job with the vegetation at hand than any livestock operation in the Intermountain West. We can rewrite the wildlife regulations; we can enhance wildlife in most cases of development and operation; we can detect when and where we've impacted wildlife populations; and we can use the flora and fauna to show us how to correct our mistakes. All we have to do is (1) agree on methodology; (2) standardize reporting and sampling periods; (3) conduct some research on our own or in cooperation with universities; and (4) get into the field and stay there.

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WILDLIFE TRENDS ON THE URBAN-RURAL FRINGE

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Abstract: Within Boulder County, Colorado, lie portions of both the greater Rocky Mountain National Park ecosystem and an expanding Denver metropolitan area. Historic and current wildlife lists and studies, as well as opinions of experts, were assembled and examined in order to reveal population trends and insight into existing problems for faunal elements of a suburbanizing landscape. The information indicated: (1) extirpated and declining species were wide-ranging or ecologically specialized; and (2) new or increasing species were eurytopic, compatible with human landscapes or water related. The trends match current perceptions of affects associated with habitat fragmentation. Recommended preservation and management actions are: (1) creation of an interconnected system of habitat for wildlife through consolidation of public ownership and acquisitions of interests in key property; and (2) restoration of degraded habitats, particularly riparian and grassland systems.

In a suburbanizing landscape, planners and land managers are continually confronted with expressing opinions on the impacts of proposed change to wildlife populations. However, in light of few long-term studies of wildlife that are relevant to a particular site, the duty of postulating impacts is at best an art. Cumulative affects of many natural and man-caused landscape alterations are difficult to assess. Extrapolating information forward or backward in time to reveal trends is often difficult yet necessary in light of the time frame within which most land use decisions are made.

Several avian studies analyzed the affects of urbanization, particularly with respect to species diversity, and had differing conclusions (Batten 1972, Emlen 1974, Guthrie 1974, Vale and Vale 1976, Sukopp et al. 1982, Horak and Cringan 1986). Important variables appear to be the degree of urbanization and the complexity of presettlement vegetation. However, a focus on species diversity may not be sensitive to declining and other species of concern, particularly of a regional level (Samson and Knopf 1982, Noss 1983).

The growing fields of conservation biology and landscape ecology emphasize that local and small-scale wildlife population changes must be put in the context of regional landscape perturbations (Knopf 1986). The term "habitat fragmentation" is being used in these fields to describe the large-scale cumulative affects of landscape elements being broken up into smaller and smaller blocks (Harris 1984, Noss and Harris 1986). Suburbanization and increased human management of the landscape would result in a form of fragmentation. Generalized affects of fragmentation on wildlife populations are: (1) the loss of large, wide-ranging, or ecologically specialized species; and (2) increasing domination by opportunistic and eurytopic species.

This paper will attempt to summarize the many historical "snapshots" from wildlife population studies and habitat descriptions in the suburbanizing landscape of Boulder County, Colorado, extrapolate trends, and compare these with the concepts of habitat fragmentation. Finally, some recommendations will be proposed for priorities in land use planning and landscape management and restoration to help alleviate adverse trends.

I thank D. Armstrong, C. Bock, A. Brown, K. Demarest, M. Figgs, J. Halfpenny, L. Hering, S. Jones, W. Kaempfer, L. Kuelthau, N. Lederer, H. McCutchin, J. Oppenlander, J. Orback, B. Peck, M. Sanders, D. Stevens, J. Strauch, R. Thompson, Boulder County Nature Association, Boulder Audubon Society and the Colorado Division of Wildlife for their contributions to Boulder County's wildlife database and impressions on the status of various species.

STUDY AREA

Boulder County, approximately 192,250 ha in size, is located north of Denver along Colorado's Front Range. Primary settlement by persons of European and Asian ancestry began around 1859 with the discovery of gold. Through the first half of the twentieth century, mining was important to the economy of the mountainous western half of the county while irrigated agriculture dominated the plains of the eastern half. County population is currently over 200,000 and is projected to grow to 320,000 by the turn of the century (Boulder County 1985a). The area's population has grown at an average annual rate of four percent from 1970 to the present. The economic base has been shifting from resource extraction and agriculture to high-tech industry and service. Population growth is becoming increasingly related to expansion of the Denver metropolitan area. Plans are being made for a circumferential beltway around Denver that could pass through the southeastern portion of Boulder County.

Ecologically, Boulder County possesses a high diversity of wildlife and associated habitats. Within a distance of 48 km, the elevation rises over 2750 m, beginning at 1524 m on the eastern plains and ending at peaks over 4270 m along the continental divide. The county contains grassland, riparian, woodland, forest and tundra habitats. Some 78 species of mammals and 284 species of breeding birds have been documented (Boulder County 1985b).

The county presents an interesting dichotomy of landscapes. The northwest and western portions are part of

the greater Rocky Mountain National Park ecosystem which contains over 400,000 ha of wilderness lands. The southeastern segment is part of a growing metropolitan area. The mountainous areas of the county that were part of the mineral belt have seen homes placed upon the patented mining claims. Mining is barely tolerated as an acceptable land use by current citizens. Few bonafide farmers exist and much of the farmland and water are being held in anticipation of being sold for "higher and better uses". A significant portion of the larger land holdings are still owned by descendants of original homesteaders.

Nearly 40% of the land is publicly owned, much by the U.S. Forest Service in the western half of the county. However, much of the public ownership is intermixed with private ownership forming a disjointed pattern.

METHODS

Historic and current wildlife accounts and habitat descriptions were reviewed while discussions were held with knowledgeable wildlife researchers for population trends and habitat change that would support such trends. The study focused on breeding birds and mammals.

The data sources can be grouped and summarized as follows:

1. Species Lists—Lists can provide information as to presence or absence at a particular point in time. Some may also provide information of relative abundance. Boulder County is fortunate to have good historic bird lists (Henderson 1908, Betts 1913, Alexander 1937) that can be compared with current records (Holitza and Krieg 1981, Chase et al. 1982). Besides presence or absence information, changes in relative abundance can be extrapolated. All lists provide an indication of the probability of finding a species in the proper habitat, the terminology generally being abundant, common, fairly common, uncommon, rare and casual. A shift in two classes in either direction was taken as an indication of population change. Additionally, D. Armstrong, using records from the Colorado University Museum supplemented with Colorado Latilong data (Bissell 1982), compiled a list of mammals for the county including species historically documented with no recent substantiation (Boulder County 1985b).

2. Bird Population Studies—Numerous bird population studies including breeding bird censuses, winter bird population studies, Christmas bird counts and studies using strip transects and point count stations comparing utilization of different habitats, have been conducted in the county. Most useful for this paper were studies by Snyder (1950), Hering (1978), Thompson and Strauch (1986), Lederer (unpubl. data), Hallock (1988 and unpubl. data) and data from the Indian Peaks Four Season Bird Counts (Hallock 1987).

3. Habitat Descriptions—Primary data sources were a recent land use and plant community map of the county (Soil Conservation Service 1980), current forest inventory data (USDA Forest Service, Boulder Ranger District 1983) and an inventory of the structural diversity of plains riparian habitat in the county (Boulder County Parks and Open Space, Boulder County Nature Association 1988).

4. Mammal Distribution and Population Studies—These are current studies concerning the population and distribution of elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), and black bear (*Ursus americanus*). Elk information combines historic data from the Colorado Division of Wildlife on the location of critical winter range with current studies of tagged and radio-collared animals. A deer study is being conducted by the City of Boulder (Mule Deer Study Update. January, 1987. Unpubl. report prepared by City of Boulder Open Space Department and Parks and Recreation Department). Black bear information is from an ongoing study being conducted in Rocky Mountain National Park (H. McCutchin, Wildlife Research Biologist, Rocky Mountain National Park, pers. commun.).

5. Consensus—Utilizing the opinions of many experts, a consensus was developed for those species, particularly mountain lion (*Felis concolor*), deer, elk and black bear, for which limited data from population studies existed.

Taking all sources together, trends of groups of species having similar habitat requirements (i.e., large mammals, grassland birds, cavity nesting birds) were combined with habitat information and perceived statewide wildlife trends (Winternitz and Crumpacher 1986) to present a picture of local trends.

RESULTS

Mammals

All of the seven extirpated mammals are wide-ranging species and most are large sized (Table 1). These species were extirpated not because of suburbanization, but due to overhunting, trapping and spatial conflicts with early settlers.

Table 1. Mammals extirpated from Boulder County, CO.

Gray Wolf	River Otter
Grizzly Bear	Pronghorn
Black-footed Ferret	Bison
Wolverine	

Source: Boulder County (1985b)

Reviewing some of the remaining wide-ranging mammals offers cautious optimism, except for the lynx (*Felis canadensis*) which may soon be added to the extirpated

Table 2. Population trends of selected wide-ranging mammals in Boulder County, CO.

Species	Status
Mule Deer	Population increasing due to natural and man-caused thinning of forests. Should be considered a eurytopic species and able to live in close proximity to human settlement.
Elk	Population appears to be slowly increasing. Although could be domesticated like European red deer, free-ranging/hunted herds may be wary of human settlement. Potential problems from mountain residential development that consumes winter range and blocks migration routes.
Lynx	No recent verification of presence.
Mountain Lion	Probable recent population increase due to abundant food (mule deer). Although are being seen in suburban areas, debatable whether breeding population can sustain without isolated foothill areas.
Black Bear	Possible population increase due to better food sources, particularly berry producing shrubs on north facing hillsides (opened by insect infestations) and insect infested deadfall. Like mountain lion, indications are that breeding population needs isolated area.

Source: Consensus of wildlife specialists.

category (Table 2). Mule deer, generally considered fairly adaptable and compatible with suburban landscapes, are proving this in and around the City of Boulder. Additionally, with forests opening from an overstocked pole stage by recent insect infestations, deer populations in the foothills and montane lifezones may be increasing.

Mountain lions appear to be responding to increased deer numbers while black bear are finding ample food sources as a result of the recent insect infestations. Both species are being seen near suburban areas, particularly mountain lions. It is unclear, however, whether or not this means habituation to humans. Evidence from the study of radio-collared black bears in Rocky Mountain National Parks suggests stable, isolated territories for breeding females and a higher probability of subadults entering a suburban landscape and being taken from the population. Hence, the increase in bear and lion sightings in suburban areas may reflect an increased population combined with limited niches. Elk appear to be increasing in population and are potentially an adaptable species to a humanizing landscape (Skovlin 1982). However, the spatial distribution of critical winter ranges for the various herds suggest an adverse affect of mountain suburban development. The herds are avoiding areas with a significant amount of rural housing.

Prairie and Grassland Species

A significant amount of prairie wildlife has been extirpated or has declined (Tables 1, 3 and 4). Bison (*Bison bison*) and pronghorn (*Antilocapra americana*) were locally extinct before the turn of the century while elk now rarely utilize the plains for winter habitat. Of the extirpated birds, mountain plover (*Charadrius montanus*) and sharp-tailed grouse (*Tympanuchus phasianellus*) were probably never found in great number, however many of the declining species were common breeders around the turn of the century. Plant community and land use mapping of the county supports the wildlife data as to the loss of native prairie habitat. Only 10% of the plains remain as native prairie, the remainder being converted to irrigated and nonirrigated agriculture and urban land uses.

Table 3. Breeding birds extirpated from Boulder County, CO.

Barrows Goldeneye	Long-billed Curlew
Peregrine Falcon	Sharp-tailed Grouse
Mountain Plover	

Source: Boulder County (1985b)

Table 4. Breeding birds declining in Boulder County, CO.

Eared Grebe (P)*	Willow Flycatcher (R)
American Bittern (P)	Western Bluebird (C)
Swainson's Hawk (P)	Mountain Bluebird (C)
Northern Harrier (P)	Northern Mockingbird (R)
Bobwhite (P)	Brown Thrasher (R)
Burrowing Owl (P)	Loggerhead Shrike (R)
Long-eared Owl (R)	Lark Bunting (P)
Lewis' Woodpecker (C)	Savannah Sparrow (P)
Red-headed Woodpecker (C)	

*Habitat: P = prairie; R = riparian; C = cavity-nesting
Source: Boulder County (1985b)

Plains Riparian Species

Five of the declining breeding bird species—long-eared owl (*Asio flammeus*), willow flycatcher (*Empidonax traillii*), northern mockingbird (*Mimus polyglottos*), brown thrasher (*Toxostoma rufum*) and loggerhead shrike (*Lanius ludovicianus*)—are associated with riparian habitat in the county with the latter four utilizing the shrub understory for nesting sites (Table 4). Habitat studies of riparian areas in the county support the feelings that good quality riparian habitat is not plentiful—only 30% of the plains riparian zone along the seven major streams showed good structural

diversity and only 60% of stream length was bordered by any quality riparian forest (Boulder County Parks and Open Space and Boulder County Nature Association 1988). Additionally, a comparison of 1937 and 1985 aerial photographs of a portion of the St. Vrain Creek revealed a 48% decline in riparian habitat (McKinley et al. unpubl. paper, Geography Department, University of Colorado, Boulder).

Cavity-Nesting Species

Four declining breeding bird species are cavity-nesters (Table 4). It is probable that a combination of factors—loss of suitable snags due to woodcutting as well as competition between species for nest sites (particularly from starlings) have contributed to their decline (Wintemitz and Crumpacker 1986).

Habitat data suggest that cavity-nesters have been at lower than usual numbers for some time. U.S.D.A. Forest Service information indicate that 42% of the forests in the county have a stand origin date between 1880 and 1909 (Boulder District 1983, unpubl. data). Many forest stands, then, are approximately 100 years of age with few suitable trees for cavity-nesters. Recent insect infestations, though producing many snags, may not have produced trees with heart-rot, which appear to be favored by primary cavity-nesters (McClelland et al. 1979). Historic and current forest management and wood-gathering practices also contribute to a shortage of suitable snags.

Most breeding bird population studies in the county have shown cavity-nesting birds to comprise 8-20% of the breeding community (Snyder 1950, Hering 1978, Thompson and Strauch 1986, Hallock 1987, Hallock 1988). However, recent studies conducted in a montane old-growth mixed forest (Lederer unpubl. data) and a mature lodgepole forest (Hallock unpubl. data) produced 30% cavity-nesting birds. Scott et al. (1980) felt that cavity-nesters generally comprised 30% to 45% of the breeding bird population in western coniferous forests. The studies in the county indicate that current levels may be low.

Waterfowl and Urban Species

The most obvious changes were an increased presence of waterfowl, the arrival of "urban" species (rock dove [*Columba livia*], European starling [*Sturnus vulgaris*] and house sparrow [*Passer domesticus*]), and the local introduction of ring-necked pheasant (*Phasianus colchicus*) and wild turkey (*Meleagris gallopano*).

Except for mountain lakes and a few prairie potholes, bodies of water were not common in the county before the turn of the century. Mallards (*Anas platyrhynchos*) were considered hypothetical breeders at the turn of the century (Henderson 1909). The construction of reservoirs and ponds created from gravel extraction produced suitable breeding grounds for waterfowl (Table 5).

Eurytopic Species

Common habitat generalists may be growing increasingly predominant in the landscape. Recent habitat change would support this trend—suburbanization, forest management and insect infestations have increased disturbance, edge and early successional forests, which favor habitat generalists. The suggested increase in mule deer would be one supportive wildlife trend.

Other studies suggest increased dominance by eurytopic species. Thompson and Strauch (1986) found European starling, mourning dove (*Zenaida mocroura*), black-billed magpie (*Pica pica*) and common grackle (*Quiscalus quiscula*) to be common summer residents in five habitats studied on City of Boulder open space. Snyder (1950) did not find brown-headed cowbirds (*Molothrus ater*) in three breeding bird plots in the forests of the county in 1947. Now, cowbirds are present in most summer bird study plots including one plot at 3,360 m (Hallock 1988). Data from the county's high elevation forests suggest increases in habitat generalists over the last seven years (Table 6) (Hallock 1987).

Table 5. Breeding birds increasing (I) or new (N) in Boulder County, CO.

Pied-billed Grebe (I)	Ring-necked Pheasant (N)
Western Grebe (N)	Turkey (N)
Double-crested Cormorant (N)	American Coot (I)
Great Egret (N)	Rock Dove (N)
Canada Goose (I)	Chimney Swift (N)
Wood Duck (N)	Western Kingbird (I)
Mallard (I)	Blue Jay (N)
Pintail (N)	Scrub Jay (I)
Blue-winged Teal (I)	American Crow (I)
Cinnamon Teal (I)	Common Raven (I)
Northern Shoveler (N)	Bushtit (N)
Gadwall (I)	European Starling (N)
Redhead (N)	Common Grackle (I)
Ruddy Duck (N)	House Sparrow (N)

Source: Boulder County (1985b)

Table 6. Change in occurrence of 5 selected eurytopic species on Indian Peaks breeding bird counts from 1982–1988 in southwestern Boulder County, CO.

	Number per count hour		
Species	1982	1985	1988
Broad-tailed Hummingbird	1.70	1.82	2.52
American Robin	2.15	3.53	3.94
Yellow-rumped Warbler	1.54	1.72	2.41
Dark-eyed Junco	1.52	1.04	1.48
Brown-headed Cowbird	.66	1.00	.70
Total	7.57	9.11	11.05

DISCUSSION

The data suggest that effects of habitat fragmentation, as defined by Noss and Harris (1986), are present in Boulder County. Large, wide-ranging species have declined and more could be affected with increased suburbanization. Habitat specialists, particularly those restricted to prairies, riparian areas, and tree cavities, are finding low amounts of suitable habitat. Habitat generalists seem to be increasing numerically and geographically. All three of the predicted trends appear to be occurring.

One item worth discussion is whether or not wildlife changes were the result of being on the urban-rural fringe or just products of cycles in habitat structure and food availability. It is probable that extirpated species disappeared due to conflicts or actions of rural lifestyles. However, reintroduction of a majority of the wide-ranging mammals is not possible in the current suburbanizing landscape except for river otter (*Lutra canadensis*) and possibly gray wolf (*Urocyon cinereoaryenteus*) in the greater Rocky Mountain National Park ecosystem. Regarding declining species, restoration of riparian areas appears possible and only within highly urbanized areas would riparian species needing large territories or undisturbed habitat connectors be adversely affected. The potential exists for restoration of prairies that could accommodate reintroduction of extirpated species except for wide-ranging mammals. However, suburbanization could preclude current opportunities. In mountain habitats, development disfavors such natural processes as fire and insect infestations as well as retention of snags and generally results in increased roads, human presence and free-ranging pets. The adaptability of remaining large, wide-ranging mammals, particularly black bear, mountain lion and elk, will be tested. The affects on other habitat specialists are less clear—development of large-diameter trees and snag and deadfall retention will be key to whether specialists will continue to be an integral part of mountain habitats. An unresolved topic is whether current trends favoring eurytopic species are simply the result of insect infestations opening the forests or if other factors related to suburbanization and increased management are important agents of this trend.

In light of the trends and concerns highlighted in the previous paragraphs of this paper, the following are priority land use recommendations for maintaining habitats conducive to problem species:

1. Decrease fragmentation of key areas and increase connectivity between areas important for wide-ranging animals by public land consolidation and acquisition (through purchase or donation) of interests in important lands to preclude additional fragmentation.
2. Encourage creation and/or retention of large-diameter trees, snags and deadfall.
3. Restore plains riparian habitat.
4. Restore of prairie habitat.

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GRIZZLY BEAR RESTORATION IN THE SOUTH SAN JUANS: A BIOLOGICAL ASSESSMENT

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Abstract: This paper examines the habitat suitability of the South San Juan Mountains for recovery of the grizzly bear (*Ursus arctos*). The study area, consisting of about 8,710 sq km in southern Colorado and Northern New Mexico, has a favorable distribution of six primary cover types (alpine, spruce-fir, mixed conifer, aspen, meadow, and dryland). Temperate zone and forest-meadow habitats are well represented. Common plants and animals likely to be used by grizzly bears include grasses, clover, dandelion, Umbelliferae spp., strawberry, blueberry, gooseberry, acorns, elk, pocket gopher, voles, and ants. A central area of about 3,056 sq km could serve as "core habitat" for an overall population of about 50–100 bears. This area is characterized by rugged and remote terrain, and relatively low levels of human use. Primary conflict between bears and people would most likely involve livestock, roads, and development of bottomland. Human-bear conflicts could be minimized through a habitat zoning system such as that prescribed for other grizzly bear ecosystems. Restoration of grizzly bears in the South San Juans should be considered as part of an overall strategy for preserving biological diversity, as well as wildlife-wildland values and opportunities, in the Southwest. Specific steps toward grizzly bear recovery in the area are outlined.

Ten years ago, an adult female grizzly bear (*Ursus arctos*) was killed by a bow hunter near the headwaters of the Navajo River in the South San Juan Mountains of Colorado (Beck et al. 1981). This bear was the last wild grizzly recorded for the southern portion of the species' geographic range, which once extended in western North America from Alaska to Mexico (Rausch 1963). Although a small number of grizzly bears may still occur in the San Juans (Seitz et al. 1982; G. Eyre, Colorado Division of Wildlife, pers. comm.), or in northern Mexico (Harting 1987), conservation of this species anywhere to the south of the Yellowstone National Park area, Wyoming, cannot be expected unless specific restoration efforts are made. The grizzly bear is federally listed as threatened south of Canada (U.S. Fish & Wildlife Service 1982), and is state listed as endangered in Colorado (Colorado Division of Wildlife 1986a).

Should the grizzly be restored to the Southwest? Conservation of biological diversity requires maintaining species, communities, and ecosystems at the regional level (Noss 1983, 1987). The grizzly bear plays a significant role in shaping biotic communities, for example, as a predator, carrion consumer, seed disperser, and semi-fossorial animal (Craighead 1975, McNamee 1984). It is an agent of community diversity. Given the grizzly's large spacial requirements (Craighead and Mitchel 1982, Canfield and Harting 1987), its conservation also fosters the preservation of large ecosystems, and the full range of natural communities, ecological processes, and other wildlife associated with them. From an autecological perspective, grizzly bear recovery in the Southwest would broaden the grizzly bear's genetic pool, and help buffer the species from unfavorable changes that might occur in northern environments. This would improve chances for the evolutionary adaptation and long-term survival of grizzly bears in an increasingly human-modified world (Soule 1987).

As conservationists well know, what is desireable from a biological standpoint is often not possible politically. While general public support for the conservation of large predators is high (Kellert 1980), specific opposition, particularly at the local level, is often the deciding factor. A proposal in the early 1970s to reintroduce the grizzly bear into New Mexico's Gila Wilderness, for example, was scuttled apparently because of opposition from the livestock industry (Brown 1985).

Fortunately, socio-political circumstances change, and adequate public support can be gained for controversial conservation proposals, such as reintroduction of the red wolf (*Canis rufus*) to North Carolina (Taylor 1986, Parker 1988). For the grizzly of the Southwest, however, time for improving human attitudes is limited, as human population growth and land development continue to erode chances for successful restoration.

The purpose of this paper is to evaluate the South San Juan Mountains as a potential grizzly recovery area, and to suggest measures that could be taken to restore grizzly bears to that ecosystem. It is hoped that this paper will stimulate interest in grizzly bear recovery in the San Juan Mountains and elsewhere in the Southwest, and that the matter will be considered by the U.S. Fish & Wildlife Service in its upcoming revision of the Grizzly Bear Recovery Plan (U.S. Fish & Wildlife Service 1982). Such consideration by the Service would be in accordance with endangered species law, which calls for recovery of threatened and endangered species in Colorado (Colorado Revised Statutes 33-2), and over significant portions of their geographic ranges (16 U.S.C. 1531 *et seq.*).

STUDY AREA AND METHODS

The study area is located in southern Colorado and northern New Mexico (Fig. 1), about 75 km east of Durango, CO and 45 km northwest of Taos, NM. Major rivers that drain the area are the Rio Grande, Alamosa, Conejos, Navajo, Blanco, and San Juan. The area includes

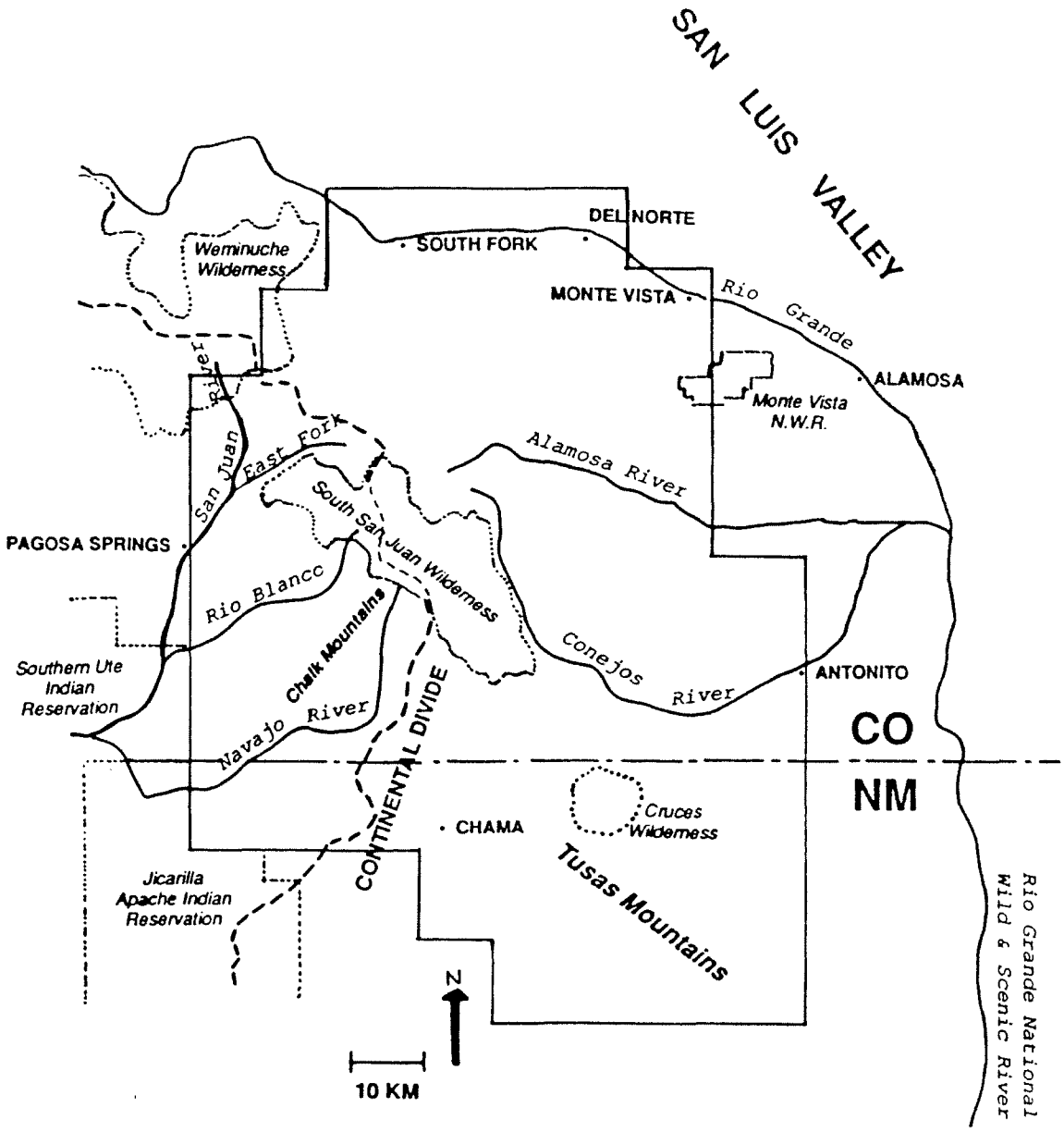


Figure 1. Location of the study area in southern Colorado and northern New Mexico.

about 8,710 sq km, of which 52% is national forest, 9% Bureau of Land Management land, and 3% state land. Thirty-five percent of the area is private land, much of which is part of the Tierra Amarilla Land Grant complex. About 1% of the study area belongs to the Southern Ute and Jicarilla Apache Indian Tribes, or is part of the Monte Vista Wildlife Refuge.

Elevations in the study area range from 2,300 m in the San Luis Valley to over 4,000 m in the South San Juan Wilderness. Annual precipation at lower elevations varies from about 25.4 cm at Del Norte to about 48.3 cm at Chama (National Oceanic and Atmospheric Administration 1987). The higher slopes in the South San Juans receive about 127.0 cm of annual precipation (U.S. Forest Service 1984). In 1987, average July temperatures for Del Norte and Chama were about 17.5 C, while average December temperatures were –7.2 C and –4.4 C for these two locations, respectively. At higher elevations in the South San Juans, summer temperatures rarely exceed 26.7 C, while winter temperatures may drop to –45.6 C (USFS 1984).

A wide range of plant communities occur in the study area. For example, Johnston (1987) lists 21 grass-forbland, 52 forest, 4 shrubland, and 13 riparian plant associations for the San Juan and Rio Grande National Forests. DeVelice et al. (1986) characterize forest habitat types of northern New Mexico and southern Colorado, listing 8 forest series.

Field work was conducted from June to August in both 1987 and 1988. Teams of 2–6 people evaluated grizzly bear

foods along ground transects, and during general field surveys. Food items and animal signs were recorded for 10 x 4 m transect segments, and, in the case of plants, given a percent ground cover rating. General surveys involved tallying grizzly bear foods and animals signs that were considered "common" within survey areas of .3–1.0 ha.

Cover type maps were prepared using U.S. Forest Service timber resource overlays, U.S. Geological Survey (USGS) orthophotoquads, and, for part of the study area, false-color infrared photographs purchased from the Agricultural Stabilization and Conservation Service. Cover type mapping in the field and/or ground truthing of draft cover type maps were done for portions of 46 (of 57) study area quads. Surface area for each cover type was calculated from a master map (1:100,000). Cover type units were measured to the nearest .5 sq km, using a planimeter.

Cover types mapped were alpine, spruce-fir, mixed conifer, aspen, meadow, ponderosa pine, oak, pinyon pine-juniper, low elevation grassland, agriculture, and non-vegetated surface. Areas having greater than 50% of a given cover type (or combination) were classified as primarily of that type. Areas with 10–<50% of a cover type (or combination) were considered to have a secondary cover type component. A given cover type had to provide at least 10% of the total cover to be included in a cover type designation.

Ungulate winter range was determined from data obtained from the Colorado Division of Wildlife and the Bureau of Land Management, and from discussions with New Mexico Department of Game and Fish officials. Data on livestock on public lands were provided by the U.S. Forest Service, the Bureau of Land Managment, and the Colorado State Board of Land Commissioners. Study area road densities were derived from U.S. Forest Service Travel Maps, with the aid of USGS quads and county maps. Areas of concentrated human use were determined using orthophotoquads, false-color infrared photos, and field survey information, while land ownership data were derived from BLM surface management status maps.

This study was conducted through The School for Field Studies, Beverly, MA. I am indebted to the students of our Landscape Ecology course in the San Juans for their efforts in the field, and to R. Noss, N. Hardy, M. Caracuel, and P. Forestall, as faculty and support staff. I am grateful to the U.S. Forest Service in Durango, Pagosa Springs, Monte Vista, and Tres Piedras for its support and assistance in providing resource management data. I thank the Bureau of Land Management in Denver and Alamosa, the Colorado Division of Wildlife in Montrose, and the Colorado State Lands Office in Denver for making available study area information. The efforts of T. Wilson and J. Shafer of the Forest Service, and S. Gregonis of the BLM, in providing computer-based data, were especially appreciated. I acknowledge the Earth First! Foundation for partial funding of the project. I thank my wildlife ecology students at the University of Colorado, Boulder, who assisted in mapping and data analysis, and am grateful to S. Elliot and E. English who helped illustrate this paper. Finally, I thank the many citizens of the South San Juans, and particularly those from the At Last Ranch, whose hospitality and encouragement were most appreciated.

RESULTS AND DISCUSSION

Grizzly Bear Foods

Grizzly bear foods for the South San Juans are listed by cover type and by climatic zone in Tables 1 and 2. These foods are known from grizzly bear diets in the northern Rockies and in the north Cascades (Craighead et al. 1982, Knight et al. 1982, Almack 1986, Mace and Bissel 1986, and Mace 1987), or were historically reported to be used by grizzly bears in the Southwest (Brown 1985).

Plants

Grasses (Gramineae spp.) generally dominated ground cover in all but the mixed conifer and spruce-fir cover types. They were the most common food in all climatic zones, and, with the exception of the foothills-plains zone, generally retained succulance throughout the 1987 and 1988 summer seasons. Grasses represent a major food for grizzly bears across seasons, and are typically consumed according to their availability (Craighead et al. 1982, Mace 1987). Sedges (*Carex* spp.) and rushes (*Juncus* spp.) were locally abundant, particularly in alpine and subalpine meadows. While important, they are somewhat less preferred by grizzlies than grasses (Craighead et al. 1982).

Grizzly bears elsewhere show a high preference for dandelion (*Taraxacum* spp.), clover (*Trifolium* spp.), horsetail (*Equisetum arvense*), and scouring-rush (*Hippochaete* spp.). In the South San Juans, dandelion was among the most prevalent of grizzly bear foods, occurring in all cover types and climatic zones, and being especially abundant in mixed conifer, aspen, and meadow cover types of the temperate zone. Clover, while more restricted in overall distribution, was very common in alpine and subalpine areas. Horsetail and scouring-rush were locally distributed in riparian and seepage areas, particularly of the temperate zone.

Other common plants in the South San Juans that are preferred by grizzly bears elsewhere are sweet cicely (*Osmorhiza* spp.), lovage (*Ligusticum* spp.), cowparsnip (*Heracleum lanatum*), and thistle (*Cirsium* spp.). Sweet cicely and lovage were most prevalent in higher elevation forest cover types, while cowparsnip was locally abundant where water tables were high. Thistle was widely distributed, but was most prevalent in the alpine zone, where *C. scopulorum* was common. Grizzly bears consume entire plants, including the underground parts, of both umbels and thistles (Craighead et al. 1982).

Two common plants whose underground parts are

Table 1. Grizzly bear foods by major cover type, as recorded along vegetation transects in the South San Juans, summer 1987 and 1988. Figures indicate % occurrence for total transect segments.

Food	Alp (N=148)	SF (N=160)	MC (N=155)	Asp (N=120)	Mead (N=260)	Dry (N=190)
Gramineae spp.	99 **	86	95 *	99 **	97 **	100 **
Carex/Juncus spp.	39 **	18	1	22 *		
Taraxacum spp.	14	21	41 *	47	53	14
Trifolium spp.	25 *	39 *			17	10*
Osmorhiza/Ligusticum spp.	14 *	34	18	36 *	3 **	
Heracleum lanatum	T		8 **	3 **	2 *	
Cirsium spp.	13	12	5	8	9	3
Oxyria digyna					1 **	
Epilobium spp.	T	3				
Opuntia spp.						28
Equisetum/Hippochaete spp.			3 **			
Bistorta spp.	36 *	6			18	
Allium spp.	1				8	6
Fragaria spp.	21	38	39 *	38 **	28 *	3
Vaccinium spp.	32 *	48 *	23 *	29 *	3	
Ribes spp.	3	37	25 *	16 *	8	8
Amelanchier alnifolia	7 **		26	11 **	8 *	11
Rosa spp.		8	21	33	2	28 *
Shepherdia canadensis			5	3		
Arctostaphylos uva-usi		5 **	T			
Sambucus spp.		3	3		4	
Prunus virginiana			T			2 *
Symphoricarpus spp.		14	52 *	75 **	17 **	38 **
Mahonia repens	2 **	5 **	17	34	7	12
Lonicera spp.	3	11	6	5 **	2	
Rubus parviflorus		3	21 *	33		
Rubus spp.		6	1			
Juniperous spp.		4	12	4	5	10
Quercus gambelii			2	2		48 **
Pinus edulis						3
Mushrooms/puffballs	7	15	5	17	5	
Cervus elaphus	27	40	9	18	33	30
Odocoileus hemionus	11	24	6	7	4	17
Thomomys talpoides	35	7	14	26	23	11
Small rodents	8	3	1	2	8	15
Ants (hills)			3	5	5	26

key: Alp = alpine meadow and krummholz
SF = spruce-fir
MC = mixed conifer
Asp = aspecn
Mead = subalpine/montane meadow
Dry = dryland: ponderosa pine, oak, pinyon-juniper, and lower evelvation grassland

** = high ground cover (≥25%) for ≥50% of transect segments within which the item occurred.
* = high ground cover (≥25%) for 25–<50% of transect segments within which the item occurred.
T = item occurred in <1% of transect segments.

ignificant in the grizzly's diet elsewhere were American istort (*Bistorta bistortoides*) and wild onion (*Allium* spp.). Bistort was especially abundant in the alpine, while onion vas more common in meadows at lower elevations.

Other plants whose underground parts are favored by grizzlies include biscuitroot (*Lomatium* spp.), alpine springbeauty (*Claytonia megarhiza*), and western spring-beauty (*C. lanceolata*). Biscuitroot (*L. grayi*) was found at wo localites in pine-oak habitat. In 1981, biscuitroot *Lomatium* spp.) was recorded at a possible grizzly bear eeding site in the study area, where it was "quite restricted" n occurrence (Beck et al. 1981). The springbeauties were ot identified during the study probably because the habitats in which they are likely to occur (Webber et al. 1976, Weber 1987) received very limited coverage by our field teams.

Berry producing plants of high potential use by grizzly bears in the South San Juans are strawberry (*Fragaria* spp.), *and Vaccinium* spp. Strawberry was common in all except the dryland cover types, and locally contributed much of the ground cover. *Vaccinium* spp., of primary importance to grizzlies in northern ecosystems, was most abundant in higher elevation forest communities, with myrtle blueberry (*V. myrtillus*) being the most common species. During this study, significant berry production was noted for strawberry, but not for *Vaccinium* spp.

Other berry producing plants of potential importance to

Table 2. Common grizzly bear foods by climatic zone, as recorded during general field surveys in the South San Juans, summer 1987 and 1988.

Food	Alpine (N=15)	Subalpine (N=43)	Temperate (N=29)	Foothills-Plains (N=12)
Gramineae spp.	**	**	**	**
Carex/Juncus spp.	**	*	+	*
Taraxacum spp.	*	*	**	*
Trifolium spp.	**	**	+	
Osmorhiza/Ligusticum spp.	+	*	+	
Heracleum lanatum		+	+	
Cirsium spp.	**	+	+	+
Oxyria digyna	*			
Opuntia spp.				*
Equisetum/Hippochaete spp.			+	+
Bistorta spp.	**	+		
Allium spp.	+	+	+	+
Fragaria spp.	+	*	*	
Vaccinium spp.	+	*	*	
Ribes spp.	*	**	*	*
Amelanchier alnifolia			*	+
Rosa spp.		+	**	*
Shepherdia canadensis		+	*	
Arctostaphylos uva-usi			+	
Sambucus spp.		+	**	
Prunus virginiana			+	+
Symphoricarpus spp.		+	**	**
Mahonia repens		+	*	
Lonicera spp.		+	+	
Rubus parviflorus		+	+	+
Rubus spp.		+	+	
Juniperous spp.		+	**	*
Quercus gambelii			+	**
Pinus edulis			+	*
Mushrooms/puffballs	+	+	+	
Cervus elaphus	**	**	**	**
Odocoileus hemionus	**	+	*	*
Thomomys talpoides	**	*	**	*
Small rodents	**	*	*	**
Marmota flaviventris	+	+	+	+
Castor canadensis		+	+	+
Ants (hills)	+	*	*	**

** = common in >50% of surveys
* = common in 25–<50% of surveys
+ = common in <25% of surveys

Alpine = alpine and krumholz cover types.
Subalpine = the spruce-fir zone.
Temperate = the mixed conifer zone.
Foothills-plains = the ponderosa pine zone, and lower elevations.

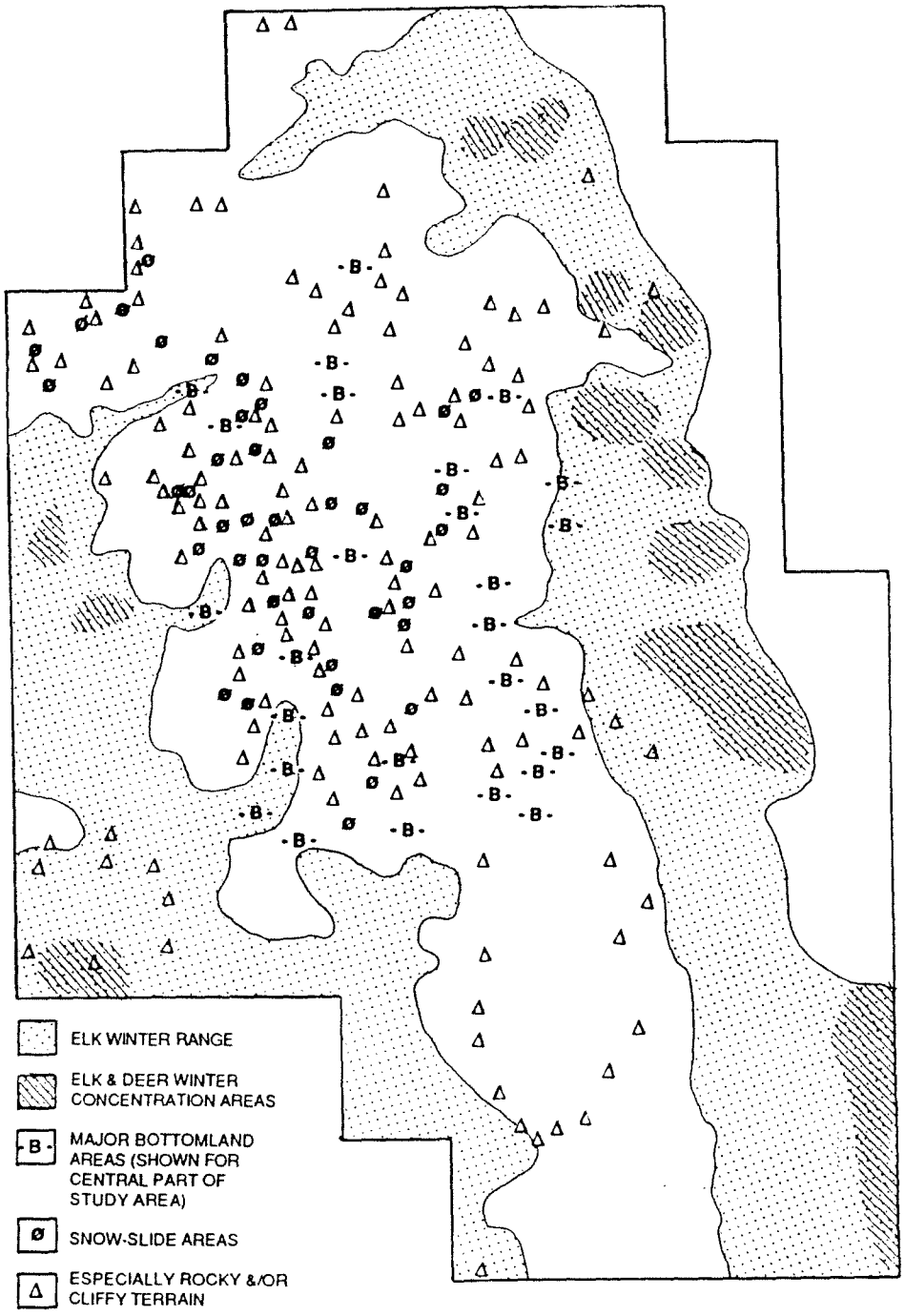
study area grizzlies include serviceberry (*Amelanchier alnifolia*), buffaloberry (*Shepherdia canadensis*), and wild rose (*Rosa* spp.), all of which were common in the temperate zone, and gooseberry (*Ribes* spp.), which was common in alpine and subalpine areas as well. These shrubs had significant fruit production during the study periods.

Gambel oak (*Quercus gambelii*) and pinyon pine (*Pinus edulus*) are common nut producing plants of lower elevations that could receive substantial use by grizzlies. Early observers reported grizzly bears feeding on both acorns and pinyon nuts in the Southwest (Brown 1982). Acorns are a preferred food of black bear (*Ursus americanus*) in southern Colorado (Beck 1983).

Plants less commonly reported as grizzly bear foods elsewhere but which could be significant for grizzlies in the study area because of their abundance and wide distribution include snowberry (*Symphoricarpus* spp.), honeysuckle (*Lonicera* spp.), hollygrape (*Mahonia repens*), juniper (*Juniperous* spp.), raspberry (Rubus spp.). bluebells (*Mertensia* spp.), willow (catkins) (*Salix* spp.), and aspen (*Populus tremuloides*). Likewise, mushrooms and puffballs, reported in bear scat in the Yellowstone ecosystem (Knight et al. 1982), were especially abundant during a period of cool, moist weather in 1988.

Animals

Elk (*Cervus elaphus*) are a major food for grizzlies in the Yellowstone area, comprising much of the spring diet,



gure 2. Elk winter range and topographic features of special significance to grizzly bears in the South San ians.

d a substantial portion of the fall diet (Knight et al. 1982, ight et al. 1984). Elk and other ungulates, wherever cally concentrated, represent an important food source for izzly bears (Mace 1987).

Elk were considered common in 71% of the general rvey areas, taking into account both direct sightings and ns. Elk population estimates for Colorado wildlife nagement units (CDOW 1986b) indicate that elk density over a broad area in southwestern Colorado, from Durango to the Continental Divide in the South San Juans, is over 2.2 elk/sq km. Projecting this density over the study area gives an elk population estimate of more than 19,000 animals.

The winter distribution of elk (Fig. 2.) is of special interest because winter-killed elk (and to a lesser extent deer) would likely be a major item in the spring bear diet. The

elevational limit for wintering elk during most years is in favorable proximity to higher, more remote slopes where bears are most likely to den (Craighead and Mitchel 1982, Servheen and Klaver 1983, Aune et al. 1984). Areas especially significant in this regard include the East Fork (San Juan River), Blanco, and Navajo River valleys to the west of the Continental Divide. Winter concentration areas for both elk and deer occur along the eastern flank of the study area (Fig. 2).

Other common mammals that are likely to be consumed by grizzly bears in the study area include mule deer (*Odocoileus hemionus*), northern pocket gopher (*Thomomys talpoides*), vole (*Microtus* spp.), mouse (*Peromyscus* spp.), golden-mantled ground squirrel (*Citellus lateralis*), yellow-bellied marmot (*Marmota flaviventris*), and beaver (*Castor canadensis*) (Knight et al. 1982, McNamee 1984, Almack 1986, Mace 1987). Pocket gophers were very abundant in the study area, particularly in alpine, aspen, and meadow cover types. Their widespread occurrence in all climatic zones could make them a major food for grizzlies in the South San Juans. In 1988, voles were especially abundant in oak and ponderosa pine cover types. Grizzly bears readily consume both gophers and voles, along with their caches, particularly during the critical spring period when other foods are limited (Knight et al. 1984).

Ants are an important grizzly bear food in other ecosystems (Knight et al. 1984, Mace 1987). In the South San Juans, ant hills were common in all but the alpine zone. They were especially abundant in dryland cover types. Ants would likely be a major food item in the study area since ant hills represent only a portion of the ant nests available to bears. In the Yellowstone area, for example, ant hills comprised only 24% of ant feeding sites for grizzly bears. Most (61%) ant nests occurred in logs (Knight et al. 1982).

Cover Types

In the South San Juans, grizzly bears would be expected to use several primary cover types in meeting their nutritional and cover requirements. Bears are mobile, wide-ranging animals that maintain themselves by drawing on resources that are often well dispersed, both spatially and temporally (Craighead 1980, Craighead and Mitchel 1982, Knight et al. 1984).

Alpine cover is prevalent in the central portion of the study area, from where it extends to the northwest (Fig. 3). It includes about 363 sq km (4%) of the study area, and, while occurring in 30% of study area quads, is the most limited of primary cover types. Alpine may rank below subalpine and temperate zone cover types in meeting the grizzly's nutritional needs (Craighead et al. 1982). However, rugged and remote alpine terrain, particularly in the west-central portion of the ecosystem, would provide important cover and seclusion for grizzly bears. Elsewhere, some grizzlies have used the alpine preferentially (Kasworm 1985).

Spruce-fir cover, comprised largely of Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*), flanks the alpine zone, and extends into the southern portion of the ecosystem. It includes about 1,361 sq km (16%) of the study area, and occurs in 49% of its quads. Cover and isolation are provided by dense forests, as well as by remote and rugged terrain. Forest-meadow edge is well represented, as 70% of the spruce-fir cover type included a significant (10–<50%) meadow component. Snowchutes commonly occur within this cover type in the central/west-central portion of the ecosystem (Fig. 2). They can be important foraging sites for grizzlies (Kasworm 1985, Mace and Bissel 1986, Mace 1987).

Mixed conifer broadly flanks the spruce-fir cover type, and often intergrades with it, as topographic and edaphic conditions allow. Major tree species are Engelmann spruce, Douglas-fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), ponderosa pine (*Pinus ponderosa*), and aspen. Mixed conifer has the widest distribution of the forest cover types, occurring in 70% of the quads. It covers an area of 1,553 sq km (18% of the study area), making it the predominant forest cover type in the ecosystem. Mixed conifer is especially well represented along the upper limits of ungulate winter range (Figs. 2 and 3). Elk calving areas are commonly located within this cover type. Mixed conifer forests often provide dense understory cover, and frequently occupy rugged mid and lower valley slopes, as, for example, along the Conejos and Navajo Rivers.

The aspen cover type is well interspersed with spruce-fir and mixed conifer types, except at upper elevations in the subalpine climatic zone, where it is uncommon, and over large areas of the southern part of the ecosystem, where it is the dominant cover type. Aspen cover is well represented and widely distributed in the South San Juans, occupying 933 sq km (11%) of the ecosystem, and occurring in 60% of its quads. Aspen stands were often characterized by heavy ground cover, with snowberry, vetch (*Vicia americana*), peavine (*Lathyrus leucanthus*), golden banner (*Thermopsis montana*), and grasses among the more common plants.

An analysis of grizzly bear habitat use in the Yellowstone ecosystem suggests a preference for aspen where it is a significant cover type (Knight et al. 1984). In Montana, aspen received primary use by radio-collared bears (26–30% of fixes), with more mesic stands preferred over those with drier understories (Aune et al. 1984, 1986).

The meadow cover type, representing 1,636 sq km (19% of the landscape), is the most widespread, occurring in 93% of the quads. While meadows are generally no larger than several sq km, large tracts of subalpine and montane meadow do occur, particularly in the southern part of the ecosystem. Meadow is the primary cover type of major bottomland areas in the central portion of the ecosystem (Fig. 2). Many of

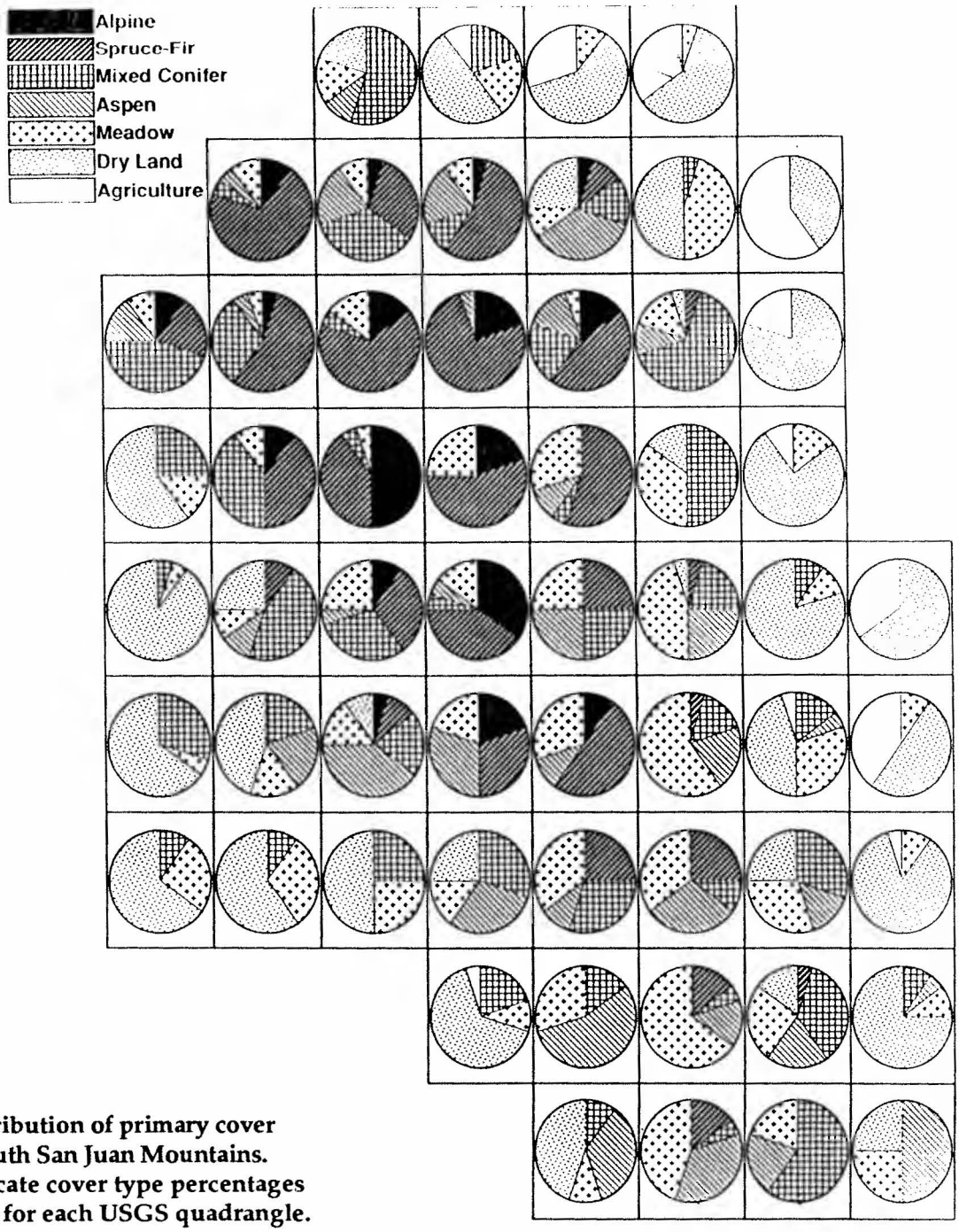


Figure 3. Distribution of primary cover types in the South San Juan Mountains. Pie charts indicate cover type percentages (to nearest 5%) for each USGS quadrangle.

these bottomland areas (17 of 26 areas) include significant spruce-fir, mixed conifer, aspen, narrowleaf cottonwood (*Populus angustifolia*), and/or willow (*Salix* spp.) components.

The cover types discussed above are encircled by dryland cover, except in the northwest and south-central portions of the study area. Dryland cover, occurring in 58% of the quads, occupies 2,419 sq km (28%) of the study area, with 51% of it being grassland, 24% oak brush, 15% ponderosa pine, and 10% pinyon-juniper cover. The distribution of cover types containing significant amounts (>10%) of oak and pinyon pine is shown in Fig. 4.

Nearly a third (2,787 sq km) of the South San Juan ecosystem was classified as forest-meadow (for which the meadow component varied from 10–<50%). Forest-meadow cover types are well represented in the study area (Fig. 4), especially within ungulate winter range along the eastern flank of the ecosystem, and near the upper Blanco and Navajo River valleys on the western side of the Continental Divide (Figs. 2 and 4). Forest-meadow cover is of special interest because grizzly bears show a high preference for forest/non-forest ecotones, and tend to occur within 100 m

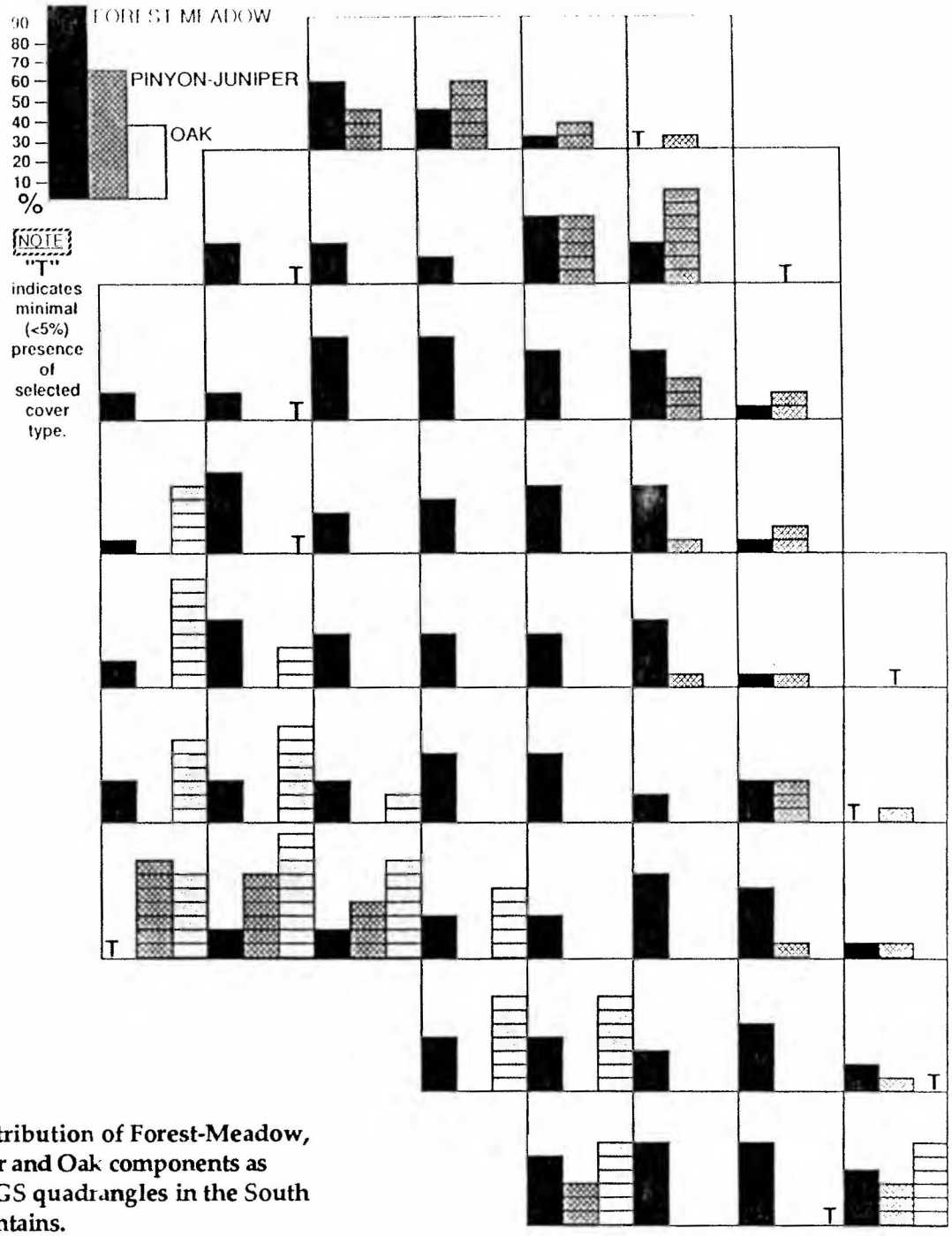


Figure 4. Distribution of Forest-Meadow, Pinyon Juniper and Oak components as percent of USGS quadrangles in the South San Juan Mountains.

or less of forest cover (Blanchard 1983, Mace 1987). In the Yellowstone area, sixty-two percent of grizzly bear feeding sites were located less than 30 m from the timber edge (Knight et al. 1982).

Major cover types in the South San Juan ecosystem are well juxtaposed, and, in the case of the mixed conifer, aspen, and meadow types are well interspersed. Being highly mobile animals, grizzly bears in the South San Juans could readily draw on resources from several different cover types during a period of weeks or even days. Bears might also make annual or alternate year use of certain cover types (Canfield and Harting 1987), as, for example, in securing ungulate carrion in mixed conifer-dryland cover, or acorns in oak cover.

Land Use

Primary human activities in the South San Juans include recreation, tourism, commerce, agriculture, ranching, livestock grazing, timber harvest, and mining. Fig. 5 shows areas of concentrated human use, as well as a central core area of contiguous habitat where human activity is relatively light.

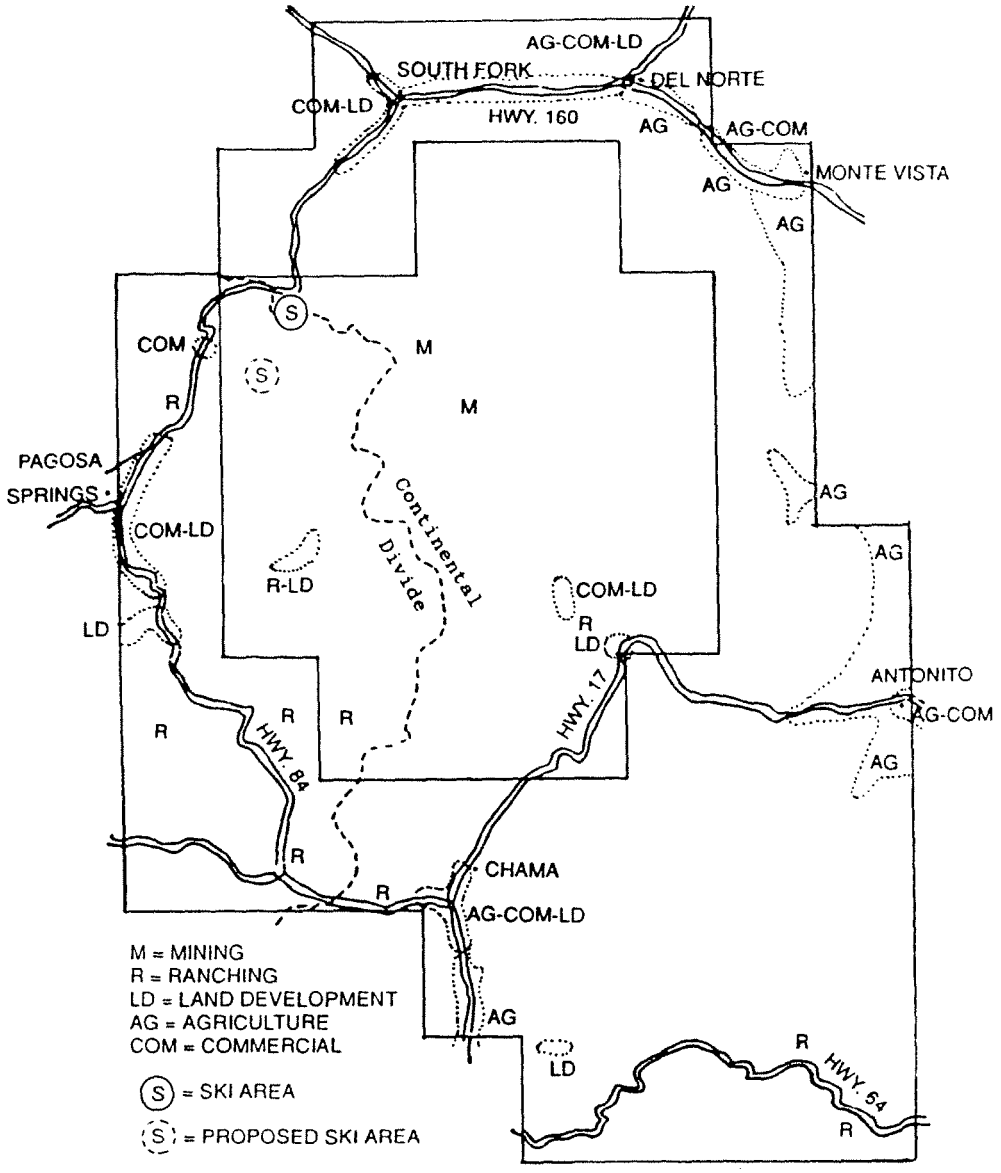


Figure 5. Areas of concentrated human use in the South San Juans. Boundary of core habitat for grizzly bears is shown in center of study area.

Major agricultural areas partially or entirely under cultivation represent 381 sq km (4%) of the study area. Agricultural lands occur primarily along the northern and eastern boundaries of the study area, and to the south of Chama, New Mexico.

Major concentrations of livestock on private lands occur along the Rio Grande east of South Fork, in the San Luis Valley between Monte Vista and Antonito, and along Highway 84, between Pagosa Springs and Chama. Some livestock grazing on private land occurs within the core area, primarily along the Blanco and lower Navajo Rivers.

Livestock use of public lands within the core area is shown in Fig. 6. In recent years, about 8,195 cattle (and some horses) and 14,904 sheep (and some goats) were present annually, representing 30,070 and 35,827 animal months, respectively.

Real estate development is occurring primarily along the Rio Grande between South Fork and Del Norte, to the south of Chama, in the Pagosa Springs area, and along the Rio Blanco. A major ski development for the East Fork of

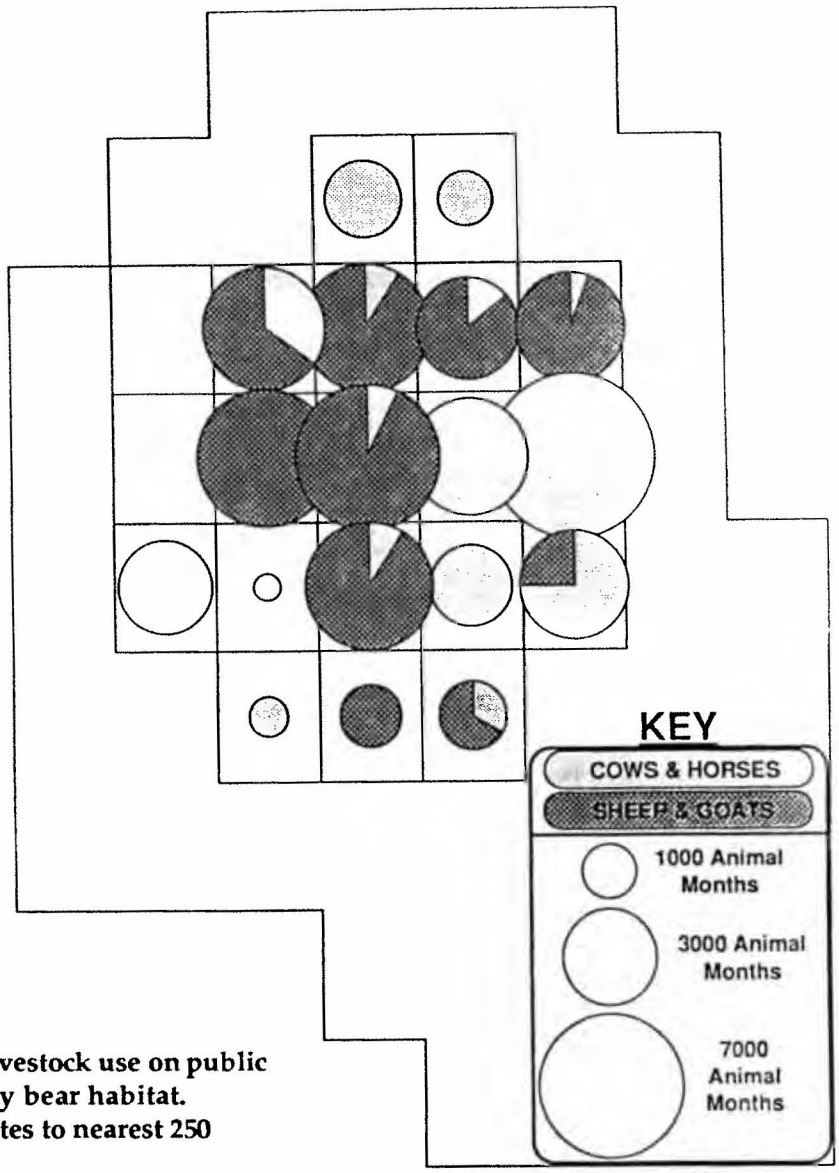


Figure 6. Comparative livestock use on public lands within core grizzly bear habitat. Figures represent estimates to nearest 250 Animal Months.

the San Juan River has been approved by the U.S. Forest Service (S. H. Hanks, U.S. Forest Service, pers. comm.), but is under appeal by the National Wildlife Federation, the Ute Mountain Ute tribe, and local conservationists. Mining occurs primarily in the north-central portion of the study area, with most activity at Summitville.

There are about 4,208 km of officially designated roads in the study area, giving an overall road density of .48 km/sq km (.78 mi/sq mi). Eleven percent are paved, while 9%, 27%, and 53% are considered all-weather, dirt, and 4-wheel drive roads, respectively. Road density for the core area is .32 km/sq km (.51 mi/sq mi). Figure 7 compares road densities for study area quads.

It is evident from land use patterns in the study area that some of it would be unavailable to grizzly bears. Bears can be expected to avoid, or limit their use of, areas intensively used by people (Dood et al. 1986). Given current land use practices and limited natural cover, grizzly bears would not likely use the Rio Grande corridor, and the area to the north of it, from the South Fork area to Monte Vista. Likewise, they would not be expected in the agricultural lands between Monte Vista and Antonito, and over much of the ranching country in the southwestern part of the study area. These areas collectively comprise about 17% of the study area. In addition, grizzly bears would likely avoid much of the San Juan River Valley, and portions of the Blanco River Basin (1% of the study area).

Substracting major human-use areas from the total study area results in about 7,142 sq km of potential habitat for grizzly bears in the South San Juans. This compares favorably with that of other small grizzly bear ecosystems, like the Cabinet-Yaak, which is considered essential to grizzly bear recovery in the Northern Rockies (USFWS 1982, 1987).

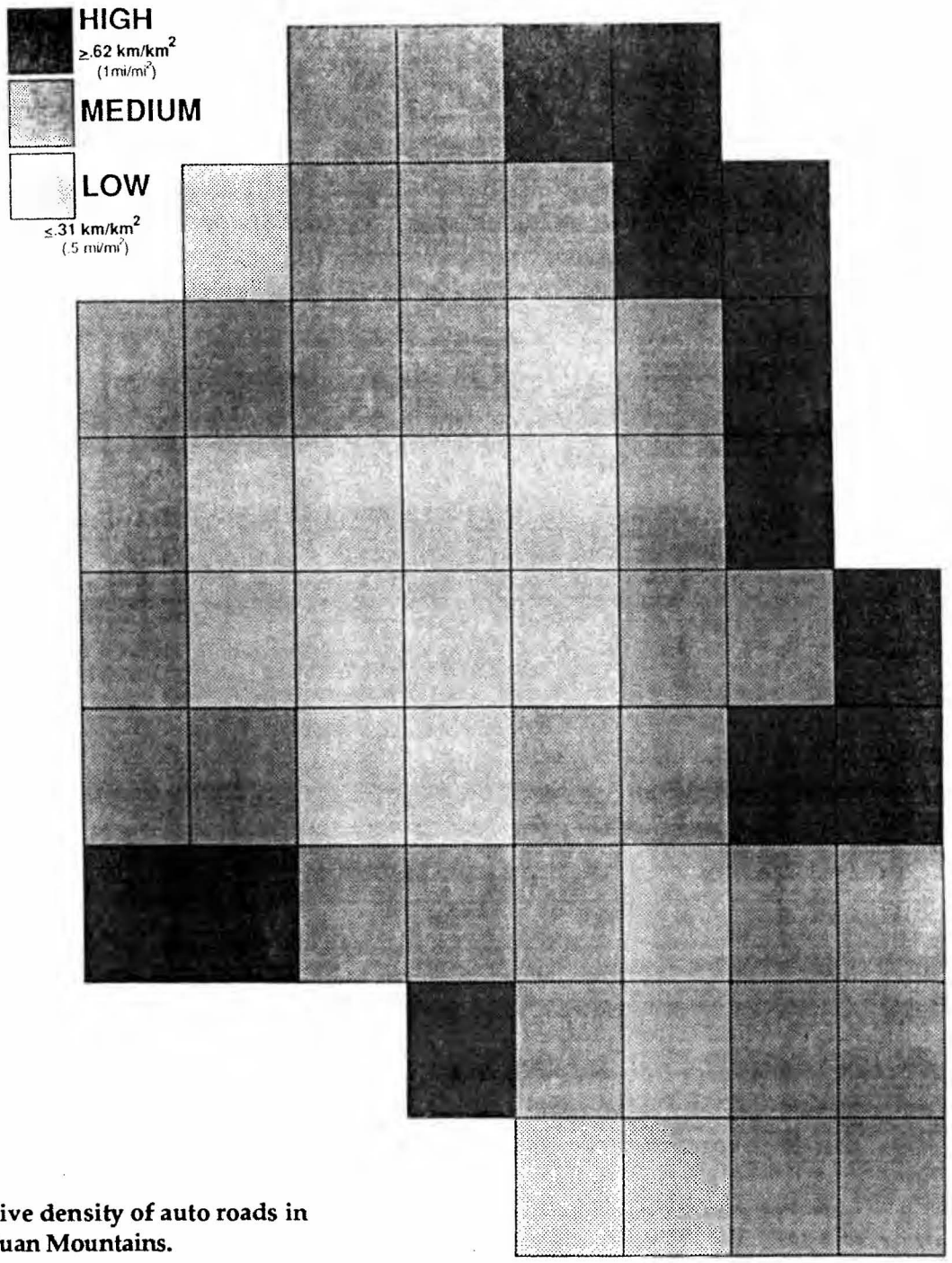


Figure 7. Relative density of auto roads in the South San Juan Mountains.

Population Size and Viability

Grizzly bear densities in the northern Rockies vary from about 1 bear/21 sq km in the high quality habitat of Glacier National Park (Martinka 1974) to a *minimum* of 1 bear/118 sq km in the lower quality habitat of the Yellowstone area (based on Knight et al. 1988). Montana has set a density of 1 bear/39 sq km to 1 bear/104 sq km as its recovery goal for various grizzly bear ecosystems in the state, exclusive of Glacier National Park (Dood et al.1986.)

Given available foods and cover, the South San Juans should be able to support a bear density comparable to that recommended for grizzly bear ecosystems in Montana. The South San Juans contain a diversity and abundance of grizzly bear foods, suitable rugged and remote terrain, dense shrub and forest cover, and, in comparison with northern ecosystems, a relatively high proportion of temperate zone habitat. The temperate zone was rated above subalpine and alpine zones for overall habitat value for grizzlies in Montana (Craighead et al. 1982), and cub production may be greater in lower elevation habitats (Dood et al. 1986).

Applying the average of the recovery densities (1 bear/72 sq km) for the grizzly bear in Montana to an

estimated 7,142 sq km of available habitat in the South San Juans gives a potential population of 42 bears for the core area, and about 100 bears overall. The author suggests that, with proper habitat restoration, the South San Juans could ultimately support an overall population of 50–100 bears.

Estimates of minimum viable population (MVP) size (having a 95% chance of persistence for 100 years) for the grizzly bear in the Yellowstone area have ranged from 40–125 bears (Shaffer 1983, Shaffer and Samson 1985, Suchy et al. 1985). Estimates varied substantially with modest changes in mortality and reproduction.

While such MVP sizes may be an essential longer term conservation goal, Dood et al. (1986) point to instances of much smaller populations of *Ursus arctos* surviving in Europe. The persistence of the grizzly in the South San Juans until at least 1979 further indicates that grizzly bears can survive in small numbers, at least for several decades.

Restoration Measures

Grizzly recovery in the South San Juans would depend largely on the control of human activities which significantly reduce available habitat and increase mortality risk for grizzly bears. Primary sources of conflict between bears and people would involve livestock, roads, and the development of bottomland.

Harting (1987) summarized how, in other grizzly bear ecosystems, the presence of livestock, particularly sheep, may result in significant mortality and displacement of bears. Yet, to some degree, grizzly bears can coexist with livestock without serious depredation conflicts. In the Yellowstone area, some livestock are permitted in grizzly habitat on national forests, although much of the ecosystem, represented by Yellowstone National Park, is livestock free (Greater Yellowstone Coord. Comm. 1987). Grizzly bear restoration in the South San Juans would likely require removal of domestic sheep, and much of the cattle, from the core area, and some reduction of livestock in areas of high quality habitat elsewhere in the ecosystem.

Roads increase the likelihood of conflict between grizzly bears and people, and contribute substantially to the risk of poaching (McLellan and Shackleton 1988). In Montana, 48% of total grizzly bear mortality, for which locations were known, occurred within 1.6 km of roads (Dood et al. 1986). Roads also displace grizzly bears from otherwise suitable habitat (Kasworm 1985, Dood et al. 1986, Mattson et al. 1987). For elk, whose sensitivity to disturbance may be comparable to the grizzly's, habitat use can be expected to decline by 25% when open road densities reach .62 km/sq km (1 mi/sq mi) (Lyon et al. 1985). Grizzly bear habitat in the South San Juans could be significantly improved by decreasing road density in the core area, and along the eastern edge of the ecosystem, where it exceeds .62 km/sq km (1 mi/sq mi) (Fig. 7).

Restoration of grizzly bears in the South San Juans would require that development of bottomland habitat, for increased residential or recreational use, be avoided in the core area, and carefully regulated elsewhere. Developed areas within prime habitat can result in levels of disturbance and mortality risk (from control actions and poaching) that threaten grizzly bear recovery (Povilitis 1986, 1987, Mattson et al. 1987).

Land development should be avoided in the northwest portion of the South San Juan ecosystem. This area represents a potential dispersal corridor between the South San Juans and the Weminuche Wilderness (Fig. 1), where a secondary grizzly population might eventually establish itself.

Human-bear conflicts in the South San Juans could be minimized by a habitat zoning system such as that prescribed for public lands in other ecosystems (Grizzly Bear Guidelines, Fed. Reg., 11/26/86). Management situation (MS) 1 areas are those essential to the survival and recovery of the grizzly bear. Habitat maintenance and improvement receive highest priority, and land uses are adjusted to meet the species needs, or are disallowed. MS 2 areas, while important to the grizzly, represent secondary habitat, where other land-uses may be given priority. MS 3 areas involve centers of human activity, where grizzly bear presence is discouraged.

Grizzly bear restoration in the South San Juans would likely require that the core area, and the New Mexico highlands in the southeastern portion of the ecosystem, be classified as MS 1. The remainder of the ecosystem could be classified as MS 2, with the exception of those areas of highest human use along the ecosystem's perimeter, which would be MS 3.

Until the issue of grizzly bear restoration in the South San Juans can be adequately addressed, federal lands within the ecosystem should be treated as MS 4, which is defined as follows:

> Grizzlies do not occur in the area but habitat and human conditions make the area potentially suitable for grizzly occupancy, and the area is needed for the survival and recovery of the species (i.e. in the Southwest). . . . Habitat and human conditions making the area suitable for grizzly occupancy will not be degraded pending decisions regarding reestablishment of grizzlies (Grizzly Bear Guidelines, Fed. Reg., 11/26/86).

Reestablishing grizzly bears in the South San Juans might involve techniques such as cross-fostering of grizzly bear cubs with resident black bear females, and the transplanting of grizzly bears from other ecosystems (USFWS 1987). Transplanted bears could be closely monitored through radio telemetry. An initial step would be to establish a "seed" population, which would expand as habitat restoration progressed.

Grizzly bear restoration in the South San Juans would require a cooperative planning effort on the part of public agencies, private landowners, Indian tribes, businesses, concerned citizens, and biologists. Primary motivation could include a desire to provide wildlife-wildlands benefits of exceptional quality for the Southern Rockies, and to actively participate in the global challenge of conserving biological diversity (Wilson 1988). Recovery of the grizzly bear could be achieved through land-use partnerships similar to those that have hallmarked the conservation of other outstanding natural areas (Lohmann 1987).

SUMMARY AND CONCLUSIONS

The South San Juans Mountains appear capable of supporting a small grizzly bear population within an estimated 7,142 sq km of available habitat. This area offers a variety and abundance of natural foods for the grizzly bear, which include grasses, forbs, berries and acorns, ungulates, small mammals, and ants. These foods, as well as cover for concealment and escape, are associated, in varying degree, with 6 primary cover types. The physical proximity of these cover types within the ecosystem would allow grizzly bears to draw on a wide range of resources in meeting their nutritional and cover needs. The South San Juans offer substantial amounts of favorable temperate zone habitat, represented by mixed conifer, aspen, and meadow cover types.

Restoration of the grizzly bear in the South San Juans would likely require withdrawal of most livestock from a 3,068 sq km area of core habitat, as well as from areas of high quality habitat elsewhere in the ecosystem. Limitiations on road access and bottomland development would also be needed. These measures would serve to minimize the risk of human-caused mortality to grizzly bears, and allow the animals fuller use of available habitat.

What needs to be done to restore grizzly bears to the South San Juans? Most urgently, available habitat must be conserved. The U.S. Forest Service and the Bureau of Land Managment should take the lead by designating public lands within this ecosystem as "management situation 4," meaning that habitat will not be degraded pending decisions regarding reestablishment of grizzlies. Secondly, interested citizens and organizations need to build local and regional support for reestablishing grizzly bears. Emphasis should be on greater wildlife-wildlands benefits and opportunities through grizzly recovery. Thirdly, field studies should continue to assess, on a finer scale, grizzly habitat potential in the South San Juans. Fourthly, the potential economic benefits and costs associated with grizzly bear recovery should be evaluated, along with alternatives for persons whose current activities would be restricted in grizzly bear habitat. Finally, private-public sector partnerships could be formed to help ensure compatibility between grizzly bear recovery and other land uses.

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WOLF AND GRIZZLY BEAR MANAGEMENT IN THE WESTERN UNITED STATES: WHERE DO WE GO FROM HERE?

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Abstract: Gray wolf (*Canis lupus*) and grizzly bear (*Ursus arctos*) management in the western United States has caused political as well as biological controversy. Although public opinion surveys have shown general approval by citizens toward predator protection and recovery, confrontations between wolf/bear advocates and certain ranchers and sport hunters persist.

The controversy has resulted in tension over state versus federal control of wildlife. Some states and local interests have voiced strong opposition to the limitations on management set forth by the Endangered Species Act (ESA), especially as interpreted by the courts. In an effort to gain more control over wolf and grizzly bear management, some states have requested expedited delistings, sport hunting seasons for some populations, and legislative changes in the ESA.

Except for defense of human life, regulations under the Endangered Species Act allow only authorized agents to take naturally occurring endangered wolves. Threatened grizzly bears can be taken by authorized agents and by hunters. Reintroduced wolves could be managed under non-essential experimental population regulations which could possibly be written to allow taking by ranchers and hunters under certain circumstances, as well as by authorized agents.

INTRODUCTION

Historical Perspective

Westward expansion by European man throughout the United States was not favorable to grizzly bears (*Ursus arctos*) or gray wolves (*Canis lupus*). As settlers cleared the land and brought in domestic livestock, these large mammalian predators became victims of habitat destruction and a distinct animosity from the growing human population. Due to loss of habitat and eradication programs, gray wolves and grizzly bears were extirpated in most of the contiguous United States. Having a historical range that extended throughout much of North America, by 1930 gray wolves existed in viable numbers in the contiguous United States only in northern Minnesota (Mech 1970). The grizzly bear once ranged throughout the western United States but now survives in only 4 states south of Canada—in 6 remnant populations (Servheen 1985). Large populations of both these species remain in Canada and Alaska.

Since the mid-1900s, some segments of the public have become more sympathetic toward wolves and grizzly bears. This helped bring about changes in predator management in many states, including dissolution of bounty laws and bans on predator poisoning (Kellert 1987). Western state agencies began actively managing for the remaining grizzly bears. Then, with the passage of the Endangered Species Act (ESA) in 1973, options for managing wolves and grizzlies changed substantially. Gray wolves and grizzly bears in the conterminous U.S. were soon listed under the ESA. This provided a greater level of legal protection for the grizzly bear and its habitat than previously available. In addition, listing the gray wolf throughout the conterminous U.S. led to efforts to re-establish wolves in the western states.

Current Public Attitudes

Although public opinion surveys have shown general approval by citizens toward predator protection and recovery (e.g., McNaught 1987), portions of the American public still cling to misconceptions about wolves and grizzly bears (Kellert 1987, Lecount and Baldwin 1983). Some misconceptions about grizzly bears develop from the rare, but well-publicized, instances of bear attacks on humans. Many misconceptions about both grizzly bears and wolves stem from tales and myths which portray these predators in an unfavorable light (Skinner 1985).

Adding to the negative attitudes fostered by a lack of knowledge of wolves and grizzly bears, some interest groups strongly oppose plans for the protection and recovery of wolves and grizzly bears. These interest groups include certain livestock ranchers and big-game hunters.

Some people in the livestock industry have long considered wolves and grizzly bears to be in direct competition with their livelihood. Both of these predators -- especially wolves -- have evolved to utilize hoofed animals in their diets. The omnivorous grizzly bear is not highly dependent on ungulates as prey; however, depredations of livestock do occur. Because of these potential predation problems, most western livestock ranchers are concerned about the prospect of increased numbers of grizzlies. A spokesperson for the National Wool Growers Association commented that the recovery of grizzly bears into parts of their former range is "ludicrous" and "absurd" (Helle 1980).

Livestock ranchers in the Northern Rockies have also shown a great deal of concern over the recovery of gray wolves. Kellert (1985) polled farmers in Minnesota and found that a majority believe they cannot "coexist in the same area" with wolves. Similar sentiment occurs in the West (Bath 1987), and emotions run even higher on the prospect of wolf reintroductions because western ranchers

have been living without the wolf for many decades (Mader 1988).

Although many hunters in the West feel that wolves and grizzly bears have a place in natural ecosystems (Tucker 1988), others have expressed concerns (Edwards 1987). Big game hunters and wolves pursue the same North American game animals such as moose (*Alces alces*), elk (*Cervus elaphus*), and deer (*Odocoileus* sp.). If wolves significantly lower the density of game, then opportunities for hunters may be reduced. In addition, guides and outfitters must follow regulations to minimize conflicts with grizzly bears.

Management Jurisdiction of Wolves and Grizzly Bears

The role the Endangered Species Act plays in managing wolves and grizzly bears in the West has created conflicts with state managing agencies. Historically, state wildlife agencies were viewed as being entitled to manage wildlife within their borders (Bean 1983). During the last 80 years, however, there has been considerable erosion of their management powers as Congress has enacted specific laws for control of migratory species and other species of national and international concern. For example, migratory birds became subject to federal regulations in 1918 with the passage of the Migratory Bird Treaty Act, and marine mammals are now managed under the Marine Mammal Protection Act of 1972 (Bean 1983).

With the passage of the Endangered Species Act, the federal government took primary responsibility for species listed as threatened or endangered, which includes the wolf and grizzly bear. States now manage these species only through cooperative agreements. To enter into a cooperative agreement a state must establish and maintain "an adequate and active program for the conservation of endangered species and threatened species." 16 U.S.C. § 1535(c)(1).

Representatives from some western states, which have a high percentage of federally managed lands, have already expressed resentment over the amount of federal government control over natural resource decisions in the West. *See, e.g.*, 134 Cong. Rec. S9766 (daily ed. July 25, 1988) (statement of Sen. McClure). Some people maintain that the ESA only exacerbates this resentment.

Purpose of this Paper

While grizzly bears and wolves have clearly distinct biological needs, three common factors bond these species together politically: (1) these species are large mammalian predators capable of destroying livestock and instilling fear in people, (2) both species, perhaps partly because of the above, require undisturbed wilderness for their survival, and (3) both are currently protected under the Endangered Species Act. Wildlife management clearly recognizes that the killing of individual animals, by predators, disease, or man, is not inconsistent with healthy populations (Errington 1967). The ESA, however, severely restricts man-caused deaths of individual animals as part of the overall effort to prevent extinction of the population.

The conflict between the desires to increase populations and to control individuals has created a variety of controversies primarily centered around the ESA's restrictions on the taking of these species. The purpose of this paper is to analyze the need for control of individual wolves and grizzly bears, to evaluate the legal and political restraints on this control, and to offer options for improving current laws and regulations.

THE ENDANGERED SPECIES ACT

Congress enacted the Endangered Species Act "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, [and] to provide a program for the conservation of such endangered species and threatened species. . . ." 16 U.S.C. § 1531(b). An endangered species is "any species which is in danger of extinction throughout all or a significant portion of its range," and a threatened species is "any species which is likely to become an endangered species within the foreseeable future. . . ." 16 U.S.C. § 1532(6), (20)(1986).

Protective Provisions

The ESA mandates protective measures for species listed as threatened or endangered. Provisions of the Act control the taking of these species. The term "take" is defined to include "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct". 16 U.S.C. § 1532(19)(1986). However, in this regard, the ESA applies differently to endangered, as opposed to threatened, species.

Threatened species are not afforded direct statutory protection from taking as is the case for endangered species. Rather, under Section 4(d) of the ESA, the Secretary is directed to "issue such regulations as he deems necessary and advisable to provide for the conservation of "threatened species. 16 U.S.C. § 1532(3)(1986). "Conservation" in the ESA means "to use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act are no longer necessary." Such methods "in the extraordinary case where population pressures within a given ecosystem cannot be otherwise relieved, may include regulated taking." 16 U.S.C. § 1532(3)(1986).

Recovery Requirements

In addition to prohibitory provisions, the ESA calls for the affirmative recovery of listed species to "the point at which the measures provided pursuant to [the ESA] are no longer necessary." 16 U.S.C. § 1532(3)(1986). Recovery

efforts may include the reintroduction of some species outside of their current range.

Amendments to the ESA in 1982 provide increased flexibility in managing these experimentally reintroduced populations of endangered species. Section 10 calls for experimental populations to be generally treated as a threatened species. 16 U.S.C. § 1539(j)(2)(c)(1986). Thus experimental populations of endangered species, like threatened species, are subject to the ESA's taking prohibitions by regulation rather than by statute. *See* 16 U.S.C. §§ 1533(d), 1539(j)(2)(C); 50 C.F.R. § 17.31(a). The circumstances under which a permit for taking a threatened species and, hence, a member of an experimental population, may be issued are somewhat broader than for an endangered species. *Compare* 50 C.F.R. § 17.22 with 50 C.F.R. § 17.32.

An experimentally reintroduced population that is considered to be "not essential to the continued existence of [the parent population of] a species" and which does not occur in national parks or refuges shall be treated "as a species proposed to be listed" for purposes of several provisions under Section 7 of the ESA. 16 U.S.C. § 1539 (j)(2)(c)(i)(1986). In contrast to the stringent consultation requirements for listed species, Section 7 only requires, for species proposed to be listed, that federal agencies confer with the FWS on any action which is likely to jeopardize such species or result in the destruction or adverse modification of proposed critical habitat for such species. 16 U.S.C. § 1536(a)(4).

WOLF AND GRIZZLY BEAR MANAGEMENT UNDER THE ESA

The Endangered Species Act is a powerful and comprehensive tool for protecting and recovering wolves and grizzly bears. While some progress has been made in recovering grizzly bear populations, the future of these two species in the conterminous United States remains uncertain.

Grizzly Bear Management

Listing the Grizzly Bear

The grizzly bear in the lower 48 states was listed as threatened in 1975. Accompanying the listing notice were regulations allowing the taking of bears in 4 circumstances: 1) in self-defense, 2) relieving a "demonstrable but non-immediate threat to human safety", 3) controlling livestock, crop, or beehive depredations, and 4) permitting a very limited sport hunt in northern Montana within the Flathead National Forest, the Bob Marshall Wilderness Area, and the Mission Mountains Primitive Area. 40 Fed. Reg. 31734, 31735 (July 28, 1975). These allowances clearly reflect the concerns of constituencies who were pressuring the FWS not to list the grizzly bear, including livestock interests and big game hunters. Sport hunting was justified in the regulations to reduce "population pressures" that could not "otherwise be relieved." However, it was probably a justification based as much on political pressures as on biological fact. According to Lynn Greenwalt (1988), the Director of the FWS at that time, the listing of the grizzly bear would not have occurred at all unless such an allowance was made.

Grizzly Bear Recovery Plan

The FWS completed a recovery plan for the grizzly bear in 1982 (a revised plan should be completed in the near future). The goal of the 1982 plan is to establish healthy, self-sustaining populations of bears in 3 of the 6 ecosystems where they were known to exist in 1975. The 3 ecosystems chosen for recovery are: 1) the Yellowstone Ecosystem of Montana, Idaho and Wyoming, 2) the Northern Continental Divide Ecosystem of northern Montana, and 3) the Cabinet-Yaak Ecosystem of northern Montana and Idaho. There is no current plan to introduce grizzly bears to parts of their former range or to expand the ecosystems beyond currently occupied habitat (Servheen 1988).

Gray Wolf Management

Listing the Gray Wolf

The listing of the gray wolf also met with opposition, but the conflicts were centered in northern Minnesota where the only viable population existed prior to protection. The wolf was automatically listed as endangered the year the ESA became law as a result of being listed as threatened under the Endangered Species Conservation Act of 1969. However, according to Yaffee (1982), political pressures from livestock interests resulted in the Minnesota wolf being reclassified to threatened status in 1978. The species elsewhere in the lower 48 states is still considered endangered. Controversy spread westward when wolf recovery plans for the northern Rockies started being discussed.

Recovery of the Gray Wolf in the Northern Rockies

Since a program for recovery is mandated by the ESA for threatened and endangered species, in 1975 the FWS appointed a team of experts to prepare a recovery plan for wolves in the northern Rockies. The first plan was approved in 1980, and an updated edition of the plan was approved in 1987. The primary goal stated in the plan is "to remove the Northern Rocky Mountain wolf from the endangered and threatened species list by securing and maintaining a minimum of 10 breeding pairs in each of three recovery areas for a minimum of 3 successive years." (U.S. Fish and Wildlife Service 1987:v)

The plan calls for the recovery of gray wolves in the following three areas of the northern Rockies: northwest Montana, central Idaho, and the ecosystem encompassing Yellowstone National Park (See Figure 1.). These 3 areas

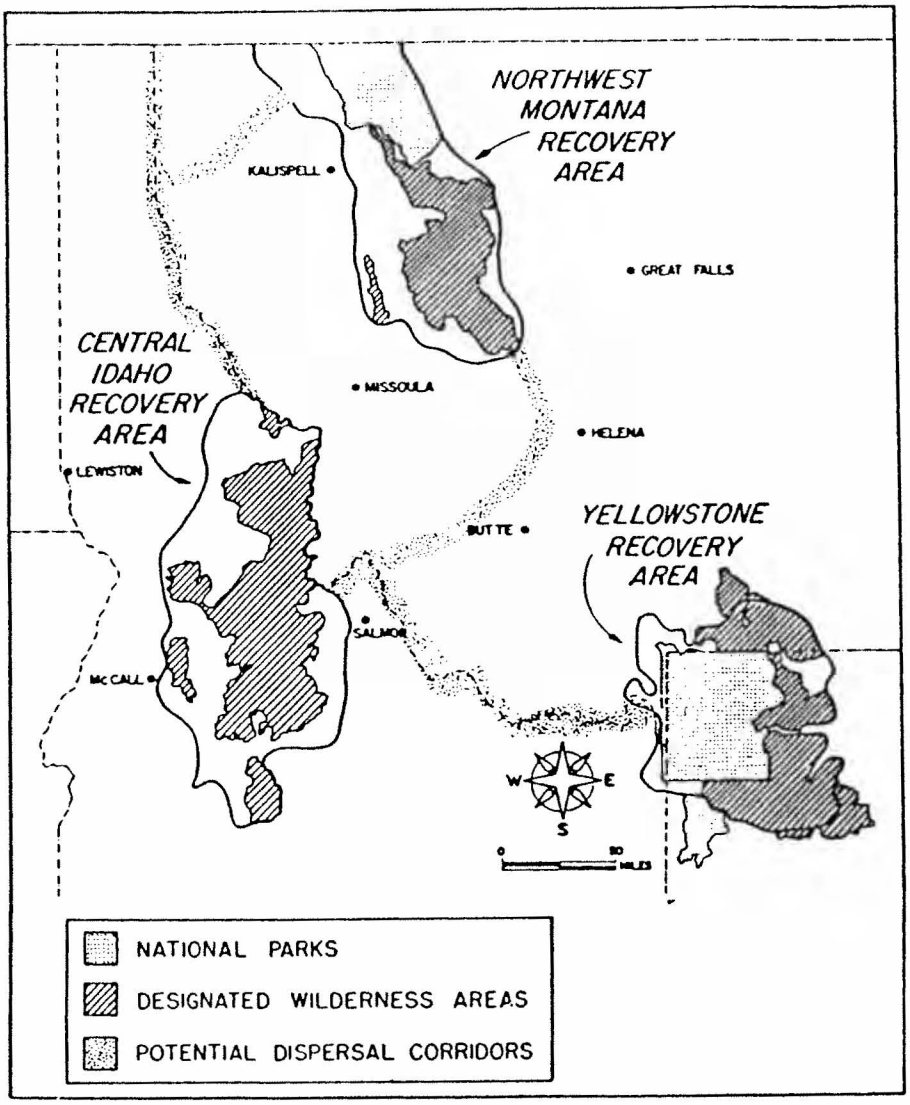


Figure 1. Recovery areas for the gray wolf in the northern Rockies (from U.S. Fish and Wildlife Service 1987:23).

were chosen for their low human population, large areas of federal land, reduced potential for livestock depredation, and abundance of natural prey (U.S. Fish and Wildlife Service 1987).

According to the recovery plan, reintroduction will be necessary in the Yellowstone Ecosystem, and natural dispersal from Canada will be relied upon for repopulation into the other two areas. Wolves are already dispersing across the Canadian border into northwest Montana. Three to five packs have been documented crossing the border intermittently into Glacier National Park. Natural dispersal into central Idaho may take longer since greater travel distances are involved (Kaminski and Hansen 1984).

LEGAL DEVELOPMENTS

Implementation of the Endangered Species Act has been addressed in several court cases. The outcome of two lawsuits regarding wolf management in Minnesota predominates in debates over how much flexibility is allowed in the management of wolves and grizzly bears in the West. A more recent lawsuit in Montana deals with the legality of private citizens killing grizzly bears in defense of livestock.

In 1978, several environmental organizations opposed the manner in which the FWS was controlling depredating wolves in Minnesota. They argued that the FWS was taking non-depredating wolves because traps were set as far as 5 miles away from where depredations had occurred, and the procedures also included trapping wolves around farms before depredations actually happened (O'Neill 1988). Regulations written by the FWS allow authorized state or federal personnel to take targeted wolves that commit significant depredations on lawfully present livestock. A court decision rendered in *Fund for Animals v. Andrus*, 11 Env't. Rep.

Cas. (BNA) 2189 [D. Minn 1978], stated that the FWS was not following its own regulations and ordered the FWS to control wolves only after significant depredations had occurred and to trap in a way that reasonably assures that only depredating individuals are taken (Goldman-Carter 1983).

In another lawsuit, several environmental organizations contested FWS regulations issued in 1984 which allowed the sport trapping of wolves in Minnesota. In *Sierra Club v. Clark*, 577 F. Supp. 783 [D. Minn. 1984], *aff'd*, 755 F.2d 608 (8th Cir. 1985), the courts concluded that the proposed sport trapping of these threatened wolves was unlawful (Bean 1986). The district court based its ruling on the ESA provision that allows the taking of threatened species in circumstances of extraordinary population pressures. In defending its actions, the FWS made no attempt to demonstrate that the sport trapping regulations were necessary to relieve population pressures of the wolves in Minnesota.

In *Christy v. Hodel*, 857 F.2d 1324 (9th Cir. 1988), livestock ranchers contested regulations which forbid them from killing grizzly bears in defense of their sheep. The regulations allow only state, federal or tribal authorities to kill bears in such circumstances. The plaintiffs contended that such regulations impair a constitutional right to protect their property. They also argued that the regulations which allow a grizzly bear sport hunt while not giving authority to livestock owners to kill grizzlies are irrational. The court disagreed with the plaintiffs, concluding that killing threatened wildlife is not a constitutional right and that allowing a regulated sport hunt is not an irrational interpretation of the law when grizzly population pressures cannot otherwise be relieved.

Some wildlife managers and others believe that these rulings unreasonably limit options for managing endangered and threatened predators. Specifically, the livestock industry is concerned about how these cases limit the ability to protect livestock from wolf and grizzly bear depredations. Notably, these cases do not address taking provisions that may be allowable under special regulations issued for non-essential experimental populations that would accompany reintroduction of wolves.

THE ROLE OF WESTERN STATES, CONGRESS, AND THE FEDERAL GOVERNMENT IN IMPLEMENTING THE RECOVERY PROCESS

Pressure from constituencies opposed to the recovery plans has impeded the recovery process. Western states, their congressional delegations, and the Reagan Administration have hesitated in supporting or carrying out the plans.

Role of the Reagan Administration

Although the FWS under the Reagan Administration prepared the Northern Rocky Mountain Wolf Recovery Plan, there was very little effort by the Administration to implement gray wolf recovery in the West. The Reagan Administration saw the ESA as an impediment to economic progress, and used the budget process to undermine it (Drabelle 1985). Frank Dunkle, the Director of the FWS, was extremely inconsistent in his position on recovery efforts (Miller 1988) and was accused of bowing to livestock and development interests (Melnykovych 1987, Williams 1988). The completion of the recovery plan does not guarantee its implementation, and there was no commitment by the Reagan Administration to implement the plan.

The only Reagan Administration official in Washington, D.C. who was supportive of recovery for bears and wolves is the Director of the National Park Service, William Penn Mott (Fischer 1987). In the face of political pressures, he was an enthusiastic supporter of wolf reintroduction into Yellowstone National Park.

Western States and Their Role

Under Section 6 of the ESA, states are encouraged to enter into "cooperative agreements" with the federal government in providing for the conservation of listed species. 16 U.S.C. § 1535(c)(1986). The Secretary is authorized to provide financial assistance to any state that has developed an approved program for conserving resident threatened and endangered species. States are concerned, however, about the lack of flexibility they have in managing bears, and have or would have in managing wolves, under the constraints of the ESA.

The recovery of wolves in the northern Rockies will involve Idaho, Montana, and Wyoming. Because of conflicts over how wolves should be managed in those states, Montana and Wyoming have excluded themselves from participating in the recovery process (Robbins 1986, Zumbo 1987). The State of Montana feels that the ESA does not allow for adequate state management options for the wolf (Schwinden 1987). Montana supports wolf recovery, including reintroduction into Yellowstone National Park, *if* the wolf is delisted.

The Montana Department of Fish, Wildlife, and Parks (MDFWP) resisted the original listing of the grizzly bear, and, because it feared that the decision in *Sierra Club v. Clark* might raise questions about the legality of northern Montana's grizzly bear hunt, it also sought an amendment to the Endangered Species Act which would overturn the court decision (Fitzgerald 1988). MDFWP contends that keeping the grizzly listed takes resources away from other species which are in more imminent trouble (Robbins 1988). The MDFWP also complains about the extra layer of bureaucratic channels and paperwork that the FWS requires for management actions when the grizzly is listed under the ESA.

In addition, a desire to modify delisting criteria for the gray wolf has been outlined by the State of Montana. Assuming that recovery in northern Montana will occur

much more rapidly than in the Yellowstone area, the MDFWP is concerned that the northern population will reach unacceptable levels before the wolf is delisted in that area. MDFWP suggests that each of the 3 recovery areas be treated separately. The 1987 recovery plan does call for downlisting to threatened status for a population of wolves that has met the recovery goal for a particular recovery area (U.S. Fish and Wildlife Service 1987:12)

The current governor of Wyoming has not taken a position on wolf recovery (Zumbo 1987), but the State of Wyoming has concerns that are similar to Montana's regarding the plan to reintroduce wolves into Yellowstone National Park. Because they feel that the reintroduction of wolves will result in a loss of livestock and big game, state biologists demand more options in controlling wolves before they will support the recovery plan (Aderhold 1987). Meanwhile, the State of Wyoming has requested a change in regulations that would allow taking of nuisance grizzly bears by hunters.

Role of Congress

Although Congress as a whole has shown overwhelming support of the Endangered Species Act, congressional delegations from western states have played significant roles in trying to reshape the ESA and stall the implementation of the wolf recovery plan. The ESA's most recent reauthorization, in 1988, passed the House by a vote of 399 to 16, and passed the Senate by a vote of 93 to 2. Reauthorization was held up in the Senate, however, for three years, partly due to concerns by western Senators about the management of wolves and grizzly bears.

The decision rendered in *Sierra Club v. Clark* prompted concerns from Senator Alan Simpson of Wyoming during reauthorization of the ESA in 1985. Partly because of these concerns, the Senate did not act on ESA reauthorization until 1988. Reportedly, Senator Simpson wanted an amendment that would allow the hunting of grizzly bears in Wyoming, and he wanted a provision that would give ranchers (rather than the government) the ability to protect livestock from wolves that cross the boundaries of Yellowstone National Park (Stern 1988). While no amendment concerning grizzly bear hunting was added to the ESA, the report by the Senate Environment and Public Works Committee that accompanied the 1988 reauthorization of the ESA noted that the FWS had "found that the situation in Montana represents the extraordinary case where pressures within the population cannot be otherwise relieved" and declared the Committee's impression that the regulated harvest of grizzly bears in Montana is consistent with the Act. Sen. Rep. No. 240, 100th Cong., 2d Sess. 5 (1987).

Urged on by livestock interests, Representative Ron Marlenee of Montana offered an amendment to the ESA during floor consideration in December 1987 that would have removed the gray wolf from the list of endangered species. Other House members argued that wolves should be preserved and that problem wolves can be dealt with within the confines of the ESA. Without the necessary support, Representative Marlenee withdrew his amendment (Fitzgerald 1988).

While not changing the Endangered Species Act, the three members of Wyoming's congressional delegation have been successful, through political pressure on the Reagan Administration, in postponing the Environmental Impact Statement (EIS) to evaluate the reintroduction of wolves into Yellowstone (Fischer 1987). In response, Representative Wayne Owens from Utah introduced a bill (H.R. 3378) in 1987 requiring the restoration of wolves to Yellowstone within three years. Stressing the fact that Yellowstone is a national and not a state park, Representative Owens' goal was to bring the issue to a debate in Congress which would, perhaps, dilute the power of the Wyoming delegation (Owens 1988). The bill did not progress through the 100th Congress.

Language concerning wolf recovery did pass the 100th Congress as part of the Interior appropriations bill for the 1989 fiscal year. In this bill, the House of Representatives appropriated money for an EIS on the reintroduction of wolves into Yellowstone. Many people believe that an EIS would be the first step in the Yellowstone wolf recovery process. However, in the subsequent conference committee between the House and the Senate, the terminology was changed from an EIS to a "study." H.R. Rep. No. 862, 100th Cong. 2d Sess. 14-15 (1988). According to draft internal memoranda within the National Park Service, the study will address wolf control options, predator-prey modeling, wolf-grizzly relationships, and recovery zone alternatives. Regardless, Congress' decision to use the word "study" instead of "EIS" removes the mandate to make an eventual decision implied in the EIS process.

WOLF AND GRIZZLY BEAR IMPACTS IN THE WEST

Management for wolves and grizzly bears could impact the livestock industry and big game hunters. The difficulty in precisely predicting the impact of predation on livestock and big game is central to the debate surrounding wolves and grizzly bears.

Livestock Depredation

Wolves

In Minnesota, Fritts (1982) found that less than 0.1% of the livestock that occur within the range of gray wolves are killed by them every year and many of these depredations are related to poor animal husbandry practices. Losses are expected to be even lower in the northern Rocky Mountain region due to lower densities of livestock in the recovery areas (Norris 1987 and Davis 1988).

Minnesota has 1200 wolves co-existing with over 234,000 cattle and 91,000 sheep in an area 16 million acres in size (Fritts 1982). In comparison, the three Rocky Mountain wolf recovery sites are large remote areas with vast wilderness and minimal grazing allotments (Norris 1987). In the Yellowstone area, for example, only 15,000 sheep and cattle are grazed in an area about 6 million acres in size. If recovery levels for wolves reintroduced into Yellowstone National Park are reached, there will be about 100 wolves; wolf populations in Yellowstone would have to reach 360 to match the density now existing in Minnesota.

A comparison of the density of livestock in the Yellowstone area and northern Minnesota is helpful in predicting livestock losses to wolves in the West; however, additional factors are involved. For example, livestock losses may be minimized in the Yellowstone area because wolves will have access to extremely large herds of natural prey, including elk, bison (*Bison bison*), moose, bighorn sheep (*Ovis canadensis*) and some deer (Davis 1988). Livestock management practices may also influence predation losses. Open range grazing, which is common in the Yellowstone area, may predispose livestock to higher predation losses, but grazing in the Yellowstone area only occurs in the summer months, which should reduce predation losses (Davis 1988).

Grizzly Bears

Grizzly bears tend to be less dependent on ungulates in their diets than wolves, but depredations do occur. Although grizzlies sometimes prey on cattle, most grizzly bear predation on domestic animals tends to be directed at sheep (Knight and Judd 1980). Overall grizzly bear depredations on sheep appear to be low. Only 0.5% of 15,707 sheep in the Targhee National Forest in the Yellowstone Ecosystem were killed by grizzly bears in 1976 and 1977, while more than 1.0% were lost to herding practices (Johnson and Griffel 1982).

There appears to be considerable variation in the extent of sheep depredations by grizzly bears. Knight and Judd (1980) found that of 28 grizzly bears sampled in national forests in the Yellowstone Ecosystem, 24 were observed using livestock grazing allotment areas and 10 were suspected of killing livestock. Other researchers reported that only 2 out of 20 marked bears which were in close proximity to sheep preyed on them (Harting 1985). Predation by grizzly bears may be a learned behavior (Knight and Judd 1980), which could contribute to large disparities in its intensity. In addition, the amount of predation on livestock can vary with the seasonal availability of natural foods (Jorgensen 1980).

Mitigation of Impacts

It is difficult to predict the overall impacts on livestock from wolf and grizzly recovery. Although losses will likely be minimal in the West, the sporadic and variable nature of depredations may result in a few ranchers incurring some significant losses. To minimize these losses, consideration has been given to the use of non-lethal predator control methods such as guard dogs and taste-aversion techniques (for wolves), aversive conditioning techniques (for grizzly bears) and encouraging ranchers to change their animal husbandry techniques. Although certain husbandry practices can significantly reduce sheep losses to predators (Robel *et al.* 1981), the use of bait laced with emetics and the use of guard dogs have not shown conclusive results (Burns 1983, Saxe 1988). In some cases, livestock allotments can be transferred out of recovery areas into nearby vacant allotments. This is now occurring for sheep allotments on the Targhee National Forest (Gore 1988).

In addition to conflicts with livestock, human/bear conflicts can best be minimized through proper education of people who enter or reside in grizzly bear habitat (Herrero 1985).

Mitigation may also entail a program of monetary compensation for ranchers who lose livestock to predators. The Minnesota Department of Agriculture compensates ranchers for verified wolf depredation losses, and the State of Wyoming pays for sheep killed by grizzly bears. The State of Montana does not pay compensation for either grizzly bear or wolf losses. Hoping to reduce opposition to wolf and grizzly bear recovery efforts, two conservation organizations, Defenders of Wildlife and the Great Bear Foundation, have instigated privately-funded compensation programs for ranchers who lose livestock to wolves or grizzly bears.

Effects of Wolf Recovery on Big Game Populations

The effects of predators on prey abundance is heavily studied but still not clearly understood. Many variables, such as weather (Mech *et al.* 1988), other prey items, and hunting, must be considered when such an assessment is attempted, and the significance of each is not always obvious. Predator/prey relationships vary over time and between ecosystems (Gasaway *et al.* 1983), allowing for only very general predictions. Although research has shown that wolves can cause a significant decline in ungulate densities (Gasaway *et al.* 1983), some studies suggest that wolves can contribute to a noticeable decrease in prey numbers only in concert with other variables, such as severe winters or over-hunting (Mech 1985).

Natural prey is abundant in the three wolf recovery areas; the Yellowstone Ecosystem has an estimated 70,000 elk and 2,000 bison. Some biologists report that ungulates are overpopulating Yellowstone National Park due to the lack of natural predators (O'Gara 1986), and they see the wolf as an essential link in the Yellowstone Ecosystem.

Some hunters are concerned that wolves may decrease hunting opportunities before they reach recovery levels.

Even if wolf populations increase to the point of delisting, there is a concern that managers will not be able to decrease predation levels by controlling wolf numbers because of potential public outcry (Zumbo 1987). The Alaska Department of Fish and Game has refrained from publicly financing aerial wolf control after encountering intense public opposition (Williams 1988).

DISCUSSION: ANALYSIS OF MANAGEMENT OPTIONS

As we have discussed, the majority of Americans, even those living in the West, favor the recovery of wolves and grizzly bears in the West. To be successful, a recovery effort must take into account the concerns of livestock owners, hunters, and state wildlife managers for sufficient flexibility in taking these species, as well as the concerns of wolf and bear supporters and the general public for adequate protection of wolves and grizzlies.

These large predators are different from other endangered species because of the perceived need to take some problem individuals from the population, even while the whole population is still in need of protection. Taking these animals often means killing them because translocation of problem individuals is considered to be largely ineffective for wolves (Fritts 1982) and only moderately effective for grizzly bears (Harting 1987).

While the ESA provides important protection for these populations, the same restrictions on taking that protect the populations are also expected to accommodate the need to control problem individuals. Once it is established that some taking is necessary, the issue becomes how taking can best be accomplished and what is allowed under current laws and regulations.

The Endangered Species Act is specifically intended to recover animals threatened with extinction. One of the primary restrictions the ESA imposes is a prohibition on the taking of listed animals. However, the Act does recognize the need to take listed animals under certain limited circumstances.

Threatened Species: Options for Controlling Grizzly Bears

Endangered species can be taken under permit from the Secretary "to enhance the propagation or survival of the affected species." 16 U.S.C. § 1539(a)(1)(A). Such permits may be available for the limited taking of threatened species as well. According to O'Neill (1988), this provision can be used by the Secretary to allow the removal of depredating animals as long as control efforts are directed only at the problem individuals and not at a population in general. In the case of depredating grizzlies, the FWS has promulgated regulations that permit Rocky Mountain grizzly bears to be killed or translocated by authorized federal, state or tribal personnel if they commit significant depredations to lawfully present livestock, crops, or beehives. 50 C.F.R. § 17.40(b)(1)(i)(C).

In the case of wolves listed as threatened in Minnesota, the FWS exercised its authority under the ESA to promulgate regulations that limited the taking of wolves to specific problem wolves that had engaged in significant depredations. An attempt by FWS to relax those restrictions without issuing new regulations was enjoined in *Fund for Animals v. Andrus*, 11 Env't. Rep. Cas. (BNA) 2189 (D. Minn. 1978). In an aside, however, the district court hinted that the more flexible approach FWS was seeking (taking of wolves without regard to whether the particular wolves could be tied to a specific depredation incident) might be permissible if FWS engaged in new rulemaking. *Id.* at 2197.

The ESA provides another option for allowing the taking of threatened species. Section 4 of the ESA allows "regulated" taking of threatened species "in the extraordinary case where population pressures within a given ecosystem cannot be otherwise relieved." 16 U.S.C. § 1532(3)(1986). This provision was used by the FWS to justify the limited grizzly bear sport hunt in northern Montana. The original regulations accompanying listing of the grizzly bear stated that the "grizzly bear population is large enough that bears are now wandering into settled areas where they threaten human safety and commit significant depredations on legally present livestock. Thus, grizzly bear population pressures definitely exist," and "a limited amount of regulated taking is necessary." 40 Fed. Reg. 31734, 31735 (July 28, 1975).

However, since the 1985 *Sierra Club v. Clark* decision that prevented the sport trapping of threatened wolves in Minnesota, proponents of the grizzly bear hunt in Montana fear that the grizzly hunt may be vulnerable to a similar lawsuit. No such suit has yet been filed, and a comparison of the sport trapping proposal for wolves in Minnesota, contested in *Sierra Club v. Clark*, and the Montana grizzly bear hunt shows some distinct differences.

In *Sierra Club v. Clark*, the FWS did not attempt to argue that the Minnesota wolves had population pressures that could not otherwise be relieved, or, in fact, that there were population pressures at all. If the legality of the Montana grizzly bear hunt were contested, the FWS and the State of Montana would likely assert that the sport hunt is necessary to relieve population pressures that cannot otherwise be relieved, since that was the original justification for the federal regulations allowing the hunt. In that case, those opposed to the hunt would have to prove that the FWS erred in its factual determination that there actually were population pressures warranting the hunt. While the Montana grizzly bear hunt could be vulnerable on these grounds, this is a much more difficult case for opponents of the hunt to make than the strictly legal argument that prevailed in *Sierra Club v. Clark*, that is: the FWS cannot allow the regulated taking of threatened species

without some showing of compelling population pressures.

While opponents to the sport hunt may not be able to convince the courts that population pressures do not exist, they may contend that there are alternative methods to relieving those pressures. How the court would rule on such a challenge is unknown. However, an opinion rendered in a recent court case, *Christy v. Hodel*, stated that the Secretary of the Interior had a "rational basis" for allowing the Montana sport hunt. 857 F.2d 1324 (9th Cir. 1988).

Absent clear indications otherwise, there is no reason to believe that the limited hunting of grizzly bears cannot continue to be used to control population pressures of grizzly bears that result in depredation or other undesirable effects. This does not remove debate over what levels of harvest should be allowed under this provision. That debate, however, will continue even after delisting of grizzly bear populations, although with less federal oversight.

Control of problem grizzly bears by government agents is authorized by the current regulations. Other methods of control have been proposed and may be allowable under the current provisions of the ESA.

Wyoming has requested a change in federal regulations that would allow the state to regulate the hunting of "nuisance" grizzly bears in the Yellowstone Ecosystem. The Denver Regional Office of the FWS is currently drafting regulations which would allow a grizzly bear hunt to occur in the Yellowstone Ecosystem within Wyoming and Idaho as well as Montana. The hunt reportedly will be designed to allow sport hunting of individual grizzly bears that would otherwise be killed by state or federal agency personnel as control measures under the interagency grizzly bear guidelines. This hunt will likely pass legal muster under the ESA if there are sufficient safeguards in place to insure that only grizzlies that were habitual offenders were taken and that the conflicts could not otherwise be avoided.

Endangered Species: Options for Controlling Naturally Occurring Wolves

Wolf populations that result from natural dispersal or immigration are regulated as an endangered species under provisions of the ESA. Sport hunting of endangered species is completely banned, but the Secretary may allow taking under the provisions previously discussed, which allows the issuance of a permit if the taking enhances the overall survival of the population. Using this provision, federal agents killed endangered wolves in Montana that were preying on livestock in August and September of 1987 (Miller 1988).

Experimental Populations: Options for Controlling Reintroduced Wolves

Options for control are increased when an endangered species is reintroduced to its former range. Based on a 1982 amendment to the ESA, wolves reintroduced to the Yellowstone Ecosystem as an "experimental population" can be managed as a threatened rather than endangered species. Congress made clear its intent for increased management flexibility of reintroduced predators in the legislative history accompanying the 1982 amendment. The House Report states that the Secretary is granted "broad flexibility in promulgating regulations" that could allow for direct taking "if depredations occur or if the release of these populations will continue to be frustrated by public opposition." H.R. Rep. No. 567, 97th Cong., 2d Sess. 34 (1982).

One example of management flexibility available for reintroduced populations of predators is the regulations accompanying the recent reintroduction of red wolves (*Canis rufus*) in the Alligator River National Wildlife Refuge in North Carolina. The FWS's approach and promulgated regulations include: (1) liberal discretion in not prosecuting unavoidable and accidental takings of the red wolf during otherwise lawful activities, (2) allowing citizens to take red wolves in defense of human life (although such circumstances are considered to be "extremely unlikely"), and (3) authorizing state and federal agents to take wolves that are responsible for depredations on livestock or other property. *See* 50 C.F.R. § 17.84(c); 51 Fed. Reg. 41790, 41793 (Nov. 19, 1986).

Although the red wolf is otherwise extinct in the wild, the reintroduced population is considered to be non-essential to the continued existence of the species because the wolf is "secured in seven widely separate captive breeding programs and zoos in the United States." 50 Fed. Reg. 41790, 41792 (Nov. 19, 1986). Because of this "non-essential" designation, the regulations state that other "agencies are not required to refrain from commitment of resources to projects as a result of" a Section 7 conference with the FWS regarding the red wolf. *Id.*

As discussed earlier, representatives of the livestock industry have severely criticized plans to reintroduce wolves in the West. William Mott, Director of the National Park Service, has responded to ranchers' concerns by stating that he would consider supporting ranchers' rights to shoot wolves on their property that were threatening their livestock (Mott 1988). While the legality of this has not been tested in court, it is conceivable that the regulations for non-essential experimental populations could allow some predator control by landowners. Based on the 1982 experimental population amendments to ESA and the accompanying report language, the FWS is considering writing regulations that would allow private citizens to take reintroduced wolves under very strict guidelines (Tilt *et al.* 1987).

While the ESA experimental population regulations allow for more flexibility in managing reintroduced wolves, they also raise other management considerations. Under the ESA, an experimental population can only be designated as such when "it is wholly separate geographically from

nonexperimental populations of the same species." 16 U.S.C. § 1539(j)(1). If wolves are reintroduced into Yellowstone National Park and subsequently found outside the recovery area, a question could arise as to whether the wolves outside the recovery area originated from a naturally occurring population or from the reintroduced population. In such a case, it could be argued that the wolves outside the recovery area cannot be treated as part of the experimental population, with its less restrictive management options. Indeed, the FWS regulations governing experimental populations provide that, when an experimental population overlaps at times with a natural population, members of the experimental population must be treated as members of the natural population during the time of overlap. *See* 50 C.F.R. § 17.80(a).

Because it is believed that there are no naturally occurring wolves in Yellowstone at this time, the FWS could reasonably conclude that any wolves occurring in the vicinity of the Yellowstone recovery area probably originated from the reintroduced population. Accordingly, the FWS could include a presumption to that effect in wolf reintroduction regulations, allowing all wolves found within a defined vicinity of the Yellowstone recovery area to be treated as members of the experimental population and placing the burden to show otherwise on those who object to the more liberal management permitted for experimental populations.

Similar management concerns could arise regarding the central Idaho recovery area. Under the ESA, experimental populations are "released." 16 U.S.C. §§ 1539(j)(1), 1539(j)(2)(A), 1539(j)(2)(B), 1539(j)(3). Thus, naturally occurring populations cannot be designated as experimental populations. Consequently, if wolf recovery in central Idaho were to rely solely on natural dispersal of wolves into the recovery area, there would be no "release" of wolves and, therefore, those wolves could not be designated as an experimental population.

On the other hand, if wolves were to be released into the central Idaho recovery area, those wolves could be managed as an experimental population under the ESA, provided that there are no naturally occurring wolves in central Idaho already. Moreover, as with the Yellowstone recovery area, the FWS could promulgate regulations creating a presumption that wolves found within a defined zone outside the central Idaho recovery area originated from the experimental population. The validity of such regulations, of course, would depend in part on the validity of a FWS conclusion that there are no naturally occurring wolves in the central Idaho recovery area at this time.

The use of regulated sport harvests to control problem wolves still protected under the ESA has not been fully explored. Because of the flexibility intended for experimental populations, this option cannot be ruled out. However, public outcry would likely be significant. The issue of sport taking is perhaps better addressed in a discussion of when delisting of these populations should occur, at which time management would be returned to the states.

Delisted Species

Some populations of grizzly bears may reach levels where they no longer require protection under the ESA and should be delisted. At this point, management options increase significantly. While management would generally be turned over to state agencies, 1988 Amendments to the ESA require the FWS to monitor delisted species for a period of five years after delisting. Endangered Species Act Amendments of 1988, § 1004, Pub. L. No. 100-478, 102 Stat. 2306, 2307 (1988). In light of this and already existing delisting requirements, 16 U.S.C. §§ 1533(a) (1)(D), 1533 (c)(2), states would be required to manage wolves and grizzlies in accordance with certain guidelines. Delisting grizzly bears in northern Montana would be accompanied by an agreement between the State of Montana and the Federal government that would offer continued protection by the state and federal agencies after delisting. Some state laws may have to be adjusted to allow state management of wolves. The State of Wyoming, for example, now classifies the wolf as a predator, precluding any management actions by the Wyoming Game and Fish Department.

Some parties have called for the immediate delisting of existing populations of gray wolves in the West, even though only one population exists in Glacier National Park, Montana. Arguments that the existence of wolf populations in Alaska should negate their endangered status in the conterminous U.S. (Steinhart 1983, Zumbo 1987) have little validity. Wildlife have inherent values in the ecosystems they occupy. These recreational, ecological, aesthetic, and other values are lost when local extinctions occur (Bean 1983). Accordingly, a distinct population of a species may be protected under the ESA even though other populations of the species are abundant elsewhere. *See Roosevelt Campobello Intern. Park v. EPA*, 684 F.2d 1041, 1050 n.5 (1st Cir. 1982).

The purpose of listing a species is to manage it in a way that will allow it to be eventually removed from the list. It is important to delist a population once it has recovered -- delisting a species promotes confidence in the ESA from citizens and government employees who have put forth efforts and have made sacrifices while a species was listed. Delisting should be based on the best scientific information available. Delisting is of no use if the population immediately declines to levels where it again requires the protection afforded by listing.

CONCLUSIONS

Several options exist for the control of problem wolves and grizzly bears. Taking of endangered species, such as populations of wolves resulting from natural dispersal or

immigration, are subject to the special permit criterion that the taking must enhance the survival of the species.

For threatened species, such as the grizzly bear, the ESA imposes somewhat less stringent restrictions on taking, though sport hunting remains subject to the ESA language requiring the extraordinary case where population pressures cannot otherwise be relieved. The courts have not fully defined the meaning of this limitation yet.

For reintroduced populations, such as the wolves which may be reintroduced into Yellowstone, the FWS is given substantially more flexibility to write regulations under legislative guidelines for non-essential experimental populations. These regulations could include a variety of taking provisions, including the possibility of a regulated sport harvest or state management. These regulations could conceivably include language that, for purposes of recovery, defines geographic areas where wolves are assumed to result from the reintroduced populations, thereby eliminating confusion as to how these wolves could be controlled.

Finally, concerns regarding the limitations imposed by the ESA on taking of listed species need to be weighed against the benefits of habitat protection afforded by the Act. Although a detailed analysis of the effectiveness of the ESA in protecting wolf and grizzly bear habitat is beyond the scope of this paper, the agency consultation requirements to avoid jeopardy and the restrictions on taking (which includes significant habitat destruction) provide a layer of protection for these species and their habitat not afforded by any other law.

ACKNOWLEDGMENTS

We wish to thank the many biologists from state and federal agencies, Congressional staff, and biologists and attorneys from conservation organizations, who reviewed earlier drafts of this paper. We are especially indebted to Bob Irvin, Jan Goldman-Carter and Michael Bean for their assistance with the legal aspects of this paper.

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YELLOWSTONE WOLVES

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Abstract: Under the Endangered Species Act of 1973, the Northern Rocky Mountain Wolf Recovery Plan signed in 1987 proposes restoration of gray wolves to Yellowstone National Park. Wolf restoration is consistent with National Park Service management policies and the purpose of the park as a U.S. biosphere reserve. Some ecological and sociopolitical aspects of wolf recovery are discussed.

Before we talk about restoring wolves to Yellowstone, I should acquaint you with what is called the Greater Yellowstone Area (GYA). Among the administrative units in the GYA are two national parks, six national forests, and two wildlife refuges.

A part of our discussion will include the potential impacts of wolf recovery in Yellowstone on livestock. Yellowstone National Park and some wilderness areas around it are closed to livestock grazing; on the national forests, allotments are open to sheep grazing and to cattle grazing (Greater Yellowstone Coordinating Committee 1987).

The gray wolf is listed in the United States as an endangered species. The gray wolf was wiped out in a holocaust of bullets, traps, and poison from the 1880s to the 1930s. Sixty years later, under the Endangered Species Act of 1973, a team of federal and state biologists, conservationists and stockgrowers drafted plans in 1980 and 1985 to recover wolves in the northern Rocky Mountains (U.S. Fish and Wildlife Service 1987).

Yellowstone is one of three recovery areas proposed in the plan. The National Park Service would also be required, by a bill introduced in September by Congressman Wayne Owens of Utah, to restore wolves to Yellowstone (Owens 1987).

We'll explore the ramifications of those proposals shortly, but first let's look at why Yellowstone was chosen as a recovery area.

Yellowstone is the world's first national park. The purpose of national parks is to conserve the scenery, their natural and historic objects, and their wildlife for people to enjoy in ways that will leave them unimpaired for future generations (U.S.C. Title 16, Sec. 1).

In 1976, UNESCO, the United Nations Educational, Scientific and Cultural Organization, designated Yellowstone as a biosphere reserve. Objectives of biosphere reserves are to conserve ecosystems, maintain genetic diversity, provide places for long-term research on ecosystem structure, function, and dynamics, to monitor environmental change and serve as a baseline of environmental quality. Finally, biosphere reserves are for education and training to promote sustainable conservation of the world's ecosystems (International Union for Conservation of Nature and Natural Resources I.U.C.N. 1984).

In 1978 Yellowstone was recognized by UNESCO as a World Heritage Site for its universal value to mankind (I.U.C.N. 1982).

Policies for resource management in natural areas of the national park system are to maintain and perpetuate their natural integrity—their wholeness—including the processes that created them (U.S. Dept. of Interior, National Park Service 1978).

It is within this context that both the Northern Rocky Mountain Wolf Recovery Plan and Mr. Owens' House Bill 3378 propose restoration of wolves to Yellowstone.

Let's look at greater Yellowstone as habitat for wolves. Then we'll consider the prey biomass and other predators in the system. Biomass, as I use the word, is the number of animals times their weight per unit area.

The Yellowstone recovery area proposed in the plan lies at the center of a vast tract of parks and wildernesses. The proposed recovery area is the largest intact ecosystem in the temperate zone of the earth—3500 square miles (9,000 km^2) in Yellowstone, 5600 square miles (14,500 km^2) of national forest wilderness, and 4200 square miles (10,900 km^2) of wildlands—13,300 square miles (34,400 km^2) total.

At 5,200 feet (1600 m) on the park's northern boundary is a Great Basin climate—11 inches (less than 30 cm) of precipitation and frequent droughts.

The mountains and high plateaus of the park are subalpine. They receive up to 80 inches (200 cm) of precipitation, mostly as snow.

The volcanic origin of the park's mountains and plateaus is evident in the greatest assemblage of geothermal features in the world.

Now, what kind of place is that for wolves? In Yellowstone there are 31,000 elk in summer and 21,000 or more elk in winter; 3,000 mule deer on the northern Yellowstone elk winter range in and out of the park; 250 bighorn sheep, recovering well from 1981–82 pinkeye epidemic; and nearly 500 pronghorn antelope on the northern range, up from 150 in 1979.

We're studying the park's moose, but we don't have a count yet. In greater Yellowstone, they may number 6,000.

Twenty six hundred bison stay in the park all year, 700 on the northern elk winter range (Singer in prep.).

Snowshoe hares and twenty species of rodents offer between-meals snacks for wolves.

Waterfowl and grouse are everywhere, adding to the variety of foods available for wolves.

At the recovery goal of 10 reproducing pairs of

wolves—ten packs of ten wolves each—we might expect about 100 wolves in the Yellowstone recovery area.

Based on studies in Canada, where wolves consume about 7–10 pounds per day (Carbyn 1974), 100 wolves would take less than 2.5 percent of the available summer biomass in the park and less than 5 percent of the winter biomass.

We listen closely when Canadian wolf authority Lu Carbyn tells us that each wolf population is unique, and you can't get the whole picture of predator-prey relationships simply by calculating the biomass. Neither Alaska, nor Canada, nor Minnesota is Yellowstone. Yellowstone's fauna is far more diverse than Isle Royale's or the Yukon's.

Lu Carbyn reminds us that ecosystems are complex; seasonal movements, environmental conditions, and alternate prey all interact (Carbyn pers. corres.).

Some people think wolves will eat up or scare away all the wildlife people come to Yellowstone to see. Others see wolves as a panacea to correct what they see as overpopulation of elk and bison. The lesson I hear from Lu Carbyn is that anyone predicting either disaster or a solution to any perceived population problem by restoring wolves is bound to be wrong.

Fortunately, park, forest, and state biologists have established baselines, monitoring hooved animal population dynamics for two decades.

We've begun a five-year study of mountain lions (Murphy and Tischerdorf 1988), and we plan to study coyotes.

Yellowstone has a quarter of a century's worth of data on grizzly bear ecology, and we can refer to worldwide studies that can help us predict broadly how wolves and grizzly bears will interact in Yellowstone.

Wolves and grizzly bears share Denali National Park, Alaska. There has been little change in the bear population since at least the 1920s (Haber 1987).

Constantine Filonov (1980) summarized 25–30 years of data on wolf and bear predation on moose from nine natural areas in the Soviet Union. He concluded that, even when predators were removed, long-term variability in moose deaths was insignificant. When fewer moose were killed by wolves, more moose died from disease.

Rolf Peterson (1988) told us that for a couple of decades wolf-moose populations on Isle Royale seemed stable. Then both populations underwent severe fluctuations. Now Isle Royale is down to 6 wolves and up to 1700 moose.

The message is clear: *long-term* studies are needed to understand predator-prey interactions.

We plan to study and monitor the effects of wolves on Yellowstone's prey species and on other predators.

In fact, recovery of wolves in Yellowstone offers an unparalleled opportunity to test the effects of restoring a major predator to a natural ecosystem after it has been absent for about 60 years.

We've considered a few scientific aspects of wolf recovery, but returning wolves to their old home offers some other rewards.

One of those is to renew what author Barry Lopez, who wrote *Of Wolves and Men* (1978), calls the respectful relationship between humans and animals, held sacred by Native Americans, where we might see wolves not just as physiological organisms, but as elements of a shared landscape. The product of wolf restoration will be wildness; the assurance that the forces—the processes—of life are still at work.

Montana author Douglas Chadwick (1987) asks, "What made moose so huge and powerful, pronghorn so fleet and flowing with grace, mountain goats and bighorn sheep such superb climbers . . . separating the fit from the less well adapted?" He says, "It is indeed the wolf. (He might have added the saber-toothed tiger and the short-faced bear). It has helped mold not only the electrically alert senses and physical majesty we admire in so many creatures but also their population dynamics and behavior. . . . With such a key agent of natural selection missing, we are prevented from . . . understanding the living, changing communities we behold."

Most of the elements are there—weather, fire, plants, animals—only one that evolved with all the rest is missing.

We've been thinking ecologically. Now let's think in social and economic terms.

Recreation is what the Greater Yellowstone Area is all about—recreation based on the natural features and wildlife.

The unique features of the place invite millions of people to enjoy greater Yellowstone every year—not always in a crowd of people, but sometimes in the throne room of the gods or enthralled by the magic of primordial steam and Pleistocene beasts.

Now, let's consider the costs involved in wolf restoration. Who's going to pay for the wolf recovery?

Our U.S. Congress allots funds to the U.S. Fish and Wildlife Service for endangered species recovery. The amounts are miniscule, within the over all federal budget; $39 million in 1988. That's nationwide —for 531 listed species (U.S. Fish and Wildlife Service 1988).

Figures from the greater Yellowstone aggregation of plans help us connect economics and ecology in the greater Yellowstone area (GYA). Recreation is the major economic activity, supporting 80 percent of jobs in greater Yellowstone. Recreation provides 14,300 jobs, and income totalling $217 million. At 13 percent of that number, timber harvest provides 1,900 jobs in the GYA and produces $42 million income. Grazing, at less than 9 percent that of recreation, produces 1,300 jobs and $30 million in income (Greater Yellowstone Coordinating Committee 1987).

Grizzly bear recovery offers us a prime example of ecological and economic conflicts among uses of the GYA. Although golden eagles and coyotes are the most significant

predators on sheep in the GYA, grizzly bears kill sheep (less than 1 percent of those lost to predation) and test the patience of managers and woolgrowers alike (Congressional Research Service 1986). Grizzly bears show several encouraging signs of recovery. Reproduction is up, and mortality is down (Knight et al. 1988).

Let's see how wolf recovery fits into this picture.

Wolf recovery and grizzly bear recovery are cut from the same cloth. Habitat management. Ecosystem integrity. A natural prey base.

Wolves reproduce faster than grizzly bears do. We won't have to excruciate over every reproducing female. Wolves will need small protected areas only in spring around their dens and in summer around their rendezvous sites.

The objective of the Northern Rocky Mountain Wolf Recovery Plan is to recover wolves in three wildland areas of the northern Rockies and to remove them from the list of endangered species. Because of the very remote possibility of natural immigration, the plan proposes translocating wolves to Yellowstone.

A 1982 amendment to the Endangered Species Act provides that wolves restored to Yellowstone can be designated an experimental population, with flexible regulations to be developed to manage and control them. Those regulations could allow landowners to kill wolves to protect their livestock after confirmation that wolves have attacked their animals.

The plan recognizes that we need to comply with the National Environmental Policy Act and prepare an environmental impact statement (EIS), when everyone's concerns can be heard and addressed, before an action plan is developed by agencies cooperating to restore wolves in the GYA.

The American public will decide if and how wolves will be restored to Yellowstone. The forums during the writing of the EIS will provide the best opportunity for those impacted to negotiate their interests.

The plan proposes three management zones to facilitate wolf recovery, which may correspond to management situations used for grizzly bears.

Zone I, perhaps the 3,500 square miles (8,900 km^2) of Yellowstone National Park, would contain all-year habitat for 10 breeding pairs of wolves. In Zone I, (along with perpetuation of the natural ecosystem, including all native species), the number one priority would be wolf recovery.

Zone II would be a flexible buffer area for wolves, but where management preference would be given to livestock grazing and other uses. Problem wolves would be controlled.

In Zone III, other uses would take priority over wolf recovery. Problem wolves would be controlled. Control agents would respond to complaints of livestock loss within 24 hours, as they do in Minnesota. If wolves were confirmed as killing or threatening livestock, trapping would begin immediately. Control of wolves is straightforward in northern Minnesota, where 1200 wolves are mixed in with 12,300 farms, 234,000 cattle and 91,000 sheep in an area of 31,250 square miles (80,900 km^2)—twice the size of greater Yellowstone. In northern Minnesota, an average of 39 wolves are captured per year in the Department of Agriculture depredation-control program. The highest reported loss of cattle to wolves there in the last 11 years was 4.5 cattle per 10,000 at risk in 1979, and the highest reported loss of sheep to wolves was 26.6 sheep per 10,000 in 1981 (Paul 1988). If we were to convert animal unit months of cattle grazed on *all* public lands in greater Yellowstone to cattle years, then we would have 68,000 in the GYA compared to 234,000 at risk in Minnesota (a third). Converting the greater Yellowstone sheep animal unit months to sheep years we get 25,000 sheep years of exposure on greater Yellowstone *public lands*, compared to 91,000 sheep at risk in Minnesota, less than one-third as many (Congressional Research Service 1986).

Now, let's remember that only Yellowstone National Park, where *no* livestock grazing is permitted, is the proposed wolf recovery area.

The recovery plan recommends a program to compensate ranchers who lose livestock to wolves. The State of Minnesota pays less than $23,000 a year (Paul 1988).

In the seven years 1974–1980, 384 wolf-livestock claims were paid in Alberta, ranging in annual cost from $30,000 to $85,000.

In 1981, cattle pastured in wolf range in Alberta totaled 300,000 (Gunson 1983), in Manitoba, 172,000, and in Saskatchewan, just less than 100,000.

In 1916, in a speech before the Montana Stock Growers' Association, Wallis Huidekoper said: "It's a well-known fact that stock-killing individuals among wolves are only a small portion of their kind . . ." (Lopez 1978) (roughly 1 out of 30 in Minnesota).

In Minnesota, failure by farmers to distinguish wolves from coyotes has contributed to an exaggerated view of wolves as livestock predators (Paul 1988). In western Canada, wolf predation on livestock is less than 1/10 of 1 percent (Gunson 1983).

A healthy wolf population will change the diet of coyotes, and furnish more carrion for red fox and wolverines (Carbyn et al. 1987). Spring through fall, this may be a boon to grizzly bears, who will find and take over wolf kills (Weaver 1986).

Big game hunters worry that wolves will decimate species they want to harvest. Results vary in studies on the effects of wolf predation on big game species, but, in many cases, overharvesting by humans, destruction of winter range, habitat deterioration, wildfire suppression, and exceptionally harsh winters contribute to large animal declines, and wolves take the blame.

One task in the recovery plan is to coordinate and

integrate wolf management objectives with state big game management objectives.

How will wolves affect park visitors and commercial uses of national forests around the park? Very little, if at all. Few visitors will see wolves, although six-to-one they favor having wolves in the park (McNaught 1985). Adjustments in visitor use and commercial activities have already been made to protect grizzly bear habitat, and an experimental population of wolves will be far easier to manage than grizzly bears.

Attitude surveys taken in the park, in Wyoming, and in Montana show widespread support for having wolves in Yellowstone (McNaught 1985, Bath 1987 a, b, c, and Lenihan 1987). Still, some stockgrowers and outfitters, as well as some hunters oppose wolf recovery.

Two questions burning in the minds of those who fear the wolf's return to Yellowstone are these: What will keep wolves in the park, once released there, and how will their numbers be controlled? A few will disperse, but the immense prey base and wolves' tendency to establish and remain in home territories will encourage wolves to stay in Yellowstone. Because wolves are territorial, their densities almost never exceed one wolf per 10 square miles. Diseases and parasites, starvation, and intense fighting all decimate wolves when they reach higher densities (Keith 1983). Upon recovery, wolves will be delisted, and can be hunted as game or trapped as furbearers under state regulations.

Long-term ecological studies on wolves, coyotes, and ungulates in Riding Mountain National Park, Manitoba, that began in 1975 (Carbyn et al. 1987), are yielding new data on wolf population dynamics and behavior that may help us predict the effects of restoring wolves to Yellowstone.

The question boils down to this: Are we willing to share the earth with another top predator?

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SESSION II:

IMPACTS ON WETLAND AND RIPARIAN ECOSYSTEMS

WETLAND RECLAMATION: MITIGATING LOSSES THROUGH REGULATORY COMPLIANCE

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Abstract: Meeting the growing need for outdoor/wildlife recreation areas in the Midwest has become an important part of post-mining land-use planning. Since the establishment of Illinois' first state parks and wildlife management areas on mined lands more than 30 years ago, considerable interest has been generated by state agencies to work with the mining industry to acquire previously mined lands, or to develop and coordinate reclamation plans of future mined areas to enhance their wildlife and recreation value. Loss of more than 90 percent of Illinois' original wetland habitat has created an urgent need to replace and restore this valuable natural resource. Although reclaimed mined lands can never mitigate this loss, the Cooperative Wildlife Research Laboratory of Southern Illinois University at Carbondale has worked with the mining industry and state and federal regulatory programs for more than 35 years to establish wetlands as a valuable component of reclamation plans. Wetland development plans have taken advantage of any opportunity ranging from slurry ponds to surface mine impoundments.

This paper highlights the planning and development of several post-law surface mine areas, totalling more than 2,000 acres, that were designed to accommodate regional and local fish and wildlife needs. These plans illustrate the acceptance of wetland reclamation as a post-mining land use that is now recognized nationally as a valuable resource that must be protected as well as developed.

WETLAND RESOURCES—RECENT TRENDS

Wetlands have become a rapidly diminishing natural resource within the United States. Prior to settlement, more than 215 million acres of wetlands occurred in the U.S.; however, by the mid-1970s less than 100 million acres remained (Tiner 1984). Not recognized for their inherent hydrologic, biologic, and socioeconomic values or functions, wetlands were perceived as a hindrance to agricultural and urban/industrial prosperity. Drainage for agricultural development was identified as being responsible for 87% of recent wetland losses, with urban development accounting for an additional 8% loss (Tiner 1984). Stream and river channelization and dredging by the U.S. Army Corps of Engineers has also directly impacted the quantity and quality of natural wetlands.

Many industries or agencies previously responsible for losses now have programs to develop wetlands and mitigate losses. The U.S. Army Corps of Engineers develops wetland habitat during dredging and channelization projects (Newling 1981). Wetland habitats have been developed in conjunction with sand and gravel mining (Svedarsky and Crawford 1982), taconite mining (Dickinson 1975), coastal urban development (Josselyn and Buchholz 1982), Polish lignite mining (Janiak 1979), phosphate mining (Haynes 1984), and highway construction (Day 1986).

Similar to other industries, wetland habitats have long been a by-product of mining for coal in the midwest (Klimstra and Nawrot 1982). However, only recently has there been nationwide acceptance of wetlands as a viable and valuable reclamation alternative. Wetland preservation, creation, and restoration is now being promoted at numerous state, regional, and national symposia, conferences, and workshops. Recognition and appreciation of wetland values are reflected in state and federal programs that have been enacted to protect wetlands from further agricultural drainage. Return of poorly drained and highly erodible agricultural lands to wetlands are now being encouraged and subsidized under the Conservation Reserve Program.

Restoration of streams and wetlands after surface mining is a high priority of the Illinois Department of Mines and Minerals, Land Reclamation Division. Restoration of pre-mine fish and wildlife habitat, including wetlands, is mandated in Illinois when land-use decision-makers determine a need exists (Illinois Department of Mines and Minerals 1987). Under IDMM regulations thousands of acres of wetland habitat have been restored on mined lands. Administration of IDMM reclamation policy and regulations is provided by Doug Downing, Supervisor of the Land Reclamation Division. Mike Sponsler, District Supervisor of the Northern Division, coordinates departmental activities associated with the planning, permitting, review, and recommendations for wetland/wildlife habitat establishment and stream reconstruction plans. In cooperation with the coal industry, IDMM reclamation specialists review the physical, chemical, and hydrologic components of wetland plans to ensure quality fish and wildlife habitat is established.

Wetland reclamation projects in Illinois have included development of shallow water wetlands and impoundments in association with riparian habitat establishment during stream reconstruction, as well as construction of wetlands within reclaimed upland wildlife areas, and even the development of wetlands on inactive slurry disposal areas.

This paper will outline the history of wetlands development during pre-law conditions and under current regulations (P.L. 95–87; The Surface Mining Control and Reclamation Act of 1977). General guidelines emphasizing basic goals and principles of wetland establishment practices are also summarized.

MINED LAND WETLANDS—PAST PRACTICES

Surface mining for coal in Illinois has affected more than 240,000 acres resulting in more than 15,000 acres of water impoundments and shallow water wetlands. Although over 40% of the acreage was mined prior to any reclamation requirement, less than 5% of the associated waters were considered adversely affected. The Cooperative Wildlife Research Laboratory of Southern Illinois University has long recognized that mining and reclamation could mitigate wetland losses; consequently, research was initiated in 1954 to identify the physical, chemical, and biological characteristics of surface mine associated waters (Bell 1956, Arata 1959, Haynes and Klimstra 1975, Coss 1981, Konik 1980). Many midwest states have documented a variety of mined land benefits, including economics of waters as irrigation sources, fish, wildlife, recreation, industrial and municipal water supplies, and residential development (Riley 1960, Roseberry and Klimstra 1964, Deane 1966, Imhoff et al. 1976, Klimstra et al. 1977, Thompson and Lindahl 1977, Gibb and Evans 1978, Grandt 1978, Christy et al. 1979, Rosso 1980).

Although pre-law impoundments were never planned or engineered to meet design criteria of P.L. 95-87, the majority of impoundments have provided excellent wetland resources. Many state record fish have been caught from surface mine lakes. These pre-law lakes and shallow water impoundments have provided outstanding waterfowl habitat in areas where none previously existed (Klimstra et al. 1963, Roseberry and Klimstra 1964, Weber 1970, Grandt 1978, Sandusky 1978, Grandt 1981, Perkins 1981, Klimstra and Thornburg 1982, O'Leary et al. 1984).

Illinois mined land wetlands were vital to the reintroduction of the giant Canada goose (*Branta canadensis maxima*), once presumed to be an extinct race (Klimstra and Thornburg 1982). In 1967, the Illinois Department of Conservation in cooperation with Peabody Coal Company reintroduced giant Canada geese on pre-law mines in west-central Illinois. In 1981, reintroductions included surface mines in southern Illinois (Butler and Lueth 1986). To enhance nesting success for resident flocks, islands were included in reclamation plans in both Kentucky (Krause et al. 1985) and Illinois (Klimstra and Nawrot 1985).

While construction of islands or artificial nesting structures is now promoted as a management tool, islands on pre-law mines resulted from minimal grading of spoilbanks. Stricter grading requirements of post-law mines have greatly reduced or eliminated islands. However, during the regulatory transition, grading to approximate original contour resulted in large tracts of rolling pastures interspersed with shallow water wetlands. Although islands were nearly eliminated, diverse moist soil and aquatic plant communities and adjacent reclaimed pastures and rowcrop areas are now important factors in winter habitat for migratory waterfowl.

In addition to more than 15,000 migratory geese wintering on southern Illinois surface mines, seasonal migration patterns of ducks and shorebirds have been favorably affected by the abundance and distribution of mined land wetlands. Most waterfowl users (excluding the giant Canada goose) are migratory; however, the mallard (*Anas platyrhynchos*) and the blue-winged teal (*A. discors*) are common breeding species (Sandusy 1978, Perkins and Lawrence 1985). The osprey (*Pandion haliaetus*) has been observed on northern Illinois surface mine wetlands; the bald eagle (*Haliaeetus leucocephalus*) has been observed on both northern and southern mine areas.

Some of the earliest pre-law wetland habitat enhancement practices on mined land were initiated by the Cooperative Wildlife Research Laboratory in southern Illinois in the mid-1950s. Experimental plantings of moist soil and emergent wetland species such as smartweed (*Polygonum muhlenbergii*), bulrush (*Scirpus acutus*), reedgrass (*Phragmites australis*), and arrowhead (*Sagittaria latifolia* and *S. rigida*) were established around surface mine wetlands on the Pyatts research area (now Pyramid State Park) (Arata 1959). Although the wildlife reclamation program at the Pyatts research area represented some of the earliest wetland plantings on mined lands, it would be decades later before wetland plant establishment would again become a popular reclamation alternative.

During the 1970s through the mid-1980s, reclamation did not emphasize establishment of wetland vegetation. In fact, during this period of stringent grading requirements, impounded areas consisted primarily of deep final cut and haulage road lakes. Moist soil and wetland plant establishment was dependent upon natural colonization in limited littoral zones (Coss et al. 1985). In contrast, pre-law shallow water impoundments were characterized by more gradual slopes, wider littoral and moist soil zones with diverse aquatic plant communities (O'Leary et al. 1984).

MINED LAND WETLANDS—REGULATORY CONSTRAINTS AND OPPORTUNITIES

As previously discussed, wetland/wildlife areas were a frequent post-mining land use of pre-law areas. However, when agricultural interests dominated the regulatory process in the late 1970s and early 1980s, opportunities for wetland habitat development were severely restricted. Fortunately, current public awareness of wetland values and functions has contributed to a greater appreciation of mined land wetlands and returned a balance to reclamation planning. State

agencies and resource planners now recognize surface mine wetlands as a desirable "natural" resource. Reclaimed wetland/wildlife areas are now viewed by public agencies and private conservation groups as much needed opportunities to meet the growing demand for outdoor recreation areas, and as fish and wildlife management areas that can help mitigate previous habitat losses.

Mitigation of previous losses through surface mine reclamation activities requires both regulatory incentive and compliance with current mining regulations. In view of the importance of agriculture as well as the extensive drainage that contributed to a 90% loss (over 8.5 million acres) of wetland acreage in Illinois, it is imperative that reclamation programs strive for and achieve a balance of agricultural and wetland/wildlife post-mining land uses. While wetland reclamation practices will never mitigate the loss of 8.5 million wetland acres, nor perfectly restore 100 percent of the natural values and functions of unmined wetlands, the State's regulatory program provides the opportunity and guidelines for coal operators to implement wetland reclamation plans.

Regulatory guidelines for wetland protection as well as wetland establishment are provided by the Surface Coal Mining Land Conservation and Reclamation Act: Permanent Rules and Regulations (62 Ill. Adm. Code 1700-1850) as administered by the Illinois Department of Mines and Minerals—Land Reclamation Division. Protection of natural wetlands from mining activities is provided for areas that may be part of the Natural Wildlife Refuge System, National Recreation Areas, or the Wild and Scenic River System (§1761.11), or wetland habitats of unusually high value (§1780.16 b3). Natural wetlands are also protected under procedures for designating lands unsuitable for mining due to the technological inability to reclaim or restore the original natural resource values (§1762.11). Intermittent and perennial stream restoration plans must provide for reestablishment of both the instream habitat (riffles, pools, drops, meanders) and riparian zone (§1816.43 and 1816.57). The riparian zone is defined as that area inundated as a result of the 2-year, 24-hour precipitation event. Reclaimed riparian zones must be reforested with a minimum of 450 trees per acre, thereby creating wooded bottomland wetlands. Under a general provision (§1816.97) for the protection of fish, wildlife, and related environmental values, coal operators are to:

> avoid disturbance to, enhance where practicable, restore, or replace, wetlands, and riparian vegetation along rivers and streams and bordering pond and lakes.

General guidelines for fish and wildlife habitat reclamation (§1816.97g, h, i) identify the principles of establishing diverse (species and distribution) vegetation that provides both food and cover while optimizing edge effect in wildlife, cropland, residential, and even industrial post-mining land uses.

Assistance to coal operators in the development and review of wildlife reclamation plans is provided by reclamation specialists in the Land Reclamation Division (IDMM) and by biologists in the Planning Division of the Illinois Department of Conservation. Development of many extensive wetland/wildlife reclamation plans have resulted from collaborative efforts of industry reclamation personnel and staff of the Cooperative Wildlife Research Laboratory at Southern Illinois University.

During the 10 years since the implementation of the Federal Surface Mining Control and Reclamation Act, wetland/wildlife reclamation plans have encompassed over 2,500 acres in Illinois. The diversity of reclamation plans and projects demonstrate the many opportunities that exist for wetland/wildlife habitat enhancement on both pre-law and post-law areas (Table 1). Reclamation opportunities have included everything from sediment ponds to surface mine impoundments. Even coal tailings ponds have been reclaimed as productive shallow water wetlands (Fig. 1) (Nawrot et al. 1987). Reclamation of pre-law "abandoned mine lands" have also provided some of the greatest challenges and best opportunities to develop diverse wetlands in previously acid-affected soils and impoundments.

A brief review of some of Illinois' wetlands reclamation practices illustrates the planning and integration of wetlands in post-mining land uses. Many of these reclamation practices have addressed the needs of agriculture as well as wildlife by complying with rowcrop reclamation standards while incorporating wetland habitat development. A recent reclamation plan submitted (~2000 acres) at the Arch of Illinois Captian Mine demonstrated that development of a wetland complex (500 acres of wetland "potholes") within an agricultural area can be designed to protect highly erodible pre-law soils while still meeting the needs of prime farmland restoration. As root medium and topsoil requirements are being met on the wildlife areas of this plan, future conversion to cropland would be feasible if society's needs would dictate.

Recent reclamation, emphasizing shallow and deepwater wetland zonation, of a 250-acre tract adjacent to a channelized segment of the Kaskaskia River, has been the focal point of a larger (~2,000 acres) reclaimed wetland/wildlife area that has been donated by Peabody Coal Company (River King No. 3 Mine) to the Illinois Department of Conservation. Previously reclaimed and current wetland/wildlife reclamation areas have recently been purchased, or are in the process of being acquired (lease and/or conservation easement practices), by IDOC to ensure adequate refuge and recreation areas are available for future needs. These acquisitions may encompass as much as 7,000 acres, of which significant portions contain wetland/wildlife habitat.

While riparian habitats of stream reconstructions (e.g.,

Table 1. Illinois Mined Land Reclamation: Planned and permitted stream restoration and wetland establishment projects (through December 1988).

Mine Site	Stream (feet)	Wetland (acres)	Regulatory/Reclamation Status	
			Approved	Constructed
Stream Restoration				
Arch-Denmark Pipestone Creek	20,000	300	X	ongoing
Arch-Captain				
Galum Creek	13,000	—	X	X
Pipestone	6,000	—	X	X
Consol-Burning Star 2				
White Walnut Creek	10,000	100	X	
Consol-Burning Star 4				
Galum Creek	25,000	137	X	ongoing
Bonnie Creek	19,700	141	X	
Midland-Rapatee, Coal Creek	1,600	2	X	
Wetland				
AMAX-Sunspot		40 (slurry)	X	X
Arch-Denmark		60 (slurry)	X	X
Arch-Captain (§711 Exp. Practice)		10 (slurry)	X	X
Arch-Wetland (#216)		500	pending	
Consol-Burning Star 5				
Wetland		30	X	X
Slurry Wetland		70 (slurry)	X	X
Little Muddy		640	X	X
Energy Resources Inc.-Moffat		30 (slurry)	X	
Midland				
Elm		38.	X	X
Rapatee		20 (slurry)	X	
Mecco		50 (slurry)	X	
Monterey No. 1		80 (slurry)	X	
Peabody				
River King 1		200 (slurry)	panding	
River King 3 "Kaskaskia Island"		250	X	X
Will Scarlet Pit 9		50 (slurry)	pending	
Totals				
Stream Restoration 95,000 feet				
Stream Restoration riparian Wetlands 680 acres				
Wetlands (includes slurry wetlands - 610) 2,068 acres				

Consol Burning Star No. 4 and 5, and Arch Captain and Denmark mines), spoilbank areas, and selectively graded final cuts and incline impoundment contribute the most wetland acreage, reclamation plans of slurry impoundments have also contributed more than 600 acre of post-law wetland in Illinois. Demonstration of slurry wetland reclamation alternatives have been implement as federally approved Experimental Practices (§711 P.L. 95-87) in both Illinois (Arch Captain Mine) and Indiana (AMAX Ayrshire Mine).

Development of wetland habitat can even be part of pre-law problem area reclamation as illustrated by the 2,400-acre Peabody Will Scarlet "Old Works" project in southeastern Illinois. Treating the source of acid runoff rather than perpetually treating the symptom (i.e., acid mine drainage) is the key reclamation principle being applied in converting the "Nation's worst" pre-law site into the most diverse wetland wildlife management area in Illinois (Nawrot et al. 1988).

These examples illustrate only a few of the many sites that have been or can be successfully reclaimed as part of pre- or post-law programs. While even though the most ambitious efforts to include wetlands in reclamation plans can make a significant contribution to local habitat enhancement, these collective efforts would still be but a drop in the bucket when compared to the millions of acres of previously drained wetlands. Nevertheless, regulators, industry, and conservation agencies should continue to work together to promote wetland reclamation plans.

MINED LAND WETLANDS ESTABLISHMENT PRINCIPLES AND GUIDELINES

While many productive pre-law wetland areas were unplanned, compliance with current regulations have demonstrated the ability to design and construct wetland/wildlife areas that are environmentally acceptable as well as economically feasible. Although wetlands are inherently



Figure 1. Shallow water wetlands have been established directly on coal slurry disposal areas without the required 4' of soil cover.

complex systems, their successful establishment on mined lands has demonstrated that this land-use alternative does not need to be costly to be effective. Including wetlands as part of the mining and reclamation process can be a cost-effective alternative if one adheres to the basic principles of wetland establishment. The following discussion highlights these basic principles as they have been applied, or can be applied, in mined land wetland development plans.

Wetlands represent the world's most complex and productive ecosystems as evidenced by the many compilations of limnologic, hydrologic, chemical, and vegetative research and management guides (e.g., Mitsch and Gosselink 1986, Greeson et al. 1978, Ratti et al.1982, Kozlowski 1984, Office of Technology Assessment 1984, Rheinheimer 1985, Brooks et al. 1985, Knighton 1982). Despite the seemingly complex nature of wetlands and associated vegetative communities the establishment of diverse and dynamic wetlands is in reality a simple matter if three key components are provided by reclamation:

- topographic diversity (i.e., shallow and deep water interspersion),
- suitable soils, and
- favorable hydrology (i.e., seasonal and/or permanent saturation or inundation).

Development of the desired topographic and hydrologic conditions are standard permitting and planning elements associated with the usual engineering, flood routing, and impoundment designs required in reclamation plans. When these key components are included in reclamation plans, natural wetland colonization by emergent macrophytes and submerged and floating aquatics will eventually provide the vegetative component of wetland habitat diversity.

The current popularity of wetland restoration has promoted an overzealous and inordinately uneconomical approach to intensive botanical restoration schemes based on detailed landscape designs emphasizing potted wetland planting stock. Despite the inherently complex temporal and spatial floristic components of wetlands, diverse and dynamic wetland plant communities can be economically established by simply enhancing the process of natural succession (Warburton et al. 1985). By definition (Cowardin et al. 1979) wetlands are transitional between terrestrial and aquatic systems and as such do not represent stable or static environments. Therefore, plant establishment is best accomplished by introduction of root and seed stock sufficient to initiate and accelerate the natural colonization process. Introduction of locally collected, ecotypically adapted species in the appropriate hydrologic zone (Fig. 2) will ensure successful reproduction and vegetative propagation to provide a self-sustaining wetland plant community. Rather than relying upon commercially available planting stock, adjacent wetlands, drainage ditches, and sediment ponds often provide the most viable source of quality planting stock and seed sources. Mechanical collection (e.g., backhoe) of wetland substrates and the

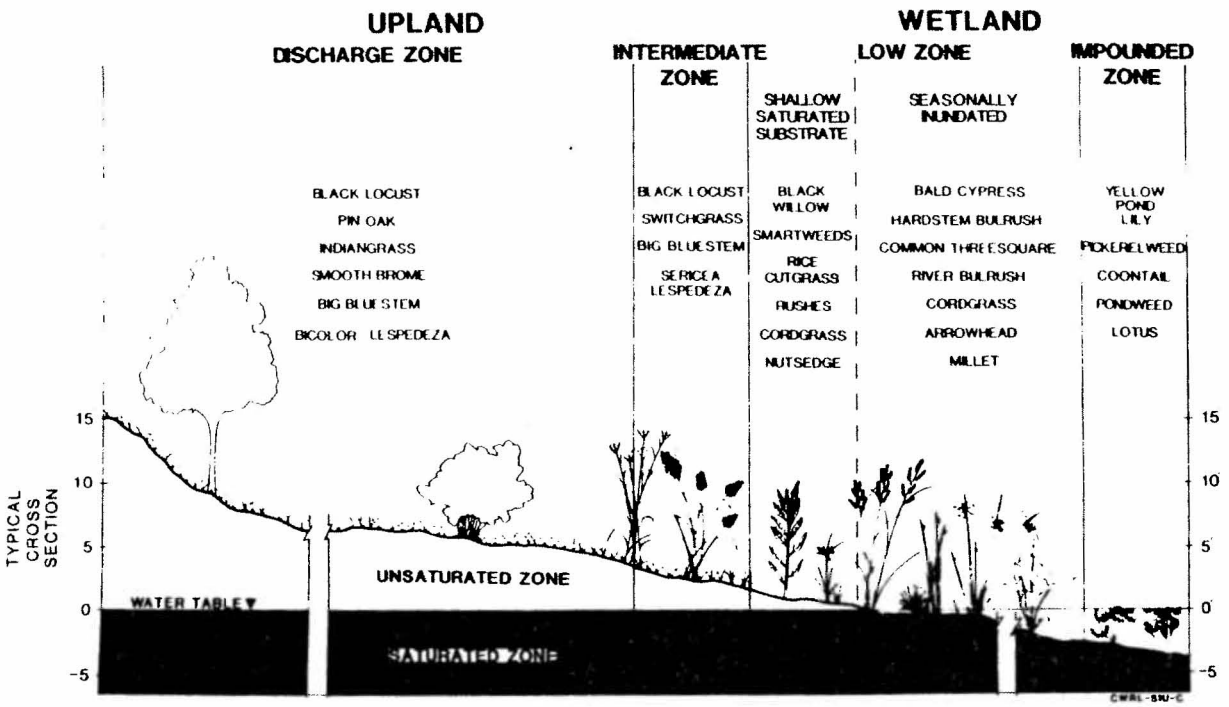


Figure 2. Establishment of locally adapted moist-soil annuals and perennial emergent species ensures diversity within wetland zones and enhances adjacent upland wildlife habitat in reclaimed areas.

associated root and seed propagules (i.e., the "seek bank" principle) represents a cost effective means of wetland community establishment.

Once established, wetlands should not be considered a permanent vegetation type characterized by "standard" species compositions. Reclaimed wetlands are not intended to be manicured golf courses, city parks, or botanical gardens that require constant management and manipulation to validate some landscape architect's notion of what a "natural" wetland should look like. By definition, wetland plant communities are dynamic. Vegetative composition as well as biomass will and should vary. If wetlands are not constantly changing something is wrong and they will cease to be productive wetlands.

Wetlands vary in response to localized and general hydroperiod (frequency and duration of inundation) fluctuations. Consequently, the vegetative component will vary throughout the growing season and from one growing season to the next. Variations (natural or managed) within wetland plant communities contribute to their productivity as a waterfowl food source (Fredrickson and Taylor 1982). Consequently, when feasible, inclusion of water level control structures (e.g., simple "stoplog" gates) provide a cost-effective means for wetland managers to produce desirable natural waterfowl foods without the expense of agricultural crop production (Weller 1978). However, development of rowcrop areas within reclaimed surface mine areas can significantly complement shallow water wetlands and deep water incline/final cut impoundments. Reclamation grading plans that allow flooding of rowcrop areas can provide a valuable asset if future waterfowl refuge/public hunting areas are possible post-mining land-use considerations.

While shallow water (i.e., 6"–5')—"pothole"—wetlands provide valuable food sources and brood rearing habitat, deep water (>5') impoundments associated with inclines and final cuts contribute nesting and wintering habitat. Current policy requires reclamation grading of final cut impoundment side slopes 5 feet below the mean low water level to increase the littoral zone and enhance impoundment productivity. Nesting habitat and brood survival is greatly enhanced when reclamation grading provides islands through selective placement of wheel spoil, or excavation and selective grading of incline perimeters to construct islands and peninsulas (Fig. 3). Fisheries habitat can also be enhanced when final cut spoils and highwall slopes are terraced and "notched" to further enlarge littoral zones and structural diversity. Structural diversity of deep water (>5') habitats can be increased by inclusion of artificial habitat devices such as tire and pipe spawning structures, and brush, boulder, and scrap equipment "fish attractors" (Nelson et al. 1982).

Interspersion of wetlands among terrestrial wildlife areas

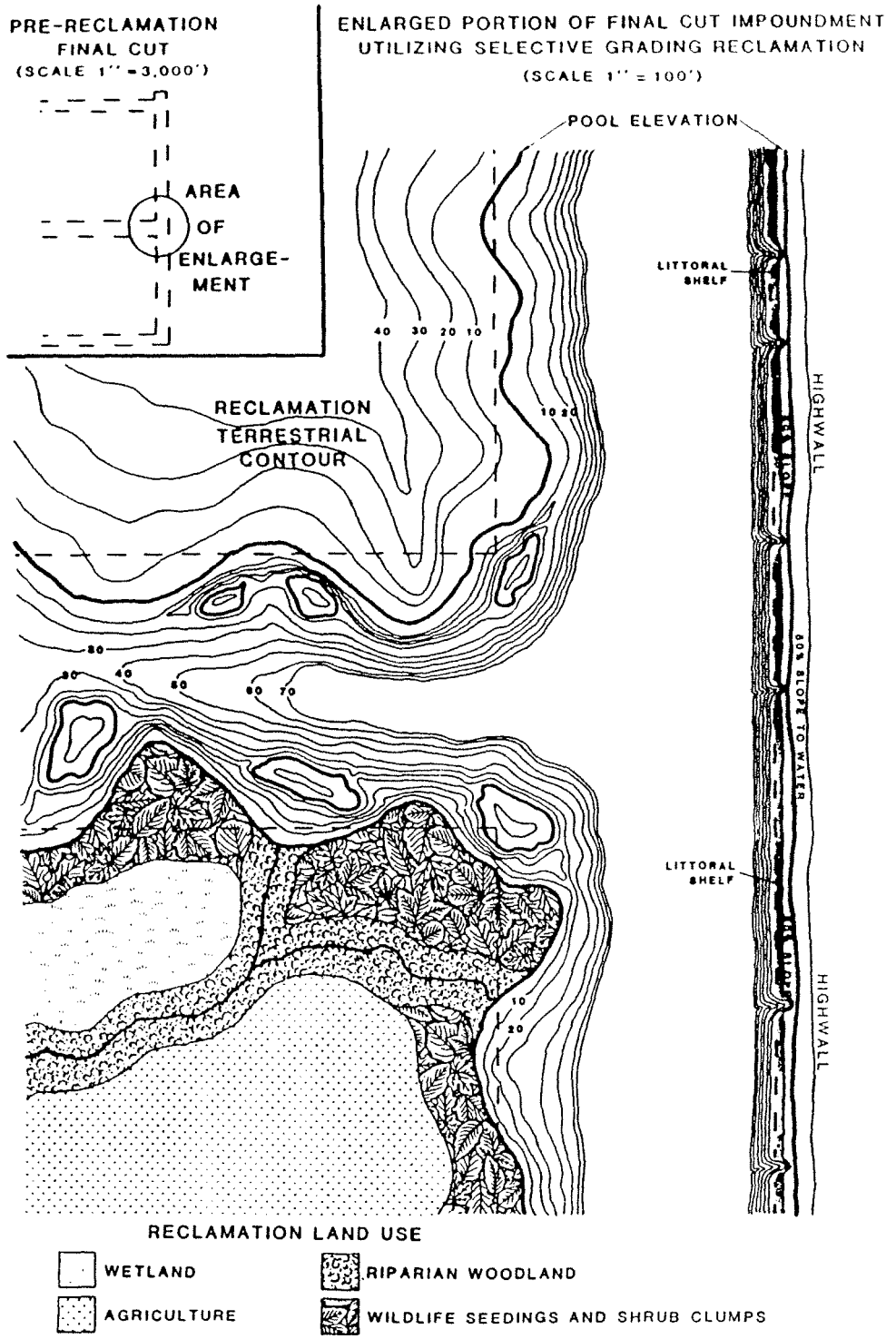


Figure 3. Selective grading to provide islands and increase littoral zones can increase habitat diversity of deep water areas of final cut and incline impoundments.

represents the most effective means of habitat enhancement. Shoreline "complexity" characterized by sinuous moist/soil emergent wetland margins contributes to enhanced "edge" effect and increased habitat productivity. When establishing wetland "pothole" systems, construction of random clusters of shallow water wetlands as part of a larger wetland complex, will inherently provide the greatest amount of desirable edge effect (Williams 1982) and waterfowl productivity (Kantrud and Stewart 1977). Management adjacent terrestrial habitat complements waterfowl habitat

management when erosion from agricultural runoff is minimized and pasture grasses are not excessively grazed (Higgins 1977, Duebbert and Lokemoen 1980, Lokemoen 1973).

The previous discussion highlighted basic economical principles of wetland establishment that serve as an "ecological and philosophical guide" for wetland reclamation. This philosophical guide has emphasized what is not needed as much as what is needed to promote successful wetland establishment. By discouraging what is not needed (e.g., complex planting schemes, or detailed hydrologic budgets for each of 55 potholes in a 250-acre wetland complex), and promoting what is needed (e.g., diverse bottom topography and hydroperiods), wetlands can be readily established without sacrificing quantity (i.e., acres) for misunderstood measures of quality that are sometimes represented by "frosting-on-the-cake" features such as parking lots, boat ramps, and nature trails.

Under the current regulatory program, the Illinois Department of Mines and Minerals has been a leader in promoting and accepting innovative wetland plans. When reviewing these diverse permit applications, which may affect as little as 2 acres or more than 200 acres, IDMM has encouraged operators to submit plans that are based on the previously discussed fundamentals of wetland establishment. An outline of these fundamentals, or performance guidelines, for shallow water wetlands is identified below:

PHYSICAL

Zonation:

- One-third to one half of wetland are should be deeper than 2 to 3' at normal pool elevation to prevent establishment of vegetative monocultures (e.g. cattails, reedgrass).
- Include depths greater than 4' (e.g., 4–6' over 1/3 to 1/2 of area) to ensure open water/deep water habitat for fish if desired.
- Intersperse shallow water zones (e.g., 0–24" over 1/3 to 1/2 of area) within deepwater zones to achieve "natural" vegetation diversity and distribution.
- Use rough grading techniques to achieve the "rough and irregular" bottom topography and shoreline contours.
- Establish multiple shallow water wetland "pothole" complexes (5 to 10 potholes @ 1/2 to 5 acres) to attain diversity within adjacent upland wildlife habitat and maximize shoreline length and complexity to enhance waterfowl nesting and brood utilization.

Islands:

- Include islands and/or peninsulas within larger potholes (>1 acre) to provide safe waterfowl nesting and loafing sites. Islands may be as small as 30x30' or as large as 2 to 3 acres within larger wetlands.
- Construct island to attain a 2–3' height above the projected mean high water elevation to prevent spring flooding of nest sites.
- Provide erosion protection through broad sloping (8:1–12:1) adjacent shorelines that promote vegetative stabilization through natural colonization by erosion resistant emergent macrophytes.
- Provide physical (rip-rap) erosion protection for those islands without adequate slope protection. Placement of rip-rap should include an 18" zone above the high water elevation and 12 to 18" below the low water elevation.
- Locate and construct islands to attain terrestrial predation protection by providing adequate deep water "buffer" zones (>2' deep and >50' from adjacent shorelines.)

HYDROLOGIC

Hydroperiod: (frequency and duration of inundation)

- Identify and plan wetland locations, numbers, and drainage patterns to achieve natural fluctuations of water levels within single large wetland basins, or among individual wetland "potholes" within larger wetland complexes (e.g., design some wetlands within the complex that may be only seasonally inundated, while others may be permanently inundated).
- Provide simple water level management drawdown structures (e.g., stoplog style gates with 24" drawdown capability) for larger wetlands that may be benefited by "moist soil" management practices.

System Interactions:

- When desirable and applicable, shallow water wetlands can and should be integrated within stream restoration riparian habitat zones to enhance seasonal wetland habitat diversity.
- When desirable and applicable, wetlands (and some stream restoration channels) may also be directly connected to discharges from final cuts and incline impoundments to stabilize flow, and/or enhance water level management (e.g., seasonal drawdown and reflooding) capability.

VEGETATION

Establishment:

- Enhance the natural process of vegetation colonization and development on adequately amended soils (limestone and fertilizer if needed) with initial

nurse crop establishment using a moist soil annual such as Japanese millet and agricultural seed cleaning screen rejects if available (e.g., rejects contain desirable moist soil plants such as chufa, smartweed, dock, and wild millet).

- Enhance moist soil annual and perennial wetland colonization and establishment using "donor" wetland substrates from adjacent ditches, sediment ponds, or wetlands to inoculate portions of wetland basin zones (i.e., "seedbank" principle ensures typical locally adapted wetland propagules (seeds, roots, tubers) are introduced).
- Collect and establish locally adapted selected wetland perennials (e.g., hardstem bulrush, threesquare, spike rush, river bulrush, cordgrass, arrowhead, etc.) if necessary to ensure introduction and eventual spread to desirable species.
- Obtain some commercially available planting stock (e.g., preferably seed such as alkali bulrush; or tubers and roots of pickerelweed, sweet flag, arrowhead, and rushes) to compensate for inadequate locally available stock.
- Initiate perennial emergent species establishment in correct inundation zones (e.g., see Figure 2) following nurse crop establishment after seasons water level fluctuations have stabilized and a growing period (8–10 weeks) of permanent saturation and/or shallow inundation is expected (e.g., a controlled drawdown to expose moist substrates followed by gradual reflooding is beneficial).
- First and second year plant establishment efforts are designed to initiate and accelerate natural colonization process, not to provide an "instant green" densely planted reclaimed "natural wetland."

Management:

- Natural hydroperiod variation and managed drawdowns (e.g., drawdown once in late spring and reflood mid-summer, or drawdown mid-summer and reflood early fall, etc.) should provide for seasonal variation in the distribution, density, and species composition of annual and perennial vegetation.
- Basin design (i.e., depth and topographic diversity), reclamation planting techniques, and eventual hydroperiod establishment (natural or managed) should contribute to an overall (i.e., over 3–4 year cycle of "normal" climatic conditions) 30 to 50% coverage of both emergent (moist soil annuals and perennials) and aquatic (submerged and floating) plant species.

The previous physical, hydrologic, and vegetative guide is meant to serve as a foundation of understanding of basic, cost-effective principles for wetland reclamation practices. Any effort to specify, design, and control by regulatory action every detail of the reclamation process defeats the ultimate goal of habitat enhancement and defies the accepted definition that wetlands are by nature complex and dynamic systems. While "cookbooks" might provide operators and consultants supposed fool-proof procedures, the associated constraints preclude the flexibility needed to implement innovative practices adapted to site-specific conditions. The general guidelines presented here, recognize that if operators provide the needed physical and hydrologic conditions for wetland construction, natural processes will enhance and maintain the vegetative component of a diverse and dynamic wetland system.

In summary, wetland reclamation has been and can continue to be an important process by which habitat diversity is included in post-mining areas. Understanding and adhering to the basic principles of wetland reclamation and continued cooperation with regulatory personnel ensure that operators will submit and implement plans that both restore and enhance this diminishing natural resource.

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SELECTION AND DEVELOPMENT OF PLANTS FOR USE IN SOUTHWESTERN RIPARIAN ZONES

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Abstract: In efforts to bring back the diverse plant community that was once a part of the flood plains of New Mexico, the USDA Plant Materials Center at Los Lunas, New Mexico, whose purpose is to assemble, test, and release plant materials to be used in conservation work, set out in the early '80s to develop superior riparian plants and to test techniques for establishment of these plants.

Studies initiated in 1980 utilizing plantings of dormant poles of Rio Grande cottonwood and black willow have proven successful. Results of these tests indicated that best survival is obtained when poles of 2 to 3 inch basal diameter and heights of up to 20 feet are used. Poles should be augered to the lowest anticipated depth of the growing season water table. Studies indicate that survival was reduced when poles were placed two feet or more above existing water tables.

Collection of Rio Grande cottonwood and black willow seedlings began in 1983 along the Rio Grande valley in an effort to select trees with superior qualities in growth rate, rooting vigor and crown spread. Six specimens of cottonwood and black willow were collected at each of 39 sites located along the Rio Grande valley. The seedlings were placed into an evaluation planting at Los Lunas PMC in 1984. By 1987, five superior Rio Grande cottonwoods and three black willows were selected. Since then tree increase blocks (cut from the same "pole") have been established of each of the selected accessions (indivudal trees), to insure adequate number for further evaluations at other sites.

While pole planting seems to be the answer for establishment of trees in riparian areas, the establishment of shrubs, grasses and forbs in dry riparian soils requires different techniques. Conventional techniques such as seeding require proper timing to take advantage of seasonal rains to cause germination. Other factors, such as drying out, drowning out, or being covered by deposited sediments, can also pose problems for survival of young seedlings. Other studies being completed show that use of individual plants from containers or use of vegetative plant parts (such as rhizomes) can insure survival when planted in riparian areas.

Water harvesting, a method whereby the soil surface is shaped into a vee ditch, has proven very satisfactory. Plants are placed in the ditch assuring adequate moisture from runoff of adjacent areas. As expected, the response of annual weed growth was also enhanced. The need for weed control was eliminated when plastic film was used to seal the slopes.

Many of the plants native to the riparian zones of New Mexico are not commercially available. Techniques for propagation and establishment are unknown for many species. With the ongoing program for the development of plant materials through the Plant Materials Center, we expect to expand our collections of hardy plants and the knowledge associated with growing them.

WETLANDS MITIGATION BANKING IN COLORADO: AN OPTION WORTH PURSUING

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Abstract: Mitigation banking and its applicability to mitigate adverse impacts to wetlands are discussed. Examples are given to demonstrate how mitigation banking could be applied. Adoption of a statewide mitigation policy is preferable to case-by-case precedents.

Keywords: Colorado, mitigation, mitigation banking, wetlands

Mitigation banking is not a new concept. It has been applied successfully for mitigation of adversely impacted habitat in various regions of the country for more than 10 years. Mitigation banking has been defined by the U.S. Fish and Wildlife Service (1981) as habitat protection or improvement actions taken expressly for the purpose of compensating for unavoidable, necessary losses from specific future development actions. Soileau et al. (1985) compared mitigation banking to maintaining a bank account. A developer undertakes measures to create, restore, or preserve fish and wildlife habitat in advance of an anticipated need for mitigation of project construction impacts. The benefits attributable to these measures are quantified, and the developer receives mitigation credits from the appropriate regulatory and/or planning agencies. These credits are placed in a mitigation bank account from which withdrawals can be made. When the developer proposes a project involving unavoidable losses of fish and wildlife resources, the losses (debits) are quantified using the same method that was used to determine credits, and a withdrawal equal to that amount is deducted (debited) from the bank. This can be repeated as long as mitigation credits remain available in the bank.

Mitigation banks have been sponsored by both public and private interests in at least 9 states. The U.S. Fish and Wildlife Service is involved in 14 existing mitigation banks in the country (Table 1) and an additional 10 banks are proposed. Ten of the 14 banks have involved fixed areas of land ranging from 4 ha to 3,809 ha (Short 1988).

Table 1. Existing Mitigation Banks.*

Bank Name	Location	Size (ha)	Established (year)
Astoria Airport	OR	13	1987
Bracut Marsh	CA	5	1981
Port of Los Angeles Inner Harbor Cabrillo Marina	CA	No limit	1984
Port of Los Angeles PacTex, Batiquitos Lagoon	CA	238	1987
Port of Long Beach Pier A, Newport Bay	CA	12	1984
Minnesota Department of Transportation	MN	No limit	1987
Tenneco LaTerre	LA	2,806	1984
Louisiana Department of Transportation	LA	1,178	1982
Company Swamp	NC	574	1985
Goose Creek	VI	4	1982
North Dakota State Highway Department	ND	No limit	1975
Bonneville	UT	3,809	1978
Idaho Transportation Department	ID	No limit	1988

*Adapted in part from Short (1988: 41–42).

FUTURE TRENDS IN MITIGATION

Economics is integral to mitigation. As scientists it is easy for us to focus solely on the technical side of mitigation (design, implementation, evaluation), ignoring the economics and politics, but the future of mitigation relies on an integrated approach.

Tom Lovejoy, a tropical ecologist, provides an excellent example of an integrated approach to mitigation, and offers a glimpse into the future of habitat mitigation (Quammen 1989). Lovejoy was pondering the relationship between the huge Third World debts and the devastation of tropical ecosystems. The Third World debtor nations needed foreign currency (especially dollars) to pay interest, and foreign currency was often obtained through the exploitation of tropical ecosystems. Lovejoy proposed to use the Third World debt crisis, which seems to be nearing financial gridlock, to help solve environmental problems. He combined these two negatives that resulted in the first debt-for-nature transaction, which was Conservation International's purchase of $650,000 worth of the Bolivian external debt in exchange for a commitment from the Bolivian government to protect almost 1.6 million ha of Amazon headwaters forest. The World Wildlife Fund is presently using this debt-for-nature approach in Ecuador, Costa Rica, and the Philippines, making $5 million worth of debt available in local currency to support preservation of tropical ecosystems in these countries.

APPLICABILITY OF MITIGATION BANKING

The future of mitigation depends on creative solutions, such as Tom Lovejoy's, that bring together funding and

incentives for both the developer and the permitting agencies that will benefit the resource. Mitigation banking has the potential to accomplish these goals. I have selected wetlands mitigation to demonstrate the various ways mitigation banking could be used because wetlands mitigation, through the Section 404 permitting process, is required for many projects in Colorado. However, the following scenarios could be expanded to other environmental issues:

Opportunity

The state highway department unavoidably will impact 25 acres of wetlands with a section of newly constructed highway. They have found 3 sites with the proper topography and hydrology that will accommodate 13 ha; they would like to bank 3 ha of wetland credit for anticipated future impacts in the region.

Cooperation and Economy of Scale

Several municipalities in the Denver metropolitan area anticipate numerous small unavoidable wetland impacts in the metropolitan area over the next few years. They would like to take advantage of the economy of scale and share the costs of constructing 1 or 2 wetland mitigation projects.

Advanced Planning and Synergism

A county wishes to offset future wetland impacts from county road and utilities construction by including wetlands creation and restoration in its open space and parks programs.

Tendering of Credits

A water and sewer district would like to use wetlands to help process their effluent; they have no need of wetland mitigation credits, but another entity in their area does.

Credits for Funding

The Colorado Division of Wildlife (CDOW) has an opportunity to acquire a conservation easement along a stretch of river with degraded wetland and riparian resources. The CDOW can afford the easement but needs O&M funding to fence the reach to exclude grazing and rehabilitate the riparian wetlands. A local river district is planning a reservoir in the region that will inundate riparian wetlands and is willing to fund the CDOW now in exchange for future wetland credits.

Acquisition of Funding, Synergism and Tendering of Credits

A city is constructing a greenbelt park system along its water courses. Funding is incomplete for the park system. The city would like to rehabilitate the riparian corridors and add a system of marshes with boardwalks as part of a nature walk/interpretive area and sell the credits, for wetlands created and restored, to area developers in need of wetland mitigation credit. Profits from the credits tendered would then be used for the park funding.

Credits for Preservation of Unprotected Wetlands

The State Engineer rules that a reservoir that has always maintained a relatively constant pool for recreation will now have to release water during the summer to satisfy senior downstream water users. The reservoir supports significant wetland resources that will be lost or degraded if the changes in reservoir operations occur. These wetlands are not protected from this action by Section 404 since there is no dredge or fill action associated with the change in operations.

A municipal water provider is willing to consider a water exchange that will satisfy senior downstream rights with effluent return flows in exchange for upstream storage in the reservoir. The water provider agrees to withdraw storage during the winter and maintain a recreation pool in the summer. The water provider would like to bank a credit for the wetlands saved to offset losses associated with construction of a nearby reservoir in the future.

NEW DIRECTIONS FOR MITIGATION BANKING

Mitigation banking has typically been established to respond to the needs of one particular entity such as a state highway department or port authority whose actions will have predictable and repeatable adverse impacts on wetlands. While this is an appropriate application of mitigation banking it only scratches the surface of a range of possibilities. The previous scenarios demonstrate that mitigation banking can be flexible and applied to a variety of situations.

If the scientific community is going to keep pace with the issues and problems in the management of impacted wildlife we need not only to improve our mitigation technology but also our mitigation policies. When properly integrated and implemented it is both policy and technology that form the framework for proper mitigation.

Mitigation banking is a highly flexible policy that has benefits for both the resource and the developer. Its use is limited only by one's creativity and agreements that can be reached among the developer and the regulatory and commenting agencies. Creatively applied, mitigation banking fills a current void in the Section 404 permitting process that regulates development in wetlands. As typically administered in Colorado and over much of the nation, Section 404 permitting is a negative process. There is no incentive to create, rehabilitate, or enhance wetlands unless an applicant seeking permission to fill wetlands needs mitigation to obtain a permit. This is not the way to protect and enhance a resource. It is a regressive form of management.

The future of mitigation depends on establishing

mitigation policies that allow the developer to be part of the mitigation process from the beginning. Mitigation banking is such a process.

STATEWIDE MITIGATION BANKING POLICY

Typically mitigation banking has been proposed on a case-by-case basis. I propose that Colorado needs to develop a statewide mitigation banking policy. There are some precedents for this proposal. California was the first state to attempt codification of the concept of mitigation banking through the California Lands Banking Act proposal (Ciupek 1984). Mitigation banks in California have been viewed as providing permit applicants and permitting agencies with a simpler, more predictable process for complying with mitigation requirements and improving the resource value of mitigation projects (Riddle 1986).

The North Dakota Legislature passed Senate Bill 2035 known as the "No Net Wetlands Loss Bill." The new law also created a wetlands mitigation bank that will be maintained by the State Engineer (Short 1988).

The advantage to a statewide mitigation banking policy is that it could allow all developers in the state to take part in mitigation banking, not just a select few that have the resources to negotiate such agreements for a particular project. This is important for a number of reasons:

1. Numerous small projects adversely impact wetlands and these impacts cumulatively amount to many acres of lost fish and wildlife habitat. Compensating for these losses is difficult and complex for all concerned parties, including regulatory agencies issuing permits and developers proposing projects. Mitigation on many small projects may never be required or if required may never be completed.

2. Developers typically do not oppose mitigation requirements if they understand that all of the development community (i.e., their competitors) are treated the same. Mitigation then becomes a built-in expense. For example, in California a mitigation fee type bank has been utilized where private parties make payments to a state agency in return for mitigation credits to cover project impacts.

3. Common standards and procedures among banks in the state will facilitate tendering and exchange of credits.

4. A statewide mitigation policy can be used as a framework to develop standards by which mitigation success can be judged.

Beginnings of a Statewide Policy

In their Mitigation Policy and Procedures and Guidelines (1987) the Wildlife Commission for the State of Colorado stated: "Mitigation banking, a method of crediting a project proponent for its activities that benefit wildlife habitat when those activities have not been credited to other projects, is an innovative concept that will allow greater flexibility in the timing of meeting the State's wildlife needs. The Division is specifically directed to investigate the concept of mitigation banking with a goal of adding that concept in a workable form both to this policy and to the *Procedures and Guidelines* as soon as practicable."

Other organizations in the State have expressed interest in mitigation banking but so far these interests have not been galvanized. An attitude expressed by many is that mitigation banking is a good concept; maybe we will apply it when we have the right project. Several problems exist with this "tomorrow" attitude:

1. Mitigation banking agreements typically will not be negotiated for small projects; it is too time intensive. Yet it is these numerous small impacts, which are rarely properly mitigated and difficult to monitor, that are best suited to mitigation banking.

2. The case-by-case approach to mitigation banking will establish policy by precedent. Depending on the precedents, the evolving policy could be sufficient or poorly applied to other projects.

3. It is easier for all parties to be objective when planning a statewide policy than when negotiating policy for a specific development.

Inevitably, some form of mitigation banking will eventually be used to compensate for adversely impacted wildlife resources in Colorado. Will it be planned on a statewide basis, or will it occur on a case-by-case basis? It is difficult to predict at this time, but for the sake of future wildlife mitigation I hope it occurs in a planned statewide context with full participation from development, regulatory and conservation communities.

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INNOVATIVE PRESERVATION OF A NEW ENGLAND WETLAND

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This paper is a case history of a solution to a dilemma at Gunstock Ski Area in Gilford, New Hampshire. Gunstock planned to expand their snowmaking capacity from 1800 to 4000 gallons per minute, and therefore needed a large additional water source. Review of several alternatives such as: (1) pumping water from Lake Winnipesaukee (a large nearby lake) uphill for 2.5 miles; (2) establishing a well field in or near the 25-acre on-site wetland; and (3) impounding the 25-acre wetland, then extracting water from the reservoir as needed, made it apparent that the only practical alternative was number 3, impounding the waters of Poor Farm Brook at the downstream edge of the 25-acre wetland.

This wetland, a 25-acre wet meadow/red maple swamp/beaver pond complex, had previously been designated a "prime wetland" by the Gilford Conservation Commission and therefore enjoyed an additional measure of statutory protection beyond that normally afforded wetlands. Impoundment of Poor Farm Brook at the proposed location would flood the bulk of this prime wetland with as much as 16 feet of water. Furthermore, as originally proposed, water would be pumped out of this impoundment as needed for snow-making purposes, which could result in great fluctuations in the winter-time impoundment water levels.

Permanent flooding and the inherent large water level fluctuations would significantly impact the ecology of this valuable wetland. Our challenge was to design the impoundment system, and to adapt the water regime, so that impacts to the stream, wetland, and wildlife would be minimal, and to mitigate for unavoidable environmental damage.

The potential and unacceptable impacts of simple, permanent, and unmitigated impoundment of this stream and wetland would be:

- Permanently (year-round) impounded stream water would warm and hold less oxygen thereby converting the impounded area and the tailwater stretch of the stream from a cold-water to a warm-water fishery.
- Decomposition of organic matter in the recently impounded reservoir could increase biological oxygen demand and decrease summer dissolved oxygen content of the reservoir and stream.
- "Prime wetland" would be flooded, forming a 16-foot deep reservoir and converting 25 acres of sedge/grass wet meadow marsh and swamp to a pond.
- Declining wintertime water levels with water extraction for snowmaking would congregate fish in a small area thereby increasing competition for space, food, and oxygen, increasing predation, and stranding or freezing others.
- Insects and burrowing animals that normally live in the mud of pond bottoms, and animals that overwinter in the substrates of ponds and streams, such as hibernating amphibians and reptiles, would be exposed to freezing temperatures with subsequent mortality, if the water level was drawn too low during snowmaking activities.
- Reduced winter water flow in the stream below the dam would decrease the amount of habitat available to aquatic insects and fish.
- Sedimentation at the dam construction site could harm downstream aquatic habitat.
- Woody vegetation in the wetland would die if it was permanently flooded, thus altering the vegetative composition of the area.

NRCS devised an alternative reservoir management strategy that, when carried out with complimentary mitigation measures, would reduce these impacts to manageable levels. The idea was to manage the impounded reservoir as a seasonal pond, filling it in late fall and draining it in late winter. Because the reservoir would be drained, there would be no impounded water to heat up and become depleted of oxygen in the summer. Low water temperatures and high dissolved oxygen contents are essential to good trout habitat. A minimum flow of approximately one half cubic foot per second was to be maintained at the dam to sustain the quality of downstream fish habitat. Delaying the fill period until wetland plants and animals are dormant in the fall reduces impacts to them.

A dike made of hay bales (hay-bale check-dam) was also to be constructed in the wetland just upstream of the main dam. This system would create a subimpoundment at the head of the impoundment, which would otherwise be dewatered earliest and in most years. The subimpoundment would terrace water in the wetland during the winter. The outflow structure of this check-dam was to be closed prior to the filling of the main impoundment. Because the snowmaking water was pumped out of the impoundment at a location between the main dam and the check-dam, the water in the subimpoundment area could not be drawn down to an elevation lower than the check-dam itself. This would

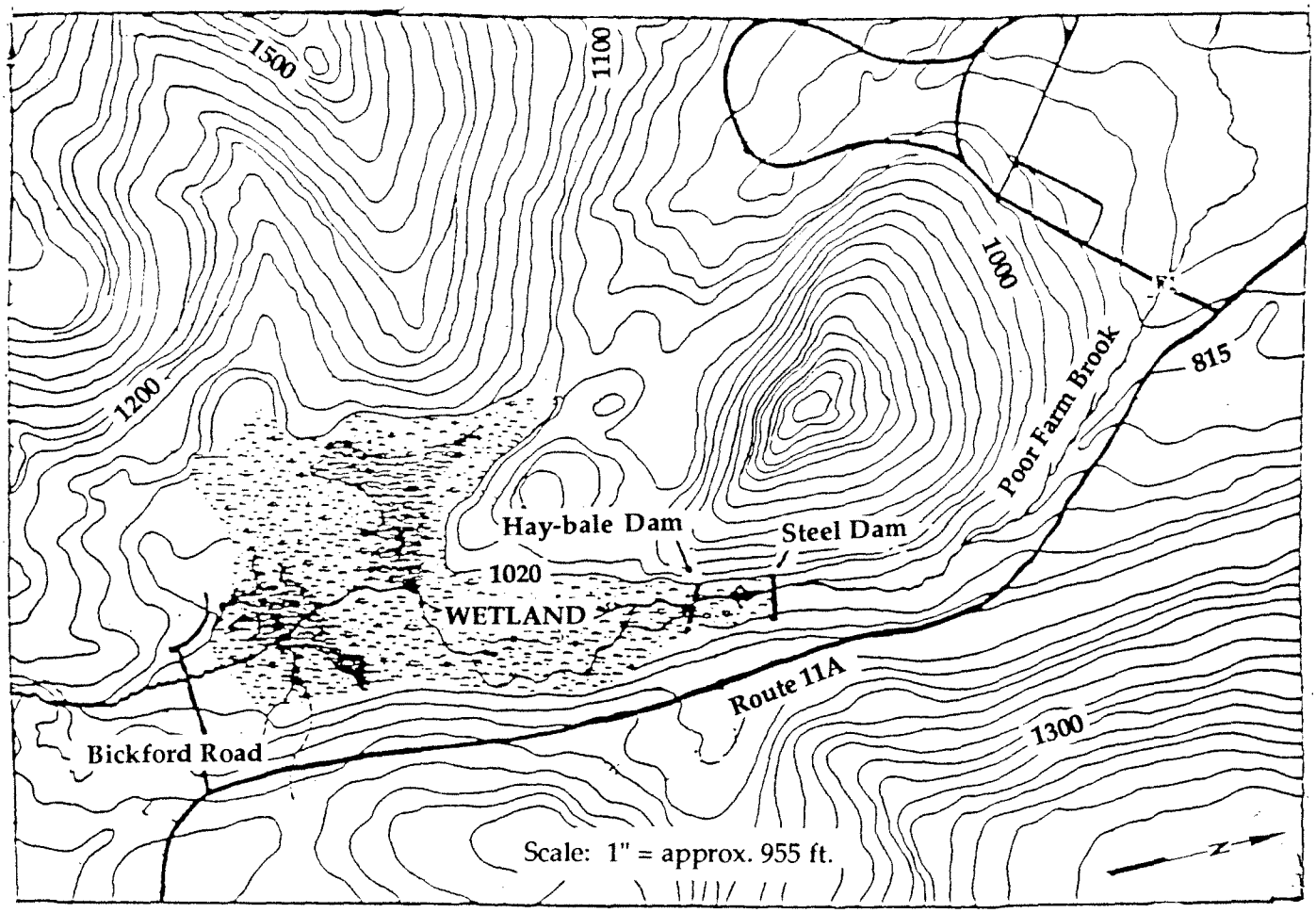


Figure 1. Wetland Steel Dam, and Hay-bale Dam for the subimpoundment at Poor Farm Brook at Gunstock Ski Area, Gilford, New Hampshire. (From Natural Resource Consulting Services, Concord, NH.)

prevent the subimpoundment water from freezing, surface to bottom, and it would prevent the substrate in the subimpoundment portion of the wetland, and animals within it, from freezing and dying when large amounts of water were withdrawn for snowmaking. Figure 1 is a schematic representation of how this technique was designed.

Modest follow-up surveys of fish, wildlife, plant life and water chemistry were designed to monitor and evaluate these mitigation measures.

STUDY AREA

Gunstock Recreation Area is a 2000 acre reservation operated by a branch of Belknap County, New Hampshire. The area ranges from 900 to 2000 feet MSL in elevation and receives an annual precipitation of about 38 inches, including 90 inches of average annual snowfall. Mean elevation of the wet meadow is 1015 feet MSL.

The drainage basin for the wetland and upstream portions of Poor Farm Brook encompasses approximately 2.5 square miles. Poor Farm Brook is a typical small, riffly, cold-water stream with a naturally reproducing brook trout (*Salvelinus fontinalis*) population. Mean year-round flow in the stream is 3500 gallons per minute (12.2 CFS).

Within the wetland, the six-foot-wide stream is deep, and serpentine, with a dense growth of grasses and sedges along its undercut banks. Beaver activity is primarily responsible for 4.3 acres of open-water ponded areas at the head end of that section. The stream substrate is one percent cobble, ten percent gravel, eighty-four percent sand, and five percent organic material, with a riffle-to-pool ratio of 1:99.

In the forested section, downstream of the wetland, the stream bed is often ten to twenty feet wide with shallow riffles and deeper pools. The forest vegetation on the banks shades the stream almost completely. Stream substrate is forty percent boulder, fifty percent cobble, and ten percent gravel, with a riffle-to-pool ratio of 6:1. Brook trout are stocked about 3000 feet below the wetland.

Most of the wetland is a grass/sedge wet meadow dominated by such species as blue-joint grass (*Calamagrostis canadensis*), fringed sedge (*Carex crinita*), lurid sedge (*Carex lurida*), and tussock sedge (*Carex stricta*), with sparse clumps of sweet gale (*Myrica gale*), and

hardhack (*Spiraea tomentosa*). The wetland edges and areas where beavers have extended the wetland are dominated by trees and shrubs such as red maple (*Acer rubrum*), maleberry (*Lyonia ligustrina*), and highbush blueberry (*Vaccinium corymbosum*), with a dense grass/sedge/fern understory.

METHODS

Construction, operation, and mitigation methods proposed by NRCS, Gunstock Ski Area, and their civil engineers Rist-Frost Associates, were eventually accepted by the regulating agencies, and statutory permits were issued.

In the fall of 1986, a steel, sheet-pile dam, with a denil-type fishway to insure ingress and egress, was constructed on Poor Farm Brook at the downstream edge of the wetland. This dam was 85 feet long with a maximum head of 16 feet. A 575-foot long, permeable hay-bale check-dam with three feet of head, was also constructed in the wetland approximately 1160 feet upstream from the steel dam.

Erosion and sedimentation control measures such as the erection of hay-bale and synthetic fabric silt barriers, were instituted during and after construction. However, a near 100-year flood event was experienced, and considerable sedimentation occurred in the stream below the dam site. Most of this sediment was subsequently removed with a hydraulic dredge. The banks at the dam construction site were stabilized with a mulch, and then seeded with wildlife food plants, and planted with wetland shrubs that were salvaged from the wetland destroyed during dam construction.

Trout habitat improvements were made in the stream below the dam. Several rock wing-dams and one log shear were constructed in the stream channel; stream configuration was improved; stream banks and overflow areas were stabilized with boulders, logs, and riprap; and some pools were deepened.

Twenty wood duck and twenty passerine bird nest boxes were erected in the wetland to enhance its value to those species.

Gunstock Ski Area officials closed the check-dam outflow, and subsequently began impounding water at the steel dam on 12 December 1986. Gradual release of the impounded water at the steel dam commenced on 4 March 1987, but water was held in the subimpoundment until released on 15 May 1987. During that winter, 15,780,000 gallons of water were pumped from the impoundment for snow-making. The greatest extent of the impoundment was 23 acres of which approximately 75 percent was within the subimpoundment. An average of 3.2 feet of water (at the dam) flooded the wetland with a winter maximum of 5.3 feet.

A similar water regime was maintained for the 1987-1988 season. Impoundment commenced on 11 December 1987 and continued until 15 March 1988 at the steel dam, and 15 May 1988 at the check-dam. Mean water depth in the impoundment (at the steel dam) was 8.0 feet (maximum = 10.1 feet) and 14,160,000 gallons of water were pumped from the impoundment for snowmaking.

NRCS monitored the ecological effects of the construction and utilization of the dam and impoundment, on Poor Farm Brook, its wetland, and wildlife. To determine the extent of change, if any, we measured certain environmental parameters in the stream and wetland, before construction (1986), and each summer for the two following years (1987 and 1988). Water quality was measured annually at stations in the stream above the wetland, in the subimpoundment portion of the stream, between the two dams, and several locales below the steel dam. Aquatic invertebrate populations were also sampled near these stations. Fish populations were sampled with minnow traps, gill nets, seines, and back-pack electro-shocker, in the same stream sections. Wildlife observations and nest box uses were recorded. Botanical information was gathered each year at four, fixed, permanent 3-meter square plots, three of which were flooded when water was impounded, and one of which was not. Canopy cover of the vegetation in each plot was estimated, by species, with a pin frame variation of the point-intercept sampling method, and with visual estimates. Woody vegetation in the plots was mapped with a coordinate system.

At the time this paper was written, we had data from the preconstruction period (Summer 1986), and from two years following construction and use (Summers of 1987 and 1988). Data will be collected in 1989.

RESULTS

Our study of ecological impacts at the snowmaking pond was not designed to measure small changes in the wetland. Sample sizes and study techniques were not sufficient to state whether or not small changes were statistically significant. The study should, however, determine if gross changes in the ecology of Poor Farm Brook and the wetland have occurred due to seasonal impoundment. We also feel that after only two years of post-project data, the results should be viewed cautiously and that firm conclusions should not be drawn for some time. This is because certain potential ecological effects, such as changes in plant communities, occur slowly.

There were some trends in the data thus far that would indicate possible negative environmental impacts (Table 1). At this time, we view these trends cautiously but are not alarmed as the differences are not great.

Vegetation in the wetland has not changed significantly since the construction of the dam. Canopy cover of plant species in the fixed plots has remained similar over the three years of the study and gross observations of the wetland indicate no change. One impact on the vegetation that was observed in 1987, was that a number of trees in the wetland had sustained damage to their bark. Apparently the surface

Table 1. Water Quality Measurements and Indicators from Poor Farm Brook, Gunstock Ski Area, Gilford, New Hampshire.

Indicator	1986	1987	1988
Mean Summer D.O. ppm *			
Wetland Section	8.1 (n=3)	6.6 (n=4)	5.7 (n=3)
(range)	(7.8-8.4)	(6.5-7.0)	(4.0-7.0)
Forested Section	10.7 (n=2)	10.1 (n=4)	8.3 (n=3)
(range)	(10.3-11.0)	(9.5-10.5)	(8.0-9.0)
Mean Summer Water Temp. C°			
Wetland Section	16.2 (n=3)	16.9 (n=4)	22.5 (n=3)
(range)	(13.6-17.9)	(15.0-18.0)	(20.0-24.5)
Forested Section	9.9 (n=2)	16.8 (n=4)	21.5 (n=3)
(range)	(9.8-9.9)	(16.0-17.0)	(22.0-24.0)
Mean Summer Air Temp. C°			
Wetland Section	18.3 (n=3)	17.6 (n=4)	27.3 (n=3)
(range)	(17.0-19.0)	(12.0-22.5)	(21.0-32.0)
Forested Section	15.5 (n=2)	18.3 (n=4)	23.0 (n=3)
(range)	(15.5-15.5)	(16.0-20.5)	(20.0-27.0)
Mean Summer pH			
Impounded Section	6.1 (n=3)	6.3 (n=4)	6.5 (n=2)
(range)	(6.0-6.2)	(6.0-6.5)	(6.5-6.5)
Forested Section	6.2 (n=2)	6.5 (n=4)	6.5 (n=2)
(range)	(6.0-6.5)	(6.5-6.8)	(6.5-6.5)
Number of Trout**			
Wetland Section	2 (2%)	2 (1%)	0 (0%)
Forested Section	35 (32%)	12 (5%)	2 (2%)
Number of Forage Fish***	71 (66%)	209 (94%)	115 (98%)

Note: * D.O is dissolved oxygen in parts per million
** Trout is eastern brook trout
*** Forage fish is primarily black-nosed dace (*Rhinichthys atratulus*)

ice in the impoundment oscillates as water is removed for snow-making and then refills, thereby scraping the bark from trees. This damage could result in tree mortality although none has been observed. Damage to low tree limbs and shrubs was heavier in 1988. Tree mortality could lead to impacts by the resultant loss of tree-top foliar habitats, and by an increase in sunlight reaching the water (less shade) with subsequent warming. On the other hand, tree mortality would increase availability of snags and cavity trees, which are important and often limiting habitat factors for many wildlife species.

We do not feel that water quality has been seriously degraded in Poor Farm Brook. It is still a cold, clear, stream with high dissolved oxygen content and a slightly acid but near neutral pH. Our data do, however, indicate a decrease in dissolved oxygen and an increase in water temperature. These trends may be more apparent than real and may be due to natural variation, and varying sample dates. For example, mean ambient air temperature at the stations increased more than did mean water temperature, and 1988 had above-average summer temperatures. Samples were taken from the stream on June 5 in 1986, on August 7 and September 17 in 1987, and on July 7 and 8 in 1988.

The diversity of terrestrial and aquatic organisms in and around the stream and wetland has not exhibited any clear trend over the three study years. There have been some changes in the species of aquatic invertebrates in our samples since 1986 but there is no pattern to these changes. It would appear that the populations were undersampled.

There was a steady decrease in relative and absolute abundance of brook trout in our fish samples. This may also be an artificial trend as less than one half as many trout were stocked by the New Hampshire Fish and Game Department in the stream in 1988, as were stocked in 1986 and 1987. This stocking is conducted at the bridge on the main access road approximately 3900 feet downstream from the steel dam. Stocked trout as well as wild trout were captured with the electro-shocker although stocked fish were taken only several hundred feet above their stocking point. Stocking dates may have also been closer to sampling periods in the two earlier years. In 1988, electro-shocking was conducted at a time of very high water. Stream water was over the banks in the wetland, hindering the process. There were many avenues of escape for trout and it was extremely difficult to see fleeing or shocked fish. On the negative side, we did have a sediment problem in 1987 that could have adversely affected trout reproduction, as could the trends in dissolved oxygen and temperature.

Wildlife usage of artificial nesting structures was high indicating their efficacy and that avian populations continued to thrive in the wetland. Of the nest boxes that were checked, 75 percent of the passerine boxes received some use, and 50 percent of the duck nest boxes were utilized.

CONCLUSIONS

Despite some cautionary trends in the data, we remain optimistic that check-dam subimpoundments and dormant-season-only flooding regimes are effective methods for mitigating the potential ecological impacts of snow-making ponds and other types of water source impoundments. Skiing is done on mountains, and by definition mountainous terrain is high in a watershed. That means that only modest amounts of water will be available naturally, and that the water that is there will be in ecologically sensitive and valuable coldwater streams and wetlands. There are ever-increasing pressures on natural resources such as those that we described and they receive very deserved protection. We feel that alternative designs and mitigation techniques such as these may, in some cases, be viable alternatives by which we can maintain streams and wetlands as they are, without significant ecological damage. Without techniques such as these, either the wetland would have been destroyed—converted to a pond, and the stream would have undergone ecological changes (possible warming), or, the project would have been denied the appropriate permits, thus depriving the county of the additional recreation opportunities.

We are not at this time drawing firm conclusions on the degree of success of our mitigation efforts. Some trends in the data are disconcerting, and the variability of the results indicates that we need greater sample sizes and more years of post-project data. If at all possible, we will intensify our monitoring efforts in the future and with additional years of data, be able to firmly evaluate their effectiveness.

MONITORING FISH, WILDLIFE, RADIONUCLIDES AND CHEMICALS AT HANFORD, WASHINGTON

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Abstract: Concern about the effects of potential releases from nuclear and non-nuclear activities on the U.S. Department of Energy's Hanford Site in southeastern Washington has evolved over four decades into a comprehensive environmental monitoring and surveillance program. The program includes field sampling, and chemical and physical analyses of air, surface and ground water, fish, wildlife, soil, foodstuffs, and natural vegetation. In addition to monitoring radioactivity in fish and wildlife, population numbers of key species are determined, usually during the breeding season. Data from monitoring efforts are used to assess the environmental impacts of Hanford operations and calculate the overall radiological dose to humans onsite, at the Site perimeter, or residing in nearby communities.

Chinook salmon spawning in the Columbia River at Hanford have increased in recent years with a concomitant increase in winter nesting activity of bald eagles. An elk herd, established by immigration in 1972, is also increasing. Nesting Canada geese and great blue herons, and various other animals, e.g., mule deer and coyotes are common. Measured exposure to penetrating radiation and calculated radiation doses to the public are well below applicable regulatory limits.

Key Words: environmental monitoring, radionuclides, chemicals, fish, wildlife.

The U.S. Department of Energy's (DOE) Hanford Site occupies a land area of about 1,450 km^2 (560 mi^2) in semi-arid southeastern Washington (Fig. 1). The Columbia River flows through the Site and forms part of its eastern boundary. The southwestern portion of the Site includes the southern terminus of the Rattlesnake Hills with elevations exceeding 1000 m. Both unconfined and confined aquifers lie beneath the Site.

Nuclear and nonnuclear industrial and research activities have been conducted at Hanford since 1943. The most environmentally significant activities have involved the production of nuclear materials and the chemical processing and waste management associated with the major product, plutonium. Byproduct wastes have included gamma, beta, and alphaemitting radionuclides, and various nonradioactive chemicals in gaseous, liquid and solid forms.

There are currently four major DOE operations areas on the Hanford Site (Fig. 1). The 100 Areas located along the Columbia River include the dual-purpose N Reactor that produced plutonium for national defense and steam for the Hanford Generating Project (HGP), operated by the Washington Public Power Supply System (WPPSS), and eight, now deactivated single-purpose, plutonium production reactors. The plutonium uranium extraction (PUREX) plant (reactor fuel reprocessing), plutonium finishing plant (Z Plant), and waste-disposal facilities are located in the 200 Areas on a plateau (elevation 229 m) about 11.3 km west of the Columbia River. The 300 Area, located just north of Richland, Washington contains the uranium fuel manufacturing facilities in support of N Reactor, and research and development laboratories. The Fast Flux Test Facility (FFTF), which has operated intermittently since 1981 to test new fuels and materials for future breeder reactor technology, is located in the 400 Area. Nongovernment facilities within Hanford Site boundaries include HGP, the WPPSS nuclear plant (WNP) sites, WNP-1, WNP-2 and WNP-4, including one commercial reactor (WNP-2) that achieved full operation status in the fall of 1984, and a commercial low-level radioactive-waste burial site near the 200 Areas, operated by U.S. Ecology. The Advanced Nuclear Fuels Corporation (formerly Exxon) fuel fabrication facility is immediately adjacent to, but not located on Hanford Site property.

Environmental monitoring at Hanford has been ongoing for 43 years. The program is conducted to assess potential impacts to individuals and populations that may be exposed to radionuclides, ionizing radiation and hazardous chemicals. Environmental monitoring currently includes air, ground and surface water, fish, wildlife, soil, vegetation, and foodstuffs (fruits, vegetables, milk). Fish and wildlife are monitored for radioactivity and to determine the population status of key species.

LAND USE, WILDLIFE AND FISHERIES

The Columbia River above and below the Hanford Reach and much of the adjacent land have experienced extensive environmental change over the last four decades due to construction of hydroelectric dams and increased irrigation (Rickard and Watson 1985). Land surrounding the Hanford Site is primarily used for agriculture and livestock grazing. Agricultural lands are found north and east of the Columbia River and south of the Yakima River. These areas contain orchards, vineyards, irrigated fields of alfalfa, various vegetable crops, and dry land fields of wheat and other cereals.

The Hanford site provides facility siting areas and a large population-free safety and security zone, and serves as an outdoor laboratory for ecological research. The Site consists mostly of undeveloped land that supports stands of native vegetation and a few exotic species (e.g., cheat-grass, Russian thistle, and tumble mustard), is free from agricultural practices, and has been essentially free from

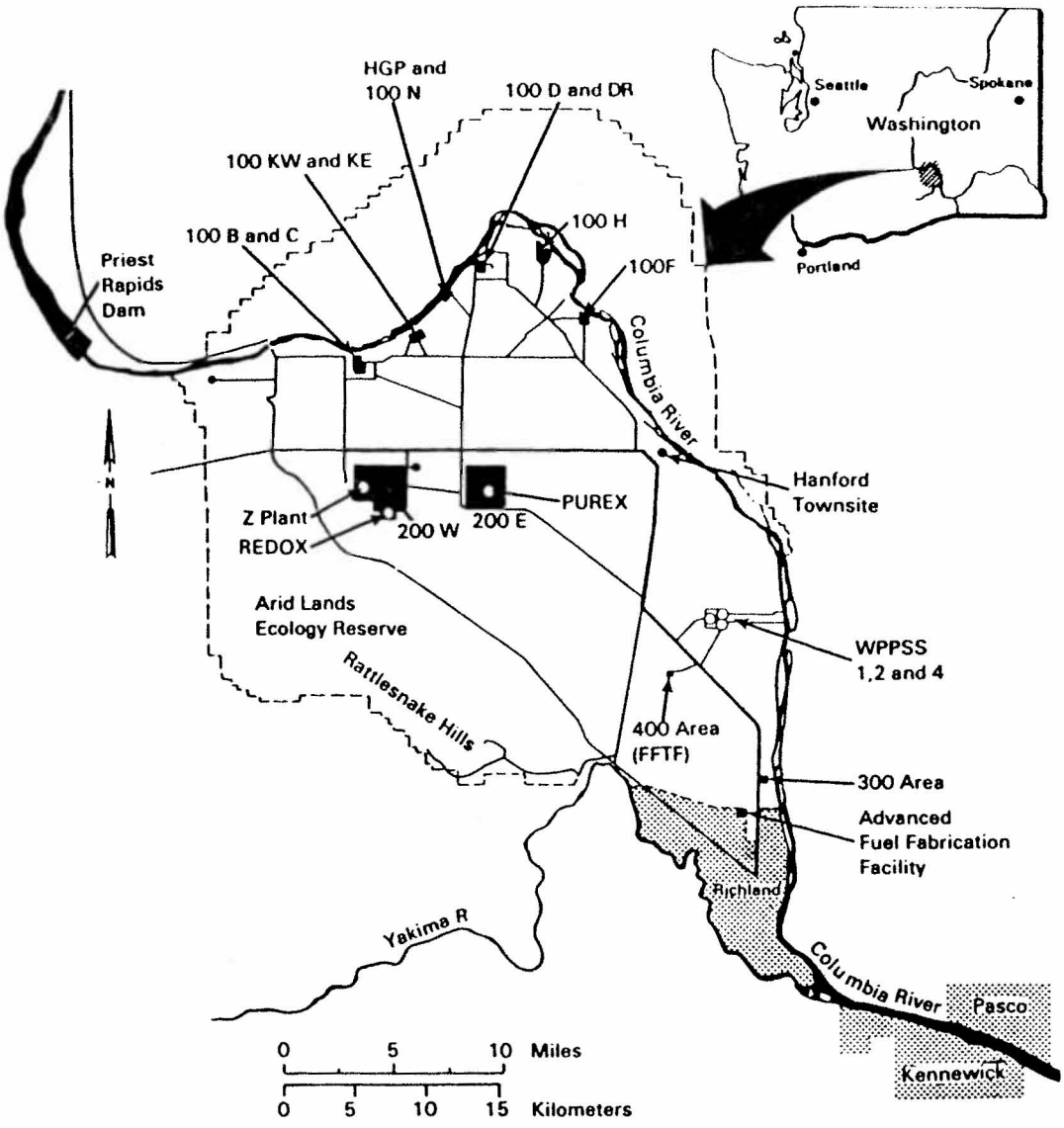


Figure 1. The Hanford Site. HGP = Hanford Generating Project; REDOX = reduction-oxidation; PUREX = plutonium uranium extraction; WPPSS = Washington Public Power Supply System; FFTF = Fast Flux Test Facility.

ivestock grazing and hunting for 45 years. Thus, the Site serves as a refuge for migratory waterfowl, elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), coyote (*Canis latrans*) and other plants and animals. Restricted land use has favored native wildlife that frequent riverine habitats, for example, mule deer, Canada goose (*Branta canadensis*), and great blue heron (*Ardea herodias*).

Use of the Hanford Site as an outdoor laboratory for ecological research and to preserve the diversity of native plants and animals predates 1952 (Vaughan and Rickard 1977). In 1977, the Hanford Site was designated as a National Environmental Research Park (Rickard et al. 1982). About 259 km^2 of land on the northeast slope of Rattlesnake Hills is designated as the Arid Lands Ecology Reserve (Fig. 1). This area supports large expanses of native shrubsteppe (sagebrush-grass) plant and animal communities, some of which are in relatively undisturbed condition. The Hanford Site north of the Columbia River is shared between a state wildlife management area and a federal wildlife refuge.

Flow of the Columbia River through the Hanford Site is regulated daily according to electric power demands. Although the river was once closed to public access, public use for recreational and barge traffic is again practical. The Columbia River at Hanford supports up to 48 species of fish (Gray and Dauble 1977). The physical and chemical characteristics of the Hanford Reach and the river's use by anadromous salmonids were recently reviewed and

summarized (Becker 1985). The Hanford Reach serves as a migration route for upriver runs of Chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*) and sockeye (*O. nerka*) salmon, and steelhead trout (*Salmo gairdneri*). It also supports the last remaining mainstem spawning habitat for fall chinook salmon. The salmon population is maintained by a combination of natural spawning, artificial propagation and regulated commercial and sport harvest of returning adults.

Based on redd (nest) counts from the air, fall chinook salmon spawning in the Hanford Reach of the mainstem Columbia River has increased dramatically since 1980 (Fig. 2). Recent observations by divers (Swan et al. 1988) showed salmon redds at depths (4.6–9.1 m) below those visible by boat or aircraft and suggests that salmon spawning in the Hanford Reach may be even greater than previously estimated. The increase in salmon spawning has attracted increasing numbers of wintering bald eagles (*Haliaeetus leucocephalus*) (Fig. 2). The bald eagle is listed by the U.S. Fish and Wildlife Service as "threatened" in the state of Washington (Rickard and Watson 1985).

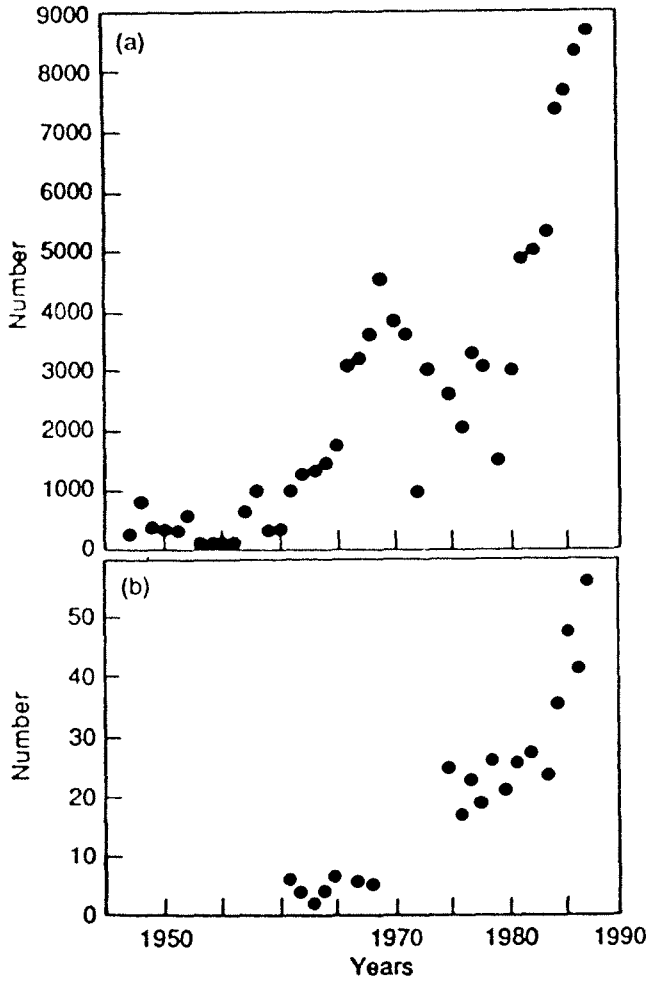


Figure 2. Numbers of (a) salmon redds (nests) and (b) wintering bald eagles (there were no counts from 1969-1974) at Hanford (adapted and updated from Rickard and Watson 1985).

The sparsely vegetated islands in the Columbia River have historically been used as nesting habitat for great basin Canada goose (Hanson and Eberhardt 1971; Fitzner and Rickard 1983). From the mid-1950s to the mid-1970s the number of goose nests declined from about 250-300 to about 100 annually (Fig. 3). From the late 1970s to the present, the number of nests has increased and appears to have stabilized at about 150-200. Initially, closure of the Hanford Reach was beneficial to the geese by providing freedom from human intrusion. However, the coyote, a natural goose predator, also benefited, and is believed to be the major cause of the decline in numbers of goose nests into the mid-1970s.

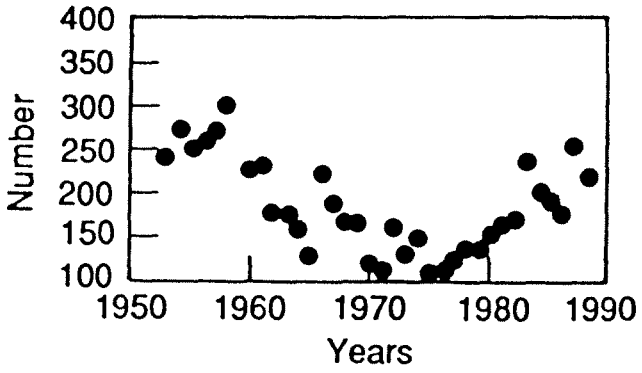


Figure 3. Numbers of Canada Goose Nests on Islands in Hanford Reach of the Columbia River, 1953-1988 (Adapted and Updated from Fitzner and Rickard 1983).

Initially, there were no nesting great blue heron on the Hanford Site. However, there are now three active colonies consisting of about 35-40 birds each, and herons are present year round.

Elk first arrived on the Hanford Site in 1972 (Rickard et al. 1977). From a small founding population, the herd size grew to about 80 animals in 1987 (Fig. 4). The rapid increase in elk is attributed to the lack of predation or human disturbance during calving, absence of onsite hunting, and the lack of competition from sheep and cattle for available forage. For the last three years, offsite hunting has killed an estimated 15 animals annually, which is equal to about 60% of the number of calves born each year onsite. The mule deer population at Hanford is estimated at several hundred animals and appears stable even in the absence of onsite hunting. Coyote predation on fawns is believed to be an important factor that maintains a stable deer population (Steigers and Flanders 1980).

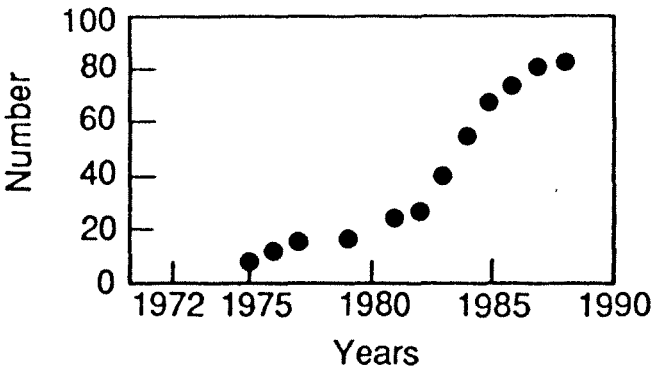


Figure 4. Estimated numbers of Elk at Hanford, 1975 to 1988, after the offsite hunting season.

RADIOLOGICAL TRANSPORT

Air

Potential airborne transport of stack releases containing radionuclides from Hanford facilities offers a direct pathway for human exposure. Thus, air is sampled continuously for airborne particulates and analyzed for radionuclides at 50 locations onsite, at the Site perimeter, and in nearby and distant cities (Price 1986; PNL 1987; Jaquish and Mitchell 1988). At selected locations, gases and vapors are also collected and analyzed. Many of the longer-lived radionuclides released at Hanford are also present in atmospheric fallout that resulted from nuclear weapons testing in the 1950's and 1960's or from nuclear accidents that occurred elsewhere. In May and June 1986, air samples collected onsite as well as those for distant locations showed increases in several long- and short-lived radionuclides (e.g., ^{137}Cs, ^{131}I, ^{103}Ru) resulting from the reactor accident at Chernobyl, April, 1986, in western Russia. However, even then, no sample exceeded 0.17% of the applicable DOE derived concentration guide (DCG) for areas permanently occupied by the public.

Ground Water

The shallow unconfined (water-table) aquifer has been affected by waste-water disposal practices at Hanford more than the deeper, confined aquifers. Discharge of water from various industrial processes has created ground-water mounds near each of the major waste-water disposal facilities in the 200 Areas, and in the 100 and 300 Areas (Fig. 1). Discharge to ground water in the 200 Areas may contribute ten times more water annually to the unconfined aquifer than natural input from precipitation and irrigation (Graham et al. 1981). These ground-water mounds have altered local flow patterns in the aquifer, which are generally from west to east.

Ground water, primarily from the unconfined aquifer, is currently sampled from over 560 wells (Jaquish and Mitchell 1988). Tritium (^{3}H) occurs at relatively high levels in the unconfined aquifer, is one of the most mobile radionuclides, and thus, reflects the extent of ground-water contamination from onsite operations. Many liquid wastes discharged to the ground at Hanford have contained ^{3}H. The PUREX facility is currently the main source for ^{3}H-containing wastes (DOE 1983). Tritium from releases prior to 1983 that passed downward through the vadose (unsaturated) zone to the unconfined aquifer continues to move with ground-water flow toward the Columbia River. Tritium concentrations in Hanford ground water range from less than 300 pCi/L to over 2,000,000 pCi/L near or within the 200 Areas (PNL 1987; Jaquish and Mitchell 1988).

Ground water from the unconfined aquifer enters the river through subsurface flow and springs that emanate from the riverbank. McCormack and Carlile (1984) identified 115 springs along a 41-mile stretch of river. Tritium concentrations in wells near the springs ranged from 19,000 to 250,000 pCi/L and averaged 176,000 pCi/L in 1985 (Price 1986). Although the distribution of ^{3}H and other nuclide concentrations in springs generally reflected those in nearby ground-water wells, the magnitude was generally less in springs due to mixing of ground and surface water. Tritium concentrations in the river were generally less than those in springs. It is noteworthy that ^{3}H also occurs naturally in the Columbia River upstream from Hanford. Tritium concentrations in springs were less than 4% of the DOE DCG (2,000,000 pCi/L). Tritium concentrations in the river were less than 0.5% of the DCG and less than half the regulatory limit for drinking water (20,000 pCi/L; EPA 1976).

Surface Water

Columbia River water is used for drinking at downstream cities, for crop irrigation and for recreational activities (fishing, hunting, boating, waterskiing, swimming). Thus, it constitutes the primary environmental pathway to people for radioactivity in liquid effluents. Radionuclides can be delivered to human foodstuffs through crops irrigated with river water, and cow's milk through irrigated alfalfa and other cattle forage. Although radionuclides associated with Hanford operations, world wide fallout, and natural phenomena continue to be found in small but measurable quantities in the Columbia River, concentrations are below Washington State and Environmental Protection Agency (EPA) drinking water standards.

Deep sediments in downstream reservoirs still contain low concentrations of some long-lived radionuclides (Nelson and Haushild 1979; Haushild et al. 1975; Robertson and Fix 1977; Sula 1980; Beasley et al. 1981). Trace amounts of ^{239}Pu, ^{60}Co, ^{137}Cs, and ^{152}Eu persist in sediments accumulated above the first downstream dam (McNary Dam).

In 1977, between 20 and 25% of the integrated plutonium inventories ($^{239, 240, 241}$Pu) in Lake Wallula sediments, 100 km downstream, were believed to originate from the 1944 through 1971 releases at Hanford (Beasley et al. 1981). However, only ^{239}Pu was believed to reflect earlier reactor operations. Further, this ^{239}Pu was derived from ^{239}Np (produced by neutron capture in natural uranium followed by decay to ^{239}Np) an abundant isotope in Columbia River water during the years of reactor operations. Thus, plutonium was apparently never actually released to the river from reactor operations.

Fish and Wildlife

Fish are collected at various locations along the Columbia River and boneless fillets are analyzed for ^{60}Co, ^{90}Sr, and ^{137}Cs. Carcasses are analyzed to estimate ^{90}Sr in bone. Following shutdown of the last single-purpose, once-through cooling reactor and installation of improved liquid effluent control systems at N Reactor, short-lived radio nuclides (including the biologically important ^{32}P and ^{65}Zn) essentially disappeared from the river (Cushing et al. 1981) through radioactive decay. Radionuclide concentrations in fish collected from the Hanford Reach of the Columbia River are similar to those in fish from upstream locations.

Wildlife have access to several onsite waste-water ponds and ditches that contain low levels of radionuclides and, thus, provide a potential biological pathway for dispersal of contaminants accumulated in water and sediments (Cadwell et al. 1979; Rickard et al. 1981; Rickard and Price 1984). Samples from these areas help estimate the dose to Hanford fauna and the potential dose impact to humans if onsite game animals were consumed.

Deer (*Odocoileus* spp.), ring-necked pheasants (*Phasianus colchicus*), mallard ducks (*Anas platyrhynchus*), Nuttall cottontail rabbits (*Sylvilagus nuttallii*) and black-tailed jack rabbits (*Lepus californicus*) are collected and tissues are analyzed for ^{60}Co and ^{137}Cs (muscle), $^{239, 240}$Pu (liver) and ^{90}Sr (bone). The dose that could be received by consuming wildlife at the maximum radionuclide concentrations measured in 1985–1987 was below applicable DOE standards (Price 1986; PNL 1987; Jaquish and Mitchell 1988).

Soil and Vegetation

Airborne radionuclides are eventually deposited on vegetation or soil. Samples of surface soil and rangeland vegetation (sagebrush) are currently collected at 15 onsite and 23 site perimeter and offsite locations (Jaquish and Mitchell 1988). Samples are collected from nonagricultural, undisturbed sites so that natural deposition and buildup processes are represented. Sampling and analyses in 1985 through 1987 showed no radionuclide buildup offsite that could be attributed to Hanford operations (Price 1986; PNL 1987; Jaquish and Mitchell 1988).

NONRADIOLOGICAL TRANSPORT

Air Quality

Nitrogen oxides (NO_x) are routinely released onsite from fossil-fueled steam and chemical processing facilities, most notably the PUREX plant. Nitrogen dioxide is sampled at eight onsite and one offsite locations by the Hanford Environmental Health Foundation (HEHF). Nitrogen dioxide concentrations measured in 1984–1987 were well below federal (EPA) and local (Washington State) ambient air quality standards (Price 1986, PNL 1987; Jaquish and Mitchell 1988).

Ground Water

In 1987, over 3000 ground-water-samples were collected and analyzed for inorganic constituents, and over 290 wells were monitored for potentially hazardous materials including pesticides, herbicides, and total organic halogen (Jaquish and Mitchell 1988). In addition, well samples were analyzed by HEHF for water quality. Detected constituents included several metals, anions, coliform bacteria, radionuclides, and total organic carbon. Many of these constituents are expected in natural ground water. Chromium, cyanide, fluoride, and carbon tetrachloride were found in wells not used for drinking water near operating areas.

Foodstuffs

The most direct way for deposited radionuclides to enter the foodchain is through consumption of leafy vegetables. Samples of alfalfa and several foodstuffs, including milk, vegetables, fruit, beef, chickens, eggs, and wheat, are collected from several locations, primarily downwind (i.e., south and east) of the Site. Samples are also collected from upwind and somewhat distant locations to provide information on radiation levels attributable to worldwide fallout. Foodstuffs from the Riverview Area (across the river and southeast) are irrigated with Columbia River water withdrawn downstream of the Site. Although low levels of ^{3}H, ^{90}Sr, ^{129}I, and ^{137}Cs have been found in some foodstuffs, concentrations in samples collected near Hanford are similar to those in samples collected away from the Site. Elevated levels of ^{131}I were detected in milk samples after the Chernobyl accident. Because there are no radionuclide concentration limits for foodstuffs, impacts are assessed by predicting radiation dose from food consumption (see below, Overall Radiological Impact from Hanford Operations).

Penetrating Radiation

Penetrating radiation (primarily gamma rays) is measured in the Hanford environs with thermoluminescent dosimeters to estimate dose rates from external radiation sources. Radiation surveys are conducted at numerous onsite locations including roads, railroads, and retired waste-disposal sites located outside of operating areas. Onsite and

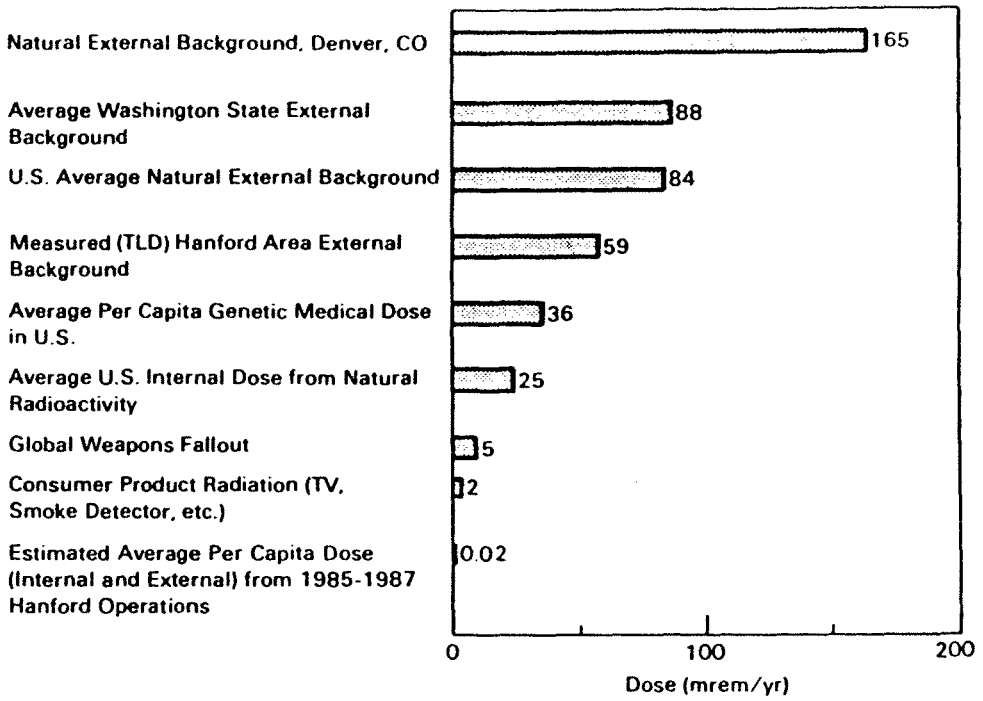


Figure 5. Annual radiation doses from various sources: external background, Denver, Colorado, Washington State and U.S. average from Oakley (1972). Genetic medical dose, U.S. internal dose, weapons fallout and consumer product radiation from Klement, et al. (1972; adapted from Price 1986; PNL 1987; Jaquish and Mitchell 1988); TLD = thermoluminescent dosimeter, does not include neutron component; mrem/yr = millirem per year.

offsite measurements and survey results for 1985–1987 were similar and comparable to past years. Dose rates near some operating facilities were only slightly higher than natural background rates.

Overall Impact from Hanford Operations

Beginning in 1974 the evaluation of radiation doses has included assessment of the maximum external dose rate at a location accessible to the general public, doses to a hypothetical maximally exposed individual, and doses to the population within 80 km of the Site. Based on these assessments, potential radiation doses to the public from Hanford operations have been consistently below applicable standards and substantially less than doses normally received from common sources of background radiation. The calculated 50 year wholebody cumulative dose received by the maximally exposed individual ranged from 0.5 to 3 millirem during the years 1981 through 1986 (PNL 1987). The maximally exposed individual is a hypothetical person who receives the maximum calculated radiation dose when worst case assumptions are used concerning location, inhalation of radioactive emissions, consumption of contaminated food and water, and direct exposure to contaminants. Expressed as effective dose equivalents, the calculated dose received by a hypothetical maximally exposed individual was 0.1, 0.09 and 0.05 millirem respectively, in 1985, 1986 and 1987. The average per capita whole-body cumulative (effective) dose for 1985, 1986, and 1987 based on the human population of 340,000 within 80 km of the Site, was 0.02, 0.03 and 0.01 millirem annually, respectively (Price 1986; PNL 1987; Jaquish and Mitchell 1988). These estimates and the measured Hanford area background radiation can be compared to and are considerably less than doses from other routinely encountered sources of radiation, such as natural terrestrial and cosmic background radiation, medical treatment and x-rays, natural internal body radioactivity, worldwide fallout, and consumer products (Fig. 5).

Columbia River

Nonradioactive waste water is discharged at eight locations along the Hanford reach of the Columbia River. Discharges consist of backwash from water intake screens, cooling water, water storage tank overflow, and fish laboratory waste water. Effluents from each outfall are monitored by the operating contractors. The Columbia River is also monitored by the United States Geological Survey, upstream and downstream of the Site, to verify compliance with Class A (WSDOE 1977) water quality requirements. In addition, numerous studies have evaluated, and in most cases resolved, the environmental issues associated with water intake and thermal discharge structures at Hanford (Page et

al. 1977; WPPSS 1978; Gray et al. 1979, 1986; DOE 1982; Neitzel et al. 1982).

SUMMARY

The Pacific Northwest Laboratory (PNL) conducts an environmental monitoring program to assess potential effects of Hanford Operations on the local environs, onsite workers, and the offsite public. Monitoring for radiological emissions at Hanford has been ongoing for over 40 years and includes air, ground and surface water, fish and wildlife, soil, vegetation, and foodstuffs. Measured and calculated radiation doses to the public have been consistently below applicable regulatory limits. Monitoring of fish and wildlife is a significant component of the overall program. The Hanford Site now serves as a refuge for key fish and wildlife species.

ACKNOWLEDGMENTS

Environmental monitoring at Hanford reflects the cooperative efforts of numerous individuals representing the staffs of DOE, PNL, HEHF, and other contractor, state and federal organizations. Environmental monitoring has been conducted by PNL since 1965, and is supported by DOE under Contract DE-AC06-76RLO 1830 with Battelle Memorial Institute.

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EFFECTS OF HEAVY METALS ON BENTHIC MACROINVERTEBRATE COMMUNITIES IN TWO HIGH-ELEVATION STREAMS OF COLORADO FRONT RANGE

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Abstract: High metal concentrations are a serious threat to aquatic biota in many areas of Colorado, particularly in the mineral belt where many inactive mines contribute metal-laden drainage. During 1987, a study was conducted to assess the impact of metals from mine drainage and natural sources on stream macro-invertebrates in two tributaries to the Snake River near Montezuma, Colorado. Peru and Deer Creeks are alpine-upper subalpine streams that were chosen for the study because they are characterized by a wide range of total metal concentrations in the water, depending on location. Peru Creek is impacted by acid mine drainage, while Deer Creek is relatively clean but does have natural sources of metal input. Water and benthic macroinvertebrate samples were collected from both creeks and analyzed for heavy metals. The invertebrates were identified to genera and sorted into functional feeding groups and major families. Insect samples were found to have accumulated metal concentrations 100 times the level of corresponding water samples. Relationships were noted between specific metal exposure and accumulation. Species diversity, populations of major macroinvertebrate groups, and community structure deteriorated with worsening water quality.

INTRODUCTION

Most field studies concerning the effects of high metal concentrations on stream macroinvertebrates have been conducted in the coal mining regions of the eastern United States (Gore and Johnson 1979; Starnes 1985). Little comparable work has been done in Colorado where about 2100 km (1300 mi) of streams have been adversely affected by elevated concentrations of heavy metals (Lewis 1987).

During the fall and early winter of 1987, this study was conducted to characterize the effect of metals from mine drainage and natural sources on stream macroinvertebrates. The benthic macroinvertebrate community was chosen as the subject of this study because of its proven ability as an indicator of habitat quality, limited mobility, relatively long developmental period for many of these organisms, and ease of macroinvertebrate sampling (Nehring 1976). Past field and laboratory studies have measured metal concentrations in the benthic fauna to be at least 100 times that of the water column (Nehring 1976; Nehring, et al. 1979).

Description of the Study Areas

The study was conducted on Peru Creek and Deer Creek, located in the Front Range portion of the Colorado Mineral Belt, approximately 100 km (60 mi) west of Denver, Colorado, in eastern Summit County. Mean annual flows for Deer Creek and Peru Creek are unavailable, however, both creeks are tributaries to the South Fork of the Snake River, which annually discharges about 45.7 million cu m (34,500 ac ft) of water into Dillon Reservoir (Holm et al. 1979). Although both watersheds have been mined, the effects of mining on Deer Creek were minor and no visible mine drainage reached the stream. In contrast, several mines contribute drainage to Peru Creek, including the Pennsylvania Mine and the Shoe Basin Mine.

The Peru Creek watershed ranges in elevation from 4350 m (14,270 ft) at the summit of Grays Peak to the north, to 2987 m (9,800 ft) at the confluence of Peru Creek and the Snake River. The watershed area is approximately 4000 ha (9900 ac) with Peru Creek running for a distance of 11.3 km (7.0 mi). The stream substrate is composed predominantly of medium gravel to small boulder-size stones. The geologic bedrock is granite and schist. Peru Creek is classified as Aquatic-Class 1 cold (intended goal) and Recreation-Class 2 by the Colorado Water Quality Control Commission.

The Pennsylvania Mine is an abandoned silver mine that discharges approximately 450 l/min (120 gpm) from an adit 244 m (800 ft) from Peru Creek. Of all the abandoned mine sites within the two watersheds, the Pennsylvania Mine is considered to have the most significant impact on water quality (Holm et al. 1979).

The Deer Creek watershed ranges in elevation from 4845 m (12,615 ft) at the summit of Teller Mountain to the southeast, to about 3220 m (10,560 ft) at the confluence of Deer Creek and the Snake River. The watershed area is approximately 1400 ha (3500 ac) with Deer Creek running for 7.2 km (4.5 mi). The stream substrate is composed predominantly of medium gravel to large boulder-size stones. The geologic bedrock is granite and schist. According to the Colorado Water Quality Control

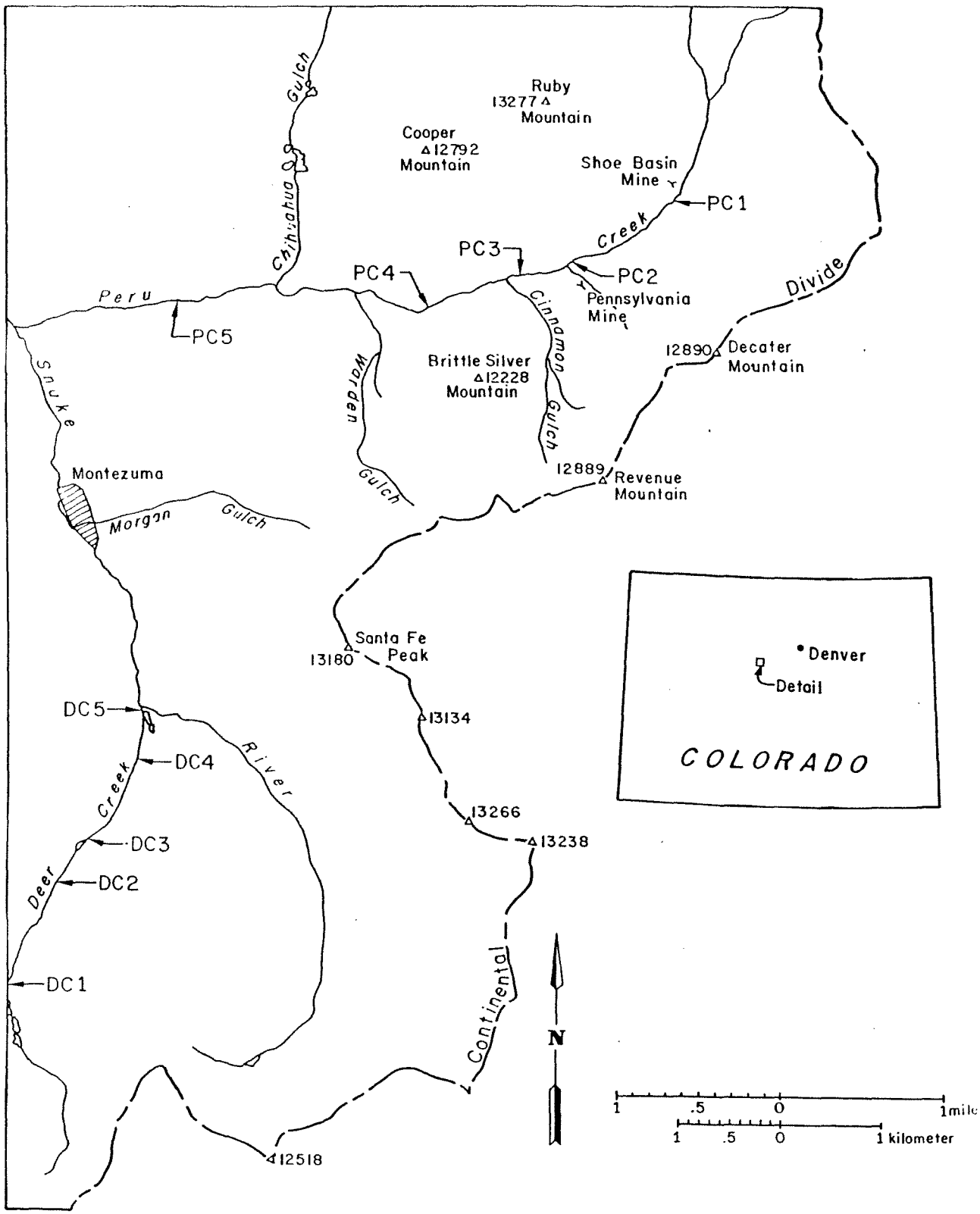


Figure 1. Location of Peru Creek and Deer Creek stations.

Commission, Deer Creek is classified as Recreation-Class 1 and Aquatic Life-Class 1 cold.

Five sites were chosen on each creek (Fig. 1). Two Peru Creek stations (PC1 and PC2) were located upstream from the Pennsylvania Mine discharge point, and three (PC3, PC4 and PC5) were located downstream. Station PC3 was located 427 m (1400 ft) below the Pennsylvania Mine effluent. This location was chosen because at this point there was assumed to be complete mixing of the mine discharge and Peru Creek water. Since Deer Creek did not have a defined point of mine discharge like Peru Creek, sites were chosen for their accessibility and similarity to the Peru Creek stations. Deer Creek stations are denoted as DC1, DC2, DC3, DC4, and DC5. The station elevations on Peru Creek ranged from 3374 to 3106 m (11,070 to 10,190 ft) and those on Deer Creek from 3456 to 3291 m (11,340 to 10,560 ft).

METHODS

Sampling was conducted in September and October 1987, a period of low flow. When low flow periods exist, the diluting capabilities of the stream are reduced, which produces a period of poor water quality and stress. Chemical, physical, and macroinvertebrate samples were collected twice during this period at each creek. The time between station visits ranged from four to seven days. During the is period there was no appreciable precipitation that could affect metals concentrations and creek flow.

Sampling was conducted in the riffle area where the cobble ranged from 3 to 15 cm (1 to 6 in). This size substrate is considered to be a productive habitat for macroinvertebrates (Pennak, personal communication/ correspondence 1987). Site variation was minimized by selecting similar depth, substrate, and current. In addition, sites were selected for accessibility and overall homogeneity of the substrate.

Water quality measurement included temperature, pH, and conductivity (Orion® meter). Water samples for analysis of dissolved metal concentrations were collected and filtered through 0.45 micrometer glass fiber filters and immediately placed in 250 ml Nalgene® polyethylene bottles that were preacidified with nitric acid. The acidified samples were kept under refrigeration until analysis. The Colorado State University Soils Testing Laboratory in Fort Collins, Colorado, analyzed the samples using inductively coupled plasma atomic emission spectrophotometry (ICP) methods.

The macroinvertebrates were collected with a Surber sampler (net mesh 250 um). This instrument samples 929 sq cm (1 sq ft) of substrate. To increase the macroinvertebrate sample size, samples at each station were actually a composite of three Surber samples from cobble substrate no larger than 15 cm (6 in) in diameter. The live insects were placed in plastic bottles containing ambient creek water and then refrigerated. In the laboratory, the aquatic insects were separated from other debris and preserved in glass vials containing 88-90% ethanol solution. The organisms were identified to genera. Following identification, the macroinvertebrate samples were sent to the CSU Soils Testing Laboratory to be analyzed for heavy metals by ICP.

RESULTS AND DISCUSSION

Metals concentrations

Some metal contamination was indicated at the upper Peru Creek stations (PC1 and PC2). Immediately below the Pennsylvania Mine outfall, however, pH decreased by two orders of magnitude, conductivity increased by an order of magnitude, and there was a slight increase in hardness (Fig. 2). These changes in physical parameters were accompanied by increases in concentrations of Al, Fe, Mn, Cu and Zn at PC3, PC4 and PC5 (Figure 3). Downstream, concentrations of Fe, Mn, Cu and Zn decreased, but Al concentration at PC5 was higher than PC3. Station PC5, the furthest downstream station, is located 5 km (3 mi) from PC1, and 4 km (2.5 mi) from the Pennsylvania Mine outfall. There was a slight increase in pH and a decrease in conductivity and hardness at PC5, which is located below Chihuahua Gulch, a tributary that has a significant freshening flow characterized by very low metals concentrations. Throughout the Deer Creek stations, the hardness, pH, and conductivity remained relatively constant with average measurements of 44.3 mg/l, 8.1, and 84.7 umhos, respectively (Fig. 2). Unlike Peru Creek, the average metals concentrations of Al, Fe, Mn, Cu and Zn did not substantially increase between stations (Fig. 3). There was, however, measurable increases of Fe at stations DC1 and DC4, and Mn at DC3, DC4 and DC5.

Similarity among sampling stations with regard to dissolved stream metals concentrations was analyzed by cluster analysis (Figure 4). A relatively high degree of similarity was shown among all Deer Creek stations and the highest in elevation Peru Creek Station. The most metal-laden sites, PC3, PC4 and PC5, represented a second major cluster of high similarity values, along with PC2, which had higher Zn and Mn concentrations than PC1.

The benthic fauna samples contained average metals concentrations 100 times the level of corresponding water samples except for Mn at stations PC3 and PC5. This relationship is reflected in the concentration factor in Table 1. The concentration factor was calculated by dividing the average metal concentration of the macroinvertebrate sample by the average metal concentration in the water. The concentration factor cluster analysis shows a similarity coefficient of 0.92 to 0.99 for both creeks excluding stations

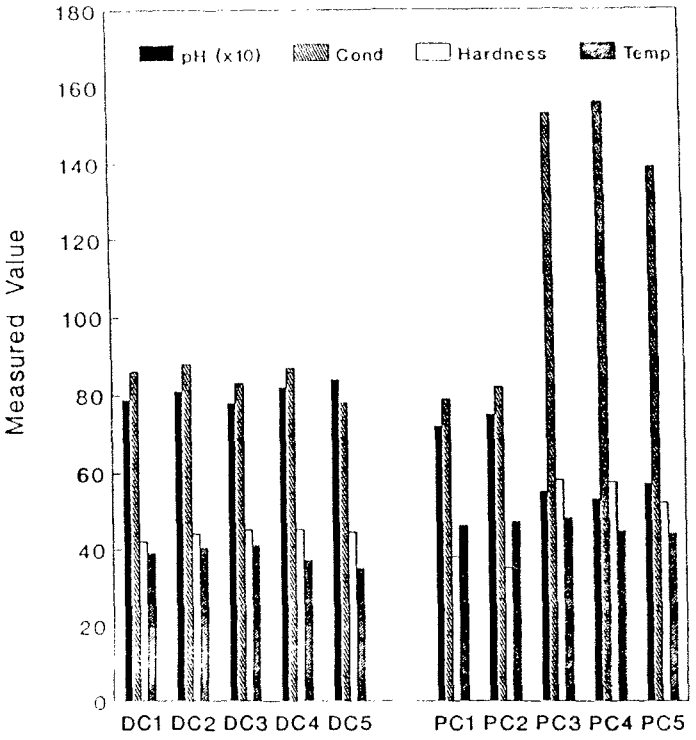


Figure 2. Average pH, conductivity, (μmhos), hardness (mg/l), and temperature (°F) of water samples from all stations.

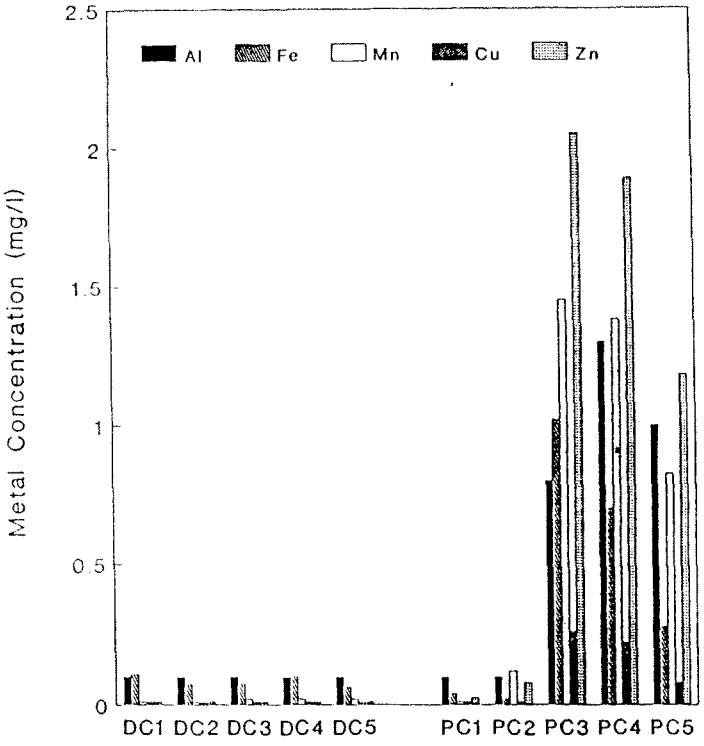


Figure 3. Average metal concentrations of Al, Fe, Mn, Cu, and Zn in water samples from all stations.

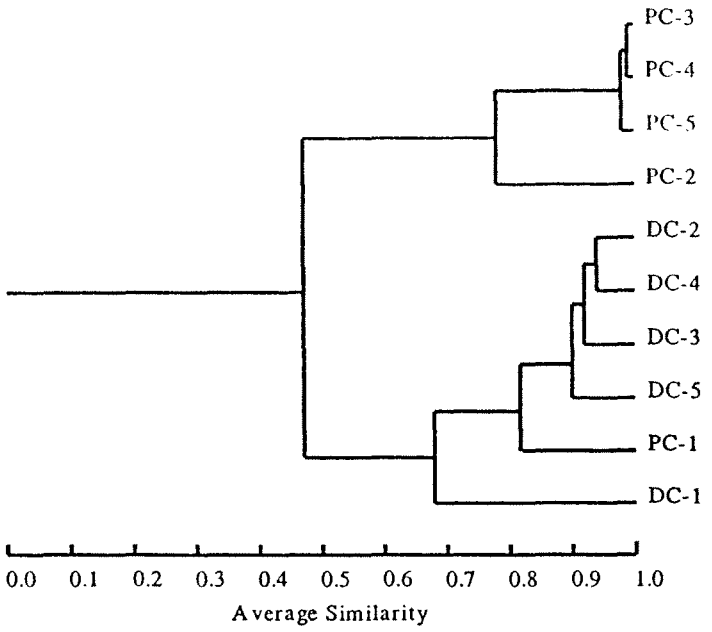


Figure 4. Cluster analysis dendogram of metals in stream water.

Table 1. Metal concentration factor. There were no organisms found at Peru Creek 4; therefore the metal concentration factor could not be calculated.

	Station				
	DC1	DC2	DC3	DC4	DC5
Al	>13550	>103000	>33250	>24150	>18500
Fe	25955	65468	71321	69250	75467
Mn	257000	72550	57000	55417	36425
Cu	>6250	>3950	>4400	>4150	>3100
Zn	>48250	37100	>37250	>34750	>60900

	Station			
	PC1	PC2	PC3	PC5
Al	>26000	>69200	3111	694
Fe	138350	443250	3681	1921
Mn	50100	8812	71	21
Cu	>6350	9250	817	975
Zn	66567	7306	232	773

PC3 and PC5, which formed a second cluster linked at the similarity coefficient of 0.84 (Fig. 5). These two main clusters did not link until 0.21.

Species Composition

A total of 53 taxa were collected from both Peru and Deer Creeks (see Table 2). No organisms were found at PC4. Excluding PC3, PC4 and PC5, there were only four

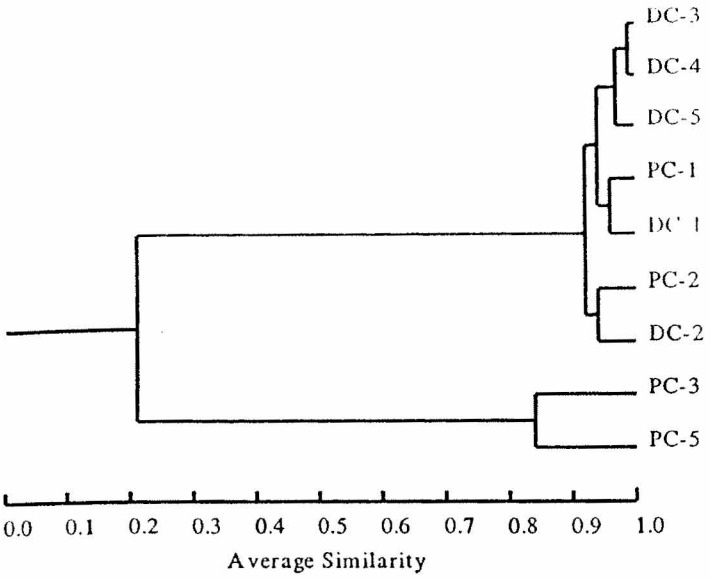


Figure 5. Cluster analysis dendogram of the metal concentrations factors.

taxa in common between the remaining seven stations. Total taxa numbers ranged from 24 to 26 in Deer Creek, while Peru Creek numbers ranged from 0 to 19. Deer Creek had higher numbers of organisms and genera than Peru Creek even at the PC1 and PC2 stations (Fig. 6). The EPT index, consisting of the total number of distinct taxa within the groups Ephemeroptera, Plecoptera and Trichoptera divided by three, was calculated for each station (Fig. 7). This index usually increases with increasing water quality (Plafkin et al. 1987). The average EPT value from Deer Creek was three times greater than the average Peru Creek value. Furthermore, the EPT value for Deer Creek is approximately 1.5 times higher than the average EPT value for PC1 and PC2.

Station similarity with respect to macroinvertebrate communities is shown in the dendrogram in Figure 8. In general, Deer Creek stations clustered into a single group with a biotic similarity of 0.5 to 0.83. The Peru Creek stations formed a second cluster linked by similarity coefficients of 0.25 to 0.45. Moreover, PC1 and PC2 had less than 30 percent of their taxa in common while Deer Creek had over 60 percent of its taxa in common. The sparse population within PC3 and PC5, and the smaller percent of common taxa are probable reasons for the low similarity values among Peru Creek stations. However, the communities of both streams were variable, not only because of metals, but undoubtedly because of habitat variability as well as sampling error.

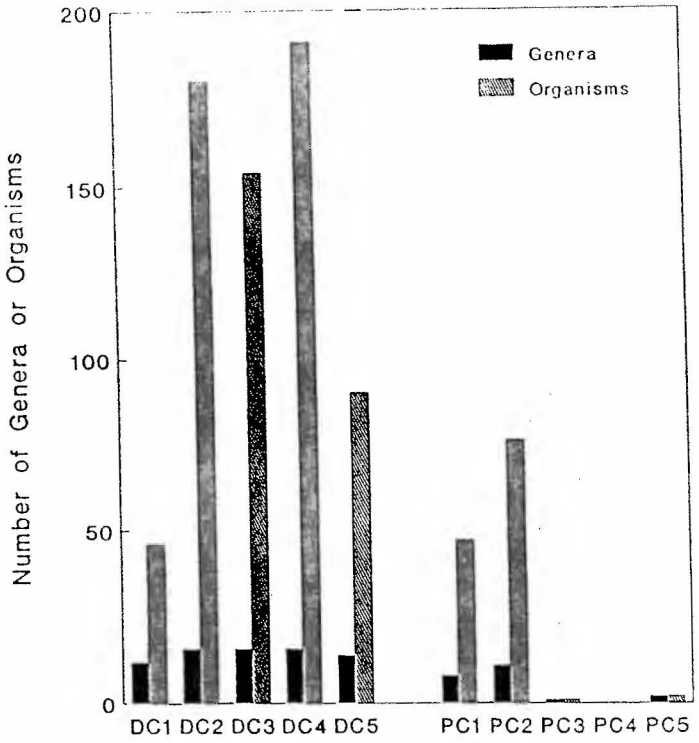


Figure 6. Average number of genera and organisms from all stations.

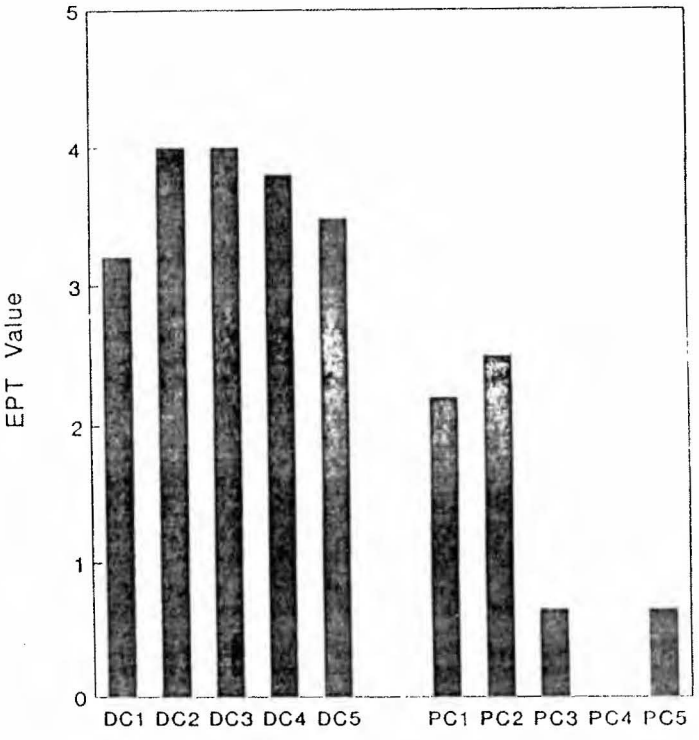


Figure 7. Average EPT value from all stations.

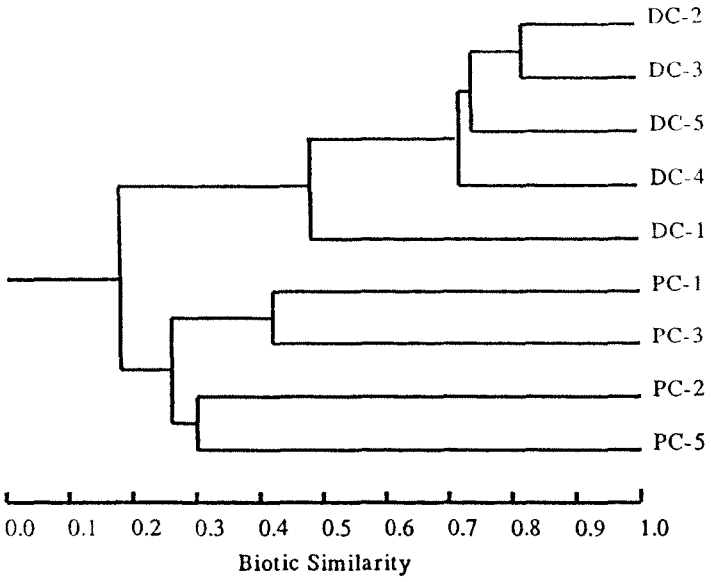


Figure 8. Cluster analysis dendogram of the numbers of organisms within each genera.

SUMMARY

In general, water quality and benthic fauna numbers and diversity decreased at stations PC3, PC4 and PC5. These observations parallel the increased concentrations of Al, Fe, Mn, Cu and Zn. Disregarding PC3, PC4 and PC5, Deer Creek still contained more taxa, greater numbers within taxa, and a higher EPT value than Peru Creek. In addition, there were more taxa in common between the Deer Creek stations than between the Peru Creek stations. The concentration factor revealed metal concentrations within macroinvertebrate samples to be, for the most part, 100 times that of the average water concentrations. Furthermore, the concentration factor cluster analysis for all the stations in Deer and Peru Creeks except PC3 and PC5 had high similarity coefficients.

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Table 2 Genera list and distribution of benthic invertebrates at Peru Creek and Deer Creek stations. No organisms were present in samples from PC4.

	Station								
	DC1	DC2	DC3	DC4	DC5	PC1	PC2	PC3	PC5
INSECTA									
Ephemeroptera									
Ameletus sp.	*******								
Attenella sp.						********			
Centroptilum sp.		********							
Choroterpes sp.	*******								
Cinygmula sp.	**********								
Drunella sp.	**********								
Epeorus sp.						********			
Ephemerellidae	**********								
Heptageniidae	**********								
Paraleptophlebia sp.	*******				**********				
Rhithrogena sp.	**********								
Stenonema sp.	**********								
Timpanoga sp.			********						
Plecoptera									
Alloperla sp.						********			
Chloroperlidae	**********								
Despaxia sp.							********		
Diura sp.					********				
Doddsia sp.				********			********		
Eucapnopsis sp.							********		
Isogenoides sp.		**********							
Isoperla sp.							********		
Leutridae							********		
Malenka sp.		**********			********				
Megarcys sp.		********		**********					
Nemouridae	**********								
Paraperla sp.	**********								
Perlodidae	**********								
Skwala sp.	**********								
Taeniopteryx sp.	**********				********		********		********
Zapada sp.	**********								
Trichoptera									
Amiocentrus sp.			********						
Anagapetus sp.		**********							
Apatania sp.	*******			********					
Ecclisomyia sp.					********		********		
Glossosoma sp.	**********								
Oumaga sp.	*******		**********						
Lepidostoma sp.				**********					
Mayatrichia sp.	*******								
Pseudostenophylax sp.							********		
Rhyacophila sp.	**********								
Coleoptera									
Gyrinidae sp.						********			
Haliplidae	**********								
Heterlimnius sp.		**********							
Diptera									
Athericidae		********							
Ceratopogonidae						********			
Chironomidae	**********								
Prosimulium sp.	*******								
Tipulidae							********		
Tanyderidae	*******								
Oligochaeta	**********						********		
Hirudinea		********		********		**********			
Hemiptera							********		
Lepidoptera									********
TOTAL NUMBER OF TAXA	26	26	24	24	24	17	19	3	4

SESSION III:

MITIGATION OF IMPACTS TO WILDLIFE FROM MINING

REDUCING IMPACTS OF HARD-ROCK MINING ON WILDLIFE IN NORTHERN NEVADA

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Abstract: Reduction of wildlife impacts caused by mineral exploration and mining has been a continuing goal for Freeport-McMoRan Gold Company (Freeport) in the Independence Range of northern Nevada. The predominantly public land in this area provides important habitat for mule deer (*Odocoileus hemionus*), northern goshawk (*Accipiter gentilis*), Lahontan cutthroat trout (*Salmo clarki henshawi*), and a variety of other species. Since 1979, the company has been involved with three major environmental reviews that included consideration of wildlife values and proposed several impact reduction/mitigation measures. Particular emphasis has been placed on habitat protection and improvement for the Lahontan cutthroat trout. Wildlife habitat enhancement has been a major objective of reclamation efforts in the area.

Freeport-McMoRan Gold Company (Freeport) has been involved with mineral exploration in the Independence Range of northern Nevada since 1976, and has been actively mining disseminated gold in this same area since 1981. Most of the Independence Range is managed by the Humboldt National Forest of the U.S. Forest Service (USFS). However, smaller portions of the area are under Bureau of Land Management (BLM) jurisdiction, and scattered parcels of private land are interspersed throughout the area. The mountains vary in elevation from approximately 1,980 m at the edge of the valley floor to over 3,050 m at the highest point. Precipitation varies directly with elevation, ranging from 20 cm to 76 cm, and occurs primarily as snow during the winter months.

Vegetation of the Independence Range is comprised of nine major types including the following: meadow bottomland, lowland sagebrush, riparian, north slope mountain brush, south slope mountain brush, aspen, sagebrush/snowberry, low sagebrush/grass, and subalpine fir. Other wildlife habitats include cliffs, rock outcrops, talus slopes, agriculture fields, and aquatic habitats associated with streams and small stock ponds.

WILDLIFE

This habitat diversity supports a corresponding diversity and abundance of wildlife populations. During three years of intensive terrestrial wildlife baseline studies in all but the subalpine fir habitat for a University of Nevada Reno research project, McAdoo (1981) identified a total of 125 bird species (mostly summer residents), 37 mammal species, 7 reptile species, and 3 amphibian species in the Independence Range vicinity.

Principal big game species in the range are mule deer and mountain lion (*Felis concolor*). The Independence Range provides primarily summer range for mule deer, although some winter range exists at lower elevations. The summer range in this area is considered by Nevada Department of Wildlife (NDOW) to be among the most valuable in the state (D. Erickson, pers. comm.).

At least 10 raptor species have been documented as nesting in or adjacent to the Independence Range (McAdoo, unpubl. data). Other species are known to travel through the area in seasonal migrations, and one species, the rough-legged hawk (*Buteo lagopus*), winters at lower elevations. Nesting species include golden eagle (*Aquila chrysaetos*), prairie falcon (*Falco mexicanus*), and northern goshawk. The latter is considered a species of special concern in Nevada because its preferred nesting habitat (mature aspen near streams) is limited in the state (Herron et al. 1985). The goshawk has also been identified as an indicator species for monitoring the land management plan of the Humboldt National Forest. The diversity and abundance of small mammals and passerine birds in the Independence Range provide an excellent prey base for raptors utilizing the area.

Gamebird species include mourning dove (*Zenaida macroura*), blue grouse (*Dendragapus obscurus*), and sage grouse (*Centrocercus urophasianus*). Mourning dove are summer residents only, while both grouse species are permanent residents. Although populations of chukar (*Alectoris graeca*) and gray partridge (*Perdix perdix*) have been observed, neither species is particularly abundant in the area.

Based on USFS research (W. Platts, pers. comm.), fish inhabiting streams of the Independence Range include Lahontan (or Humboldt) cutthroat trout, rainbow trout (*Oncorhyncus mykiss*), brook trout (*Salvelinus fontinalis*), and several nongame species. The Lahontan cutthroat inhabits only the east side of the mountain range and is of special interest because of its current federal status as an endangered species (Nelson et al. 1987).

IMPACT REDUCTION AND MITIGATION

Since 1980, three environmental reviews (as required by the National Environmental Policy Act) have been completed for each of Freeport's three mine projects in this

area. The first was an Environmental Impact Statement (EIS) and the others were Environmental Assessments (EA's). Because of the high wildlife values of the Independence Range, wildlife considerations were emphasized in each of th environmental reviews. Impact reduction provisions included guidelines for minimizing erosion (with sediment catchment basins, silt screens, and seeding of haul road cut and fill slopes), minimizing construction activity in the vicinity of raptor nests, avoiding aspen wildlife habitat where possible, using specialized culverts for crossing Lahontan cutthroat trout streams, and monitoring of ground water and surface water quality/quantity.

The environmental reviews also produced goals for post-mined land use that were used to drive the mitigation planning process. For example, in one project area the importance of a stream (North Fork Humboldt River) as Lahontan cutthroat trout habitat brought about a post-mined land use goal of improving habitat conditions (as compared to pre-mined conditions) for this species. This goal is in step with an ongoing effort by NDOW to de-list this threatened species through a program of habitat improvement (Coffin 1982). Steps taken by Freeport to being this about include (1) implementing sediment control measures (with catchment basins, silt screens, and canyon haul road seeding), (2) constructing stream enhancement structures, and (3) providing funds to support intensive management of riparian habitat along this stream. The EA requires annual monitoring of stream macroinvertebrate populations, as well as alternate year surveys of stream habitat characteristics and trout populations.

As an offsite mitigation effort, Freeport has contributed funding for a riparian area management system involving three other Lahontan cutthroat trout streams in the Independence Range. Another off-site project included construction of stream improvement structures in a tributary considered critical trout-rearing habitat. In an attempt to mitigate loss of recreational use (by hunters and fishermen) of primitive camp sites along the North Fork Humboldt River, Freeport also constructed a campground (off-site) along yet another stream across the mountain range.

Site-specific field reviews prior to mineral exploration activities have resulted, with proper planning, in avoidance of critical wildlife habitat (e.g., raptor nest sites in aspen trees, deer fawning grounds) in some areas. During the construction of single lane roads for drill rig access, "ramps" have been constructed to facilitate deer and livestock access across road cut slopes in steep terrain. In those areas where use of drill roads was expected to continue beyond one field season, berms have typically been seeded to minimize erosion and increase interim vegetation productivity until reclamation is completed. To help minimize adverse impacts brought about by road-building, Freeport has used track-mounted drill rigs in some areas where terrain is not prohibitively steep. During exploration, drillers have been instructed to use only non-toxic and biodegradable additives and to contain drill cuttings/effluent on-site.

Freeport has recently taken management action to enhance wildlife habitat on company-owned native lowland meadow habitat (not mined) at the base of the Independence Range. Lowland meadows are very limited in Nevada and provide critical habitat for many unique wildlife species (McAdoo et al. 1986), including the greater sandhill crane (*Grus canadensis*), which is a state listed "sensitive" species. Proposed actions for the near future include Freeport cooperation to improve an existing reservoir fishery.

CONCURRENT RECLAMATION

The emphasis of Freeport's reclamation program to date has been the reclamation of single lane exploration (drill) roads. Since 1979, approximately 30% of the exploration roads in the Independence Range have been reclaimed. Primary short-range reclamation objectives have been to: (1) hold the soil, thus decreasing erosion, (2) minimize invasion by noxious alien weeds, and (3) restore wildlife habitat and livestock forage. Long-range objectives include the enhancement of secondary succession to promote the return of natural and diverse vegetation and recovery of esthetic values.

Exploration road reclamation has consisted of recontouring and seeding. Reclaimed roads have been seeded for several years using a BLM and USFS approved mixture of four perennial grasses and one forb species. However, during the last two years a total of 18 different seeding mixes (including grasses, forbs, and shrubs) have been developed, based on habitat, precipitation, aspect, and other site-specific characteristics. Seeding success has been good to excellent in most cases, varying of course with soil type, precipitation zone, elevation, seed depredation, and grazing pressure. In many cases, percent basal herbaceous cover of vegetation on reclaimed sites during the first growing season has been similar to that measured in nearby "ecologically equivalent" undistributed sites.

We are currently conducting a study, in cooperation with the University of Nevada-Reno and the U.S. Agricultural Research Service, of secondary succession on these reclaimed roads. Study objectives are to: (1) evaluate secondary succession by habitat and age of sites, (2) identify changes in seed mixes that could enhance succession, and (3) monitor wildlife use of reclaimed areas. Preliminary results from first year data show that up to 35 native species have advanced onto older (5–6 yr) reclaimed sites. Both forb and shrub species richness was typically higher in the more mesic habitat types. Many of the invading species have been identified previously as important forage species for mule deer (Selby 1985). Reclaimed sites are receiving use by mule deer, sage grouse, white-tailed jackrabbits (*Lepus townsendii*), and a variety of nongame wildlife. An increase in wildlife species utilized seeded areas may be expected as plant succession proceeds (McAdoo et al. 1989).

Mine-site reclamation is just beginning in the Independence Range. Separate and detailed reclamation plans, the result of Freeport-USFS cooperation, have been written for each of the 3 mine project areas. Reclamation planning for these projects was based on site-specific post-mining land use goals that were identified during the formal environmental reviews (EIS and EA's). These goals were related directly to pre-mining land uses. Thus, goals for wildlife habitat enhancement were an integral component of each reclamation plan. Specific goals for the recovery of habitat for mule deer and Lahontan cutthroat trout were emphasized.

The reclamation planning process detailed the need for topsoil recovery and stockpiling. Each plan specified requirements for annual report of topsoil recovery amounts and outlined details for retrieval, stockpiling, and application. Emphasis was also placed on site-specific seed mixtures of adapted plant species. We developed objectives for basal herbaceous cover, shrub stem densities, and forb cover on reclaimed sites. These objectives were made contingent upon results obtained from study plots. Plans were also developed to plan aspen seedlings in specified areas.

Accomplishments to date include back-filling and seeding of an 8.1 ha pit. A larger pit is currently being back-filled and a waste-rock dump is also being reclaimed. Since pits are not typically back-filled (due to economic constraints and geological, logistical and environmental considerations), we have set up study plots to evaluate alternative reclamation techniques. A 0.7 ha segment of abandoned haul road is being used to evaluate various combinations of fertilization, mulch, and topsoil depth treatments placed in a randomized block design. Recent experimental reclamation includes willow wattling on steep slopes and direct planting of shrub wildings.

CUMULATIVE EFFECTS ANALYSIS

In 1988, Freeport became cooperative involved (including funding) with the USFS in an analysis of the cumulative effects of mining, mineral exploration, and other land uses on renewable resources in the Independence Range. Two other mining companies with smaller operations in this vicinity are also partially funding the study. Special emphasis is being placed on terrestrial wildlife habitat and trout streams. More specifically, upland vegetation is being mapped according to community type and site potential. Streams in the area are being classified hierarchically (based on ecological processes) and riverine-riparian habitats are being mapped as well. This information, along with maps of critical wildlife areas (e.g. deer winter range, goshawk nest sites), as well as maps for other resources, livestock grazing allotments, elevational contours, and planimetric information will be digitized for use in a Geographic Information System (GIS). "Disturbance" layers for mine sites, exploration roads, etc. will be digitized similarly. These computer-based maps can then be used as over-lays to help evaluate land-use impacts on various resources. Use of GIS as a tool to evaluate cumulative effects has been used successfully in other areas (Winn and Barber 1985). Assessment of cumulative effects as described should improve the process for making balanced and sound environmental decisions in the Independence Range.

CONCLUSION

Mineral exploration and mining in northern Nevada obviously affect the habitats and/or populations of some wildlife species. However, we believe that through proper planning to minimize impacts and mitigate losses where possible, and by implementing effective concurrent reclamation, mining activity and thriving wildlife populations need not be mutually exclusive.

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MITIGATING DUCK LOSSES AT CYANIDE PONDS— METHODS, COSTS AND RESULTS AT AN OPERATING GOLD MINE

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Abstract: The Copperstone Gold Mine was built in 1987 in the desert of western Arizona. The mine is over 12 miles away from the Colorado River and in an arid region with very little vegetation. The site is not good waterfowl habitat.

Shortly after commissioning the mine in October 1987, waterfowl mortalities began occurring as migratory birds attempted to utilize the 23 acres of cyanide-containing ponds. Mortalities ranged from single birds to flocks of more than 70. A series of hazing techniques was implemented with limited success; losses of avian species other than waterfowl continued at low but persistent rates through the summer of 1988. Hazing alone did not work, and the U.S. Bureau of Land Management (BLM) required that the problem be mitigated.

A study of alternatives was completed in July 1988. Conceptual feasibility studies were completed for detoxification, cyanide recovery, cyanide destruction, physical barriers, and hazing in conjunction with alternative "decoy" pond construction.

Engineering estimates for the different hazing, pond covering, detoxification, and decoy pond construction methods are presented.

Data on observed bird mortalities and avian responses to mitigation measures are presented, as are conclusions and recommendations.

INTRODUCTION

The number of operating gold mines has increased over the last 5 years, and bird mortality in the cyanide ponds associated with these milling and heap leaching facilities has been the subject of increasing concern. Some mines have experienced no mortalities, while large losses have been experienced at other operations. Much of the mortality has occurred at larger tailing impoundments. Many, but not all, of the mines with problems are located in desert areas where the nearest water is 5 to 50 miles distant. These impoundments are attractive to a great variety of bird species because they are large and support expanses of open water and mudflat type areas resembling tidal mudflats. The possibility of avian mortality problems at Copperstone was considered during the preconstruction environmental review and approval phase of the project. However, the magnitude of the problem was unexpected.

Since construction of the mine, usage of the pond areas has been attempted by at least 33 avian species and 3 mammal species (Table 1, Appendix). This diversity includes resident as well as migratory species.

STUDY AREA

The Copperstone Mine was built in 1987 in the desert of western Arizona. The operation extracts gold ore from an open pit, subjects the rock to crushing and grinding, and leaches gold from the ore in high pH water and cyanide slurry. Cyanide is an expensive, but necessary, ingredient for dissolving and recovering gold from Copperstone ore. For environmental and financial reasons, the cyanide and water are recovered for re-use in the plant. To accomplish this, tailing is pumped either to the the 23 acre pond or to the 35 acre pond where the suspended solids settle out. The clear water is collected in a 2.5 acre reclaim pond and recycled to the plant.

CHRONOLOGY OF BIRD PROTECTION EFFORTS (TABLE 2)

At the time of construction, the reclaim water pond was surrounded by an 8' high chain-link fence topped with barbed wire. At the base of this fence above and below ground, was 1/4" mesh hardware cloth to exclude small animals. Loudspeaker alarm horns were placed around the ponds, and flagging was installed over the ponds to frighten birds. Shortly after commissioning of the mine, avian mortalities were observed.

As the spring migration brought additional mortalities, the Copperstone tactics did not appear to be as effective as hazing at other mines with similar problems. Accordingly, in March 1988, the problem was brought to the attention of the BLM, Arizona Game and Fish Department, and the U.S. Fish and Wildlife Service.

An intensified program of hazing was initiated that increased flagging over the reclaim pond and standing water areas in the tailing pond. The total linear amount of flagging presently is approximately 8 miles. In addition, Zon guns, or propane cannons, were purchased and installed to dissuade waterfowl from using the area. Owl decoys and pinwheels also were placed in further efforts to frighten birds.

Despite these efforts, the BLM notified the mine in May 1988 that continuing losses of waterfowl were unacceptable. The BLM also ordered an evaluation of possible solutions to the problem. The mine responded immediately by adding additional Zon guns and increasing research to find an appropriate permanent solution.

During the summer of 1988, several experts investigated the literature on wildlife hazing and methods to detoxify water containing cyanide. In addition, the mine received and evaluated numerous suggestions from outside sources. The detoxification alternatives were extremely

Table 1. List of species recorded as mortalities or observed attempting to land at the Copperstone Mine during 1987–1989.

GREBES	**SHOREBIRDS/GULLS**
Eared grebe	Spotted Sandpiper
	Sandpiper
HERONS/BITTERNS	Killdeer
Snowy egret	American avocet
Egret	Black-necked stilt
	Other wading bird
WATERFOWL	Ring-billed gull
Canada goose	Mew gull
Snow goose	Gull
Unidentified goose	Tern
Green-winged teal	
Mallard	**DOVES**
Northern pintail	White-winged dove
Cinnamon teal	Dove
Northern shoveler	
Lesser scaup	**PASSERINES**
Redhead	Black phoebe
Ring-necked duck	Rough-winged swallow
Barrow's goldeneye	Unidentified swallow
Bufflehead	Unidentified swift
Waterfowl	American crow/common raven
	Warbler
RAPTORS	Sparrow
American kestrel	Passerine
Northern harrier	
Hawk/falcon	**MAMMALS**
	Bat
CRANES/RAILS/COOTS	Fox
American coot	Rabbit

Table 2. Chronology of key hazing activities.

February 7, 1988	First flagging of reclaim pond
March 17, 1988	First propane cannons installed
March 21, 1988	First bird-loss logs were kept
March 27, 1988	Flagging of tailings pond begins
April 12, 1988	Flagging of tailings pond complete
June 5, 1988	Installed twelve additional propane cannons
July 12, 1988	First person hired to haze waterfowl
August 14, 1988	Construction of alternative pond began
September 8, 1988	First hazing records kept, showing effectiveness and species type. Five persons hired to haze. Three shifts per day.
September 16, 1988	Started covering reclaim pond with net
October 8, 1988	Netting goes on reclaim pond
November 1, 1988	Started neutralizing program in plant and tailings
November 1, 1988	Finished netting reclaim pond

expensive. Studies suggested that the mine install a fresh water pond nearby as a "decoy" pond. The logic was that hazing birds away from one water source would only work well when there was a desirable alternative source. This recommendation was proposed to the BLM in a report included in a request for an operating plan modification.

In July 1988, a new 35 acre tailing pond was completed. The standing water area of this pond was covered with a network of wire from which flashing strips of mylar were hung as per recommendations of biologists. More Zon guns were installed at the new pond (a total of 24 at the mine). In early August, a small fresh water decoy pond was constructed to attract birds from the tailing pond (duck decoys were floated on this pond). The decoy pond was meant only as a temporary measure until permanent solutions were in place. In mid-August, the mine received notification from the BLM that the proposal for use of a decoy pond in conjunction with additional hazing was insufficient. The BLM stipulated that Copperstone either detoxify or completely cover the ponds with 1" mesh netting.

Serious consideration to covering the ponds with netting previously had not been given because of large size (up to 1400' across) and the strong winds in the area. Nevertheless, the mine began immediately to assemble information on sources of netting material, delivery times, and construction contractors. The engineering firm selected estimated that, given the design and logistics involved, the completion of net cover on the 35 acre pond could not be completed until the end of January 1989. Meanwhile, avian mortalities continued.

The BLM was briefed regarding construction time constraints in mid-September. At this time, Copperstone committed to additional efforts in other areas, such as covering the 2.5 acre reclaim pond with netting and mechanical changes to eliminate the open flow of cyanide-bearing water in a tailing line ditch. The mine also initiated a program of 24 hour patrol of the ponds by personnel hired and trained specifically to scare birds using shotguns and loud but harmless cracker shells. The BLM assisted by providing a wildlife specialist to train the hazers in bird identification and reporting. Avian report forms were designed to improve the quality of data capture.

While proceeding with haste in the design of the netting project, cyanide detoxification was evaluated as a solution either on a short term basis or as a long term alternative to netting. Information from the BLM indicated that a mine in Nevada was having success with ferrous sulfate treatment of their tailing.

Based on the positive reports from Nevada for ferrous sulfate, Copperstone began laboratory testing of the method. Results were mixed, so an in-plant test was scheduled and a truckload of reagent was obtained. The tests were conducted the third week of September, but the results were unsatisfactory in achieving a low enough level of cyanide. Additional laboratory work during late September revealed that the addition of sodium sulfite caused a more successful reaction with Copperstone tailing. Additional in-plant testing of ferrous sulfate and sodium sulfite was conducted in mid-October, but proved, ultimately, to be ineffective.

While reagent testing was in progress, other potential detoxification techniques were researched. Hydrogen peroxide was tested, but costs were projected to be so high that mine profitability was endangered. In addition, the high iron content of Copperstone ore interfered with the peroxide oxidation reaction. Alkaline chlorination also was tested in

the laboratory and in the pond system. Success finally was reached with a commercial product called Diklor. Diklor has been successfully used since November 1988 to oxidize the cyanide solutions and to detoxify the tailing slurry as it leaves the plant and settles in the tailing ponds.

COSTS OF AVIAN PROTECTION EFFORTS

By any estimation, the dollar costs of bird protection have been high. Table 3 shows that the three workable options of hazing, netting, and detoxification all involve expenditures of $480,000 to $3,000,000.

Table 3. Engineering cost estimates for hazing, netting, and neutralization.

Hazing		
Wire grid (30' centers)	$346,000	
New alternative pond (2 acres)	62,000	
Hazing devices (zon guns, flagging)	10,000	
Personnel costs/yr. (hazers)	62,000	(Annually)
Hazing total	$480,000	
Netting (One Inch Mesh)		
Reclaim pond (2.5 acres)	$ 39,000	
Engineering desing	45,000	
Cover tailing ponds (58 acres ±)	2,600,000	
Netting total	$2,694,000	
Neutralization		
Temporary dosing system	$ 8,000	
Reagent cost	3,000,000	(Annually)
Makeup cyanide	144,000	(Annually)
Neutralization total	Over $3,000,000	Annually

The cost of the cable/mylar and hazing methodology as proposed to the BLM is estimated at $500,000 initially with annual personnel costs of $60,000-$70,000. for full-time hazers during migration periods. The major cost factor for hazing is the wire grid: aircraft cable stretched on 30' centers in a criss-cross manner to keep birds from landing on the open tailing pond. The BLM rejected this proposal as untested and unproven in favor of netting or neutralization.

The capital costs for netting are much higher. The reclaim pond was covered with 1" mesh polyethylene netting for $39,000 (~$20,000 per acre). However, unit costs for the expansive, 58 acre tailing ponds are on the order of $50,000 per acre. The engineering challenge to cover long spans (1/4 mile) with a complete cover of netting are enormous. In a harsh desert environment with design wind speeds of 100 mph, there is significant risk and uncertainty in a $2.5 million netting program. The fear of lightning damage to the supporting cable grid and plastic mesh, and the damaging effects of high wind shear have prevented acceptance of the netting alternative to date by the mine.

In contrast to netting, the initial capital costs for chemical neutralization so far have been low. However, operating and maintenance costs have been high. A temporary dosing system has been installed for under $10,000, but a much more elaborate system would be required to optimize operational efficiency to reduce extremely high reagent costs. Monthly reagent costs have averaged about $250,000 since November. An additional $12,000 per month is required to purchase replacement cyanide. Total annual costs for destroying cyanide will exceed $3,000,000 unless a successful alternative technology is discovered.

Obviously, costs of this magnitude are significant. The expenditure of $3,000,000 per year adds approximately $50 per ounce to the cost of gold production at Copperstone.

EFFECTIVENESS OF AVIAN PROTECTION EFFORTS

In 16 months since tailing was first deposited at Copperstone, at least 821 avian mortalities have occurred. Although record keeping was not started until March 1988, the estimate of losses through December 1988 are:

Waterfowl	31.8%	—	285
Wading Birds/Gulls	28.3%	—	254
Raptors	1.7%	—	15
Other Birds	29.8%	—	267
Mammals (bats, fox)	8.5%	—	75

By examining data relating avian losses to hazing (Fig. 1), it is apparent that approximately 85% of early losses were in the reclaim pond prior to the initial flagging (February 1988). Flagging the reclaim pond shifted mortalities to the large mudflat areas of the tailing ponds. Only 38 of 285 waterfowl mortalities occurred after the initial flagging of the reclaim pond. Because of the large size of the mud expanses and the initial focus on waterfowl, hazing began on the water areas of the tailing ponds where flagging and mylar strips were suspended from overhead wires.

At this point, mortalities switched to species of birds attracted to mudflat areas (shorebirds, etc.). Shorebirds, swallows, and passerines comprised approximately 80% of all birds recorded around the Copperstone property. Hazing and the use of an alternative pond have shown good success with these groups of birds. However, since 8.5% of the birds were not affected by hazing, losses still occurred.

The use of cyanide neutralization has almost totally eliminated remaining mortalities, reducing losses to about 0.9% (Table 4). However, this success has not been achieved without a tremendous financial cost. On a $/bird basis, Copperstone spends about 35 times as much on neutralization as on hazing.

Copperstone spends approximately $295/bird to protect 99% of the birds affected by the operation. Comparing this figure to the $8.58/bird required for 92% successful hazing

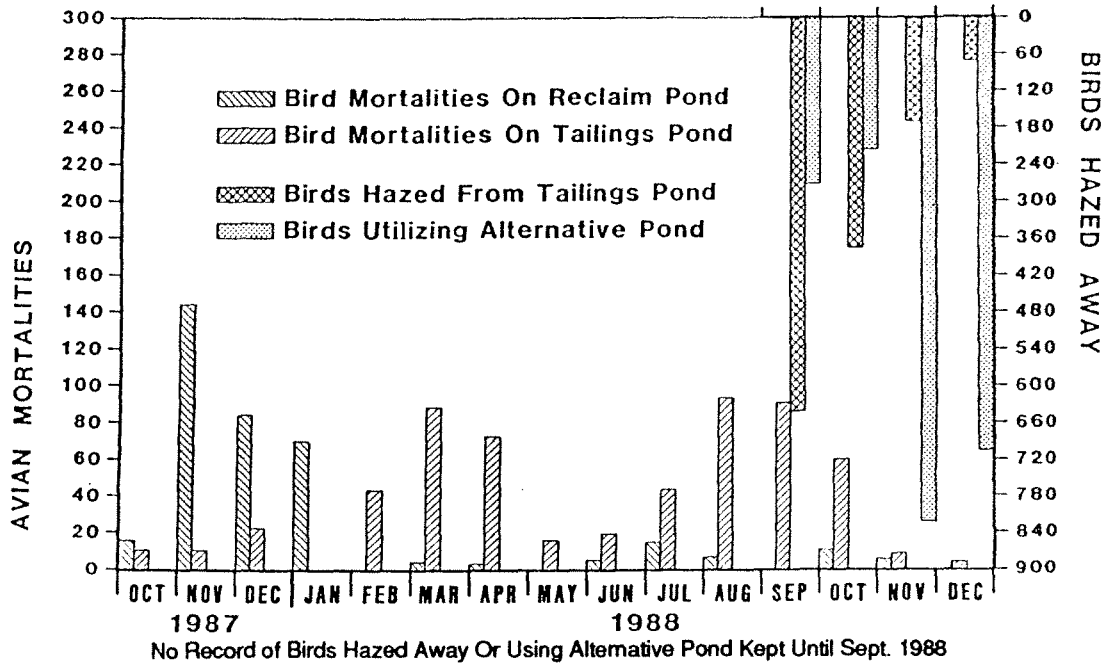


Figure 1. Copperstone avian losses and effects of hazing program.

Table 4. Comparison of hazing and neutralization during mitigation.

Month	Birds Lost	Total Birds Hazed	Encountered	% Success
Hazing				
September	90	908	998	91
October	70	975	1,045	93
Hazing total	160	1,883	2,043	92
Neutrallzation				
November	13	986	999	99
December	3	773	776	99
Neutralization total	16	1,759	1,775	99

illustrates a classic example of the law of diminishing returns (Table 5).

Until January 26, 1989, the program was considered successful. On that day, the BLM notified Copperstone that "zero mortality" would be required. No mortalities occurred during the month of January.

Table 5. Cost per bird using hazing and neutralization.

	$/Bird Lost	$/Bird Hazed	$/Total Birds Encountered	% Success
Hazing	109.61	9.31	8.58	92
Neutralization	32,750.00	298.00	295.00	99

CONCLUSIONS

1. The need for, and success of, hazing is site-dependent as shown by the literature.

2. Hazing with flagging, alarms, and propane cannons was approximately 75% effective at this mine where no other water was available within 10 miles.

3. Hazing with personnel working in conjunction with flagging, propane cannons, and a small, decoy pond achieved 92% success at this particularly challenging location where desert habitat offered no other habitat within 10 miles.

4. The cost to protect the remaining 8% through neutralization is 35 times the cost to protect the first 92% via hazing.

5. It seems probable that mortalities can be brought into the range achieved by neutralization (<1%) using a larger alternative pond or multiple ponds, full-time hazing crews, and a deterrent wire grid over the entire tailing pond.

RECOMMENDATIONS

1. The state-of-the-art for recorded distress calls, alarm sounds, or other audio-hazing methods should be advanced.

2. More economic cyanide treatment techniques, such as in-plant recycling and detoxification, should be developed.

3. Other hazing techniques such as (but not limited to) laser netting, decoy ponds, music, water coloring, and odor repellants should be researched.

4. A full-scale effort at alternative pond utilization at some location should be attempted and quantified.

5. Toxicological research is needed for determining acute lethal dosages, so that appropriate treatment targets can be set.

APPENDIX: Total birds lost and hazed (by area)

Species	Lost in Reclaim Pond Prior to Netting	Lost in Tailings Pond (Mostly Prior to Hazing)	Hazed From Tailings & Reclaim Access	Utilizing Alternative Pond
GREBES				
Eared grebe			2	
WATERFOWL				
Bufflehead				3
American coot			1	2
Blue-winged teal		2		1
Lesser scaup			1	3
Northern shoveler		3		3
Mallard		3	3	1
Northern pintail			2	
Canada goose			19	
Unidentified waterfowl	160, (*158)	117, (*88)	129	9
HAWKS & FALCONS				
American kestrel			2	
Northern harrier			2	
Unidentified hawks & falcons		12	12	
WADING BIRDS				
Spotted sandpiper	2	11	88	675
Killdeer		2	118	33
Black-necked stilt			251	168
American avocet			2	63
Unidentified wading birds	(*79)	155, (*44)	27	5
GULLS		5	12	6
DOVES		6	18	18
OWLS	1	2		
NIGHTHAWKS OR POORWILLS	1	8	1	1
HUMMINGBIRDS	1			
FLYCATCHERS			18	10
SWALLOWS & SWIFTS		17	303	720
CROWS OR RAVENS			11	1
WARBLERS		2		
SPARROWS		8	62	183
OTHER UNIDENTIFIED BIRDS	93	131	133	23
BATS	5	69	22	3
FOXES	1		1	
MISCELLANEOUS			9	
TOTAL BY AREA	343	553	1,249	1,931
GRAND TOTAL	896		3,180	

(*Number of total estimated prior to detailed records.)

WILDLIFE IMPACT MITIGATION AND RECLAMATION IN OPEN PIT, CYANIDE HEAP LEACH GOLD MINING

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Abstract: Hard rock gold mining in the Black Hills, South Dakota primarily employes the open pit, cyanide heap leaching process. Experience with this mining technique has resulted in adoption of certain management practices to reduce wildlife exposure to cyanide solution. Exposed collection ditches resemble small streams and are particularly attractive to songbirds, but lethal. These ditches now must be covered to prevent wildlife contact. Ponds containing cyanide solution were found to attract migrant waterfowl. Companies are now required to install flagging to dissuade waterfowl from landing. This has been effective except during inclement weather. Fences are required around the entire mining facility to prevent ingress by big game. These practices have reduced annual cyanide-related wildlife mortalities by about 95% at the mine where these problems were encountered.

Wildlife habitat reclamation objectives in the Black Hills are to convert from the premining ponderosa pine (*Pinus ponderosa*) dominated habitat to a deciduous woodland/open meadow complex. Revegetation is primarily with species native to the Black Hills; however, some introduced woody species beneficial to wildlife will be evaluated. Mine pits not backfilled will have portions of the highwalls and benches sculpted by means of selective blasting. This will create talus slopes, ledges and crevices for wildlife as well as ameliorate the visual aspect. Remaining benches will be revegetated. Although bond release is based on vegetative factors, companies are required to monitor wildlife use of reclaimed areas in relation to off-site controls. Research designed to evaluate wildlife benefits from postmining reclamation will be needed to ensure that objectives are met.

Gold mining in the Black Hills of South Dakota has been continuous in one form or another since 1874 (Dewitt et al. 1986). Recently a new mining boom has resulted from exploitation of low grade ore deposits using open pit, cyanide heap leach technology. In 1983 there was 1 state permit for a mine of less than 200 acres. Today there are 4 permitted open pit mines employing heap leaching that affect 1,756 acres. All of this acreage is located in the north central hills, around the communities of Lead and Deadwood. Based on experience gained during the past 7 years, the Department of Game, Fish and Parks (GF&P) and mining industry have developed some techniques to minimize lethal impacts to wildlife and to design reclamation criteria for wildlife habitat. This paper will present information on both of these items.

Before addressing these subjects, I would like to briefly explain the regulatory role of GF&P in mineral development. By legal authority, GF&P is involved as a review agency from exploration through bond release. The department has specific responsibilities in overseeing wildlife and fisheries baseline and monitoring studies. proposing restrictions that will minimize impacts to threatened or endangered species and riparian habitat and recommending techniques to reduce harmful effects to wildlife and fishery resources. We review all mine proposals and work closely with the Department of Water and Natural Resources (state permitting agency) and the mining company to design wildlife habitat reclamation, either as a primary land use or as a multiple-use benefit.

Initially GF&P was faced with a mining technology with which we had no previous experience. It was necessary to learn as much as possible about other operations, mainly in Nevada, and try to project what impacts to wildlife may be important in the Black Hills ecosystem. This was the basis for our initial impact mitigation requirements. GF&P also had to work with the companies to formulate reclamation plans that would benefit wildlife. All of our input was needed prior to the life-of-the-mine permit hearing.

MITIGATION TO MINIMIZE LETHAL IMPACTS TO WILDLIFE

We identified resident white-tailed deer (*Odocoileus virginianus*), mule deer (*Odocoileus hemionus*) and transient elk (*Cervus elaphus*) as species susceptible to cyanide impacts. A primary goal was to reduce the potential for these species coming into contact with the exposed cyanide solution in ponds and collection ditches. This was achieved by requiring an 8 foot high deer-proof fence around any exposed cyanide solution. Included were the ponds, heaps and collection ditches. Through six years at the Wharf Resources mine, there have been no reported big game mortalities in the processing area. A few deer have entered the area through access gates, but these have been successfully herded out. The only mortality to date within a processing facility occurred this fall at one of the newly permitted mines after a snag fell across and knocked down a portion of fence; allowing deer to enter the facility. During a herding attempt, a white-tailed buck bolted into the fence and broke his neck. Thus far we feel that this approach has been successful in limiting impacts to big game.

A second area of concern not initially recognized was the use of cyanide laden solution ponds by waterfowl, especially during migration. The Black Hills are not located in a primary migration route, and there is minimal nesting in the mining district. However, some waterfowl do migrate through each year. Twenty duck mortalities were recorded in ponds during 1984 and only two in 1985 (Fig. 1). After

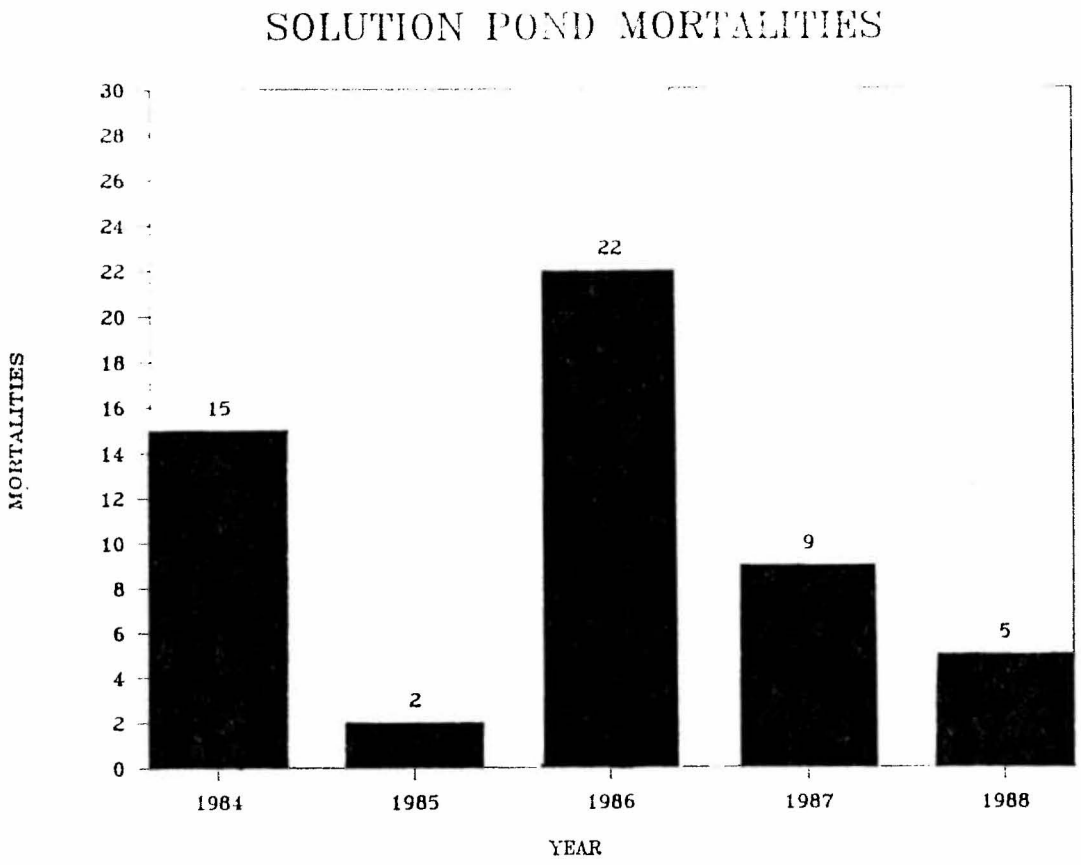


Figure 1. Reported waterfowl mortalities in cyanide solution ponds.

incurring 11 pond related deaths in 1986, bright orange flagging was installed at 50 foot intervals across both 3-acre processing ponds. Since that time, at least 11 deaths occurred during a severe storm, (which decreased flag effectiveness) and 2 other ducks landed in a pond prior to restringing the flags after winter in 1988. Although good data is not available, the mining company biologists feel that most mortalities recorded since initial pond flagging can be attributed to poor visibility periods of storms and moonless nights. Two other mines that began production in the fall of 1988 with flagging have not had a waterfowl death. At this point, we feel that for the Black Hills area, flagging across ponds containing toxic materials is an effective waterfowl deterrent.

In the northern Black Hills the most lethal aspect of heap leach mining proved to be the collection ditches that carry gold-bearing cyanide solution from the heaps to the processing ponds. The initial year at the first heap leach mine, we did not detect nor were there are reports of problems with these ditches. However, during the latter part of the summer in the second year, a couple of circumstances combined to result in a significant wildlife die-off at the mine (Fig. 2). First, late summer/early fall is the dry time of year, and natural water sources other than the perennial creeks go dry. In fact, during this time of year in a 2-mile radius of the mine, there are only three perennial streams. A 6-foot wide solution ditch with a continuous flow of clear cyanide solution a few inches deep, looks very similar to a small stream. This is also the time of year birds begin flocking after the breeding season. The result was a die-off of 573 birds in 1984 consisting primarily of red crossbills (*Loxia curvirostra*) and pine siskins (*Carduelis pinus*). During the late fall of 1984, the ditches were covered with crushed rock and the solution piped to the ponds. Since that time there have been few deaths associated with these ditches and only when solution puddled on top of the rock. It is now standard policy not to allow open solution-bearing ditches.

WILDLIFE HABITAT RECLAMATION

Three basic regulatory criteria serve as a guide in formulating reclamation plans for wildlife habitat (ARSD 74:29:07:22).

1. Reclamation must be directed toward optimizing habitat diversity for game and nongame species.
2. The species to benefit from reclamation must be identified.
3. Revegetation mixtures must be composed of native trees, shrubs, forbs and grasses or other approved vegetation.

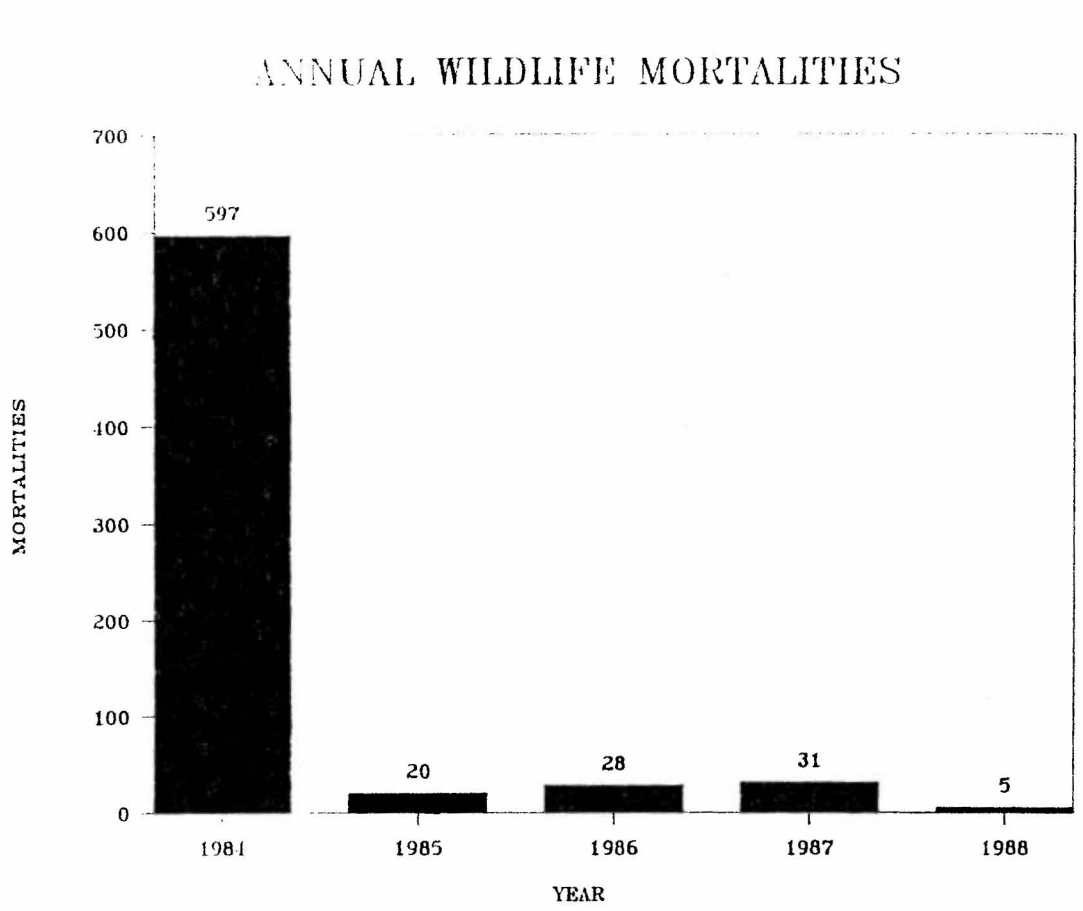


Figure 2. Total reported wildlife mortalities for a heap leach processing facility.

GF&P works with the proponent to design a plan that adequately addresses these points and will benefit wildlife.

The northern Black Hills, where the 4 heap leaching operations are currently active, are characterized by a dense forest canopy dominated by ponderosa pine. Ponderosa pine is the climax tree over vast areas of the hills, and because of its aggressiveness and high reproductive capabilities, this species also is abundant as a seral species (Hoffman and Alexander 1987). Past land management practices (e.g. heavy grazing) and many years of fire suppression have resulted in pine encroachment and a loss of open parks and meadows (Richardson and Peterson 1974). Since deer, the key management species for the area, have been detrimentally impacted by forest encroachment (Richardson and Peterson 1974) our goals is to take advantage of the open aspect of newly reclaimed mines to establish meadows and hardwood complexes.

South Dakota regulations require topographical reclamation that results in contours compatible with the surrounding area and maintains watershed integrity (ARSD 74:29:07:04). Consequently, the postmining topography will provide growing site diversity with ridges and swales, emphemeral drainages and various slope aspects. Three plantings will be concentrated on favorable growing sites (e.g. swales, north-facing slopes) and will be planted at a rate of about 200 per acre. Emphasis has been on native species such as quaking aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), bur oak (*Quercus macrocarpa*) and white spruce (*Picea glauca*). Grasses, forbs and shrubs will be seeded throughout the reclaimed area using species, primarily native, appropriate for the area. Each mine is required to maintain test plots to evaluate species success using the prescribed reclamation techniques. Alternative species may be tested and used in reclamation if approved by the regulatory agencies. It is anticipated that the reclamation product will result in open meadows with clusters of shrubs and trees. This emphasis on seral state revegetation will benefit not only deer but also nongame birds and many mammals.

Characteristically, hard rock open pit mines are not backfilled. In fact, backfilling tends to be the exception. South Dakota regulations require topographic reclamation that is visually and functionally compatible with the configuration of the surrounding area and suitable for the postmining land use. Under these constraints, the preregulation practice of topsoiling and revegetating benches had to be modified. In response to this need Dr. Larry Brown (Larry Brown and Assoc., Idaho Springs, CO) introduced us to the concept of selective blasting at the end of mining to moderate the typical engineered straight lines associated with

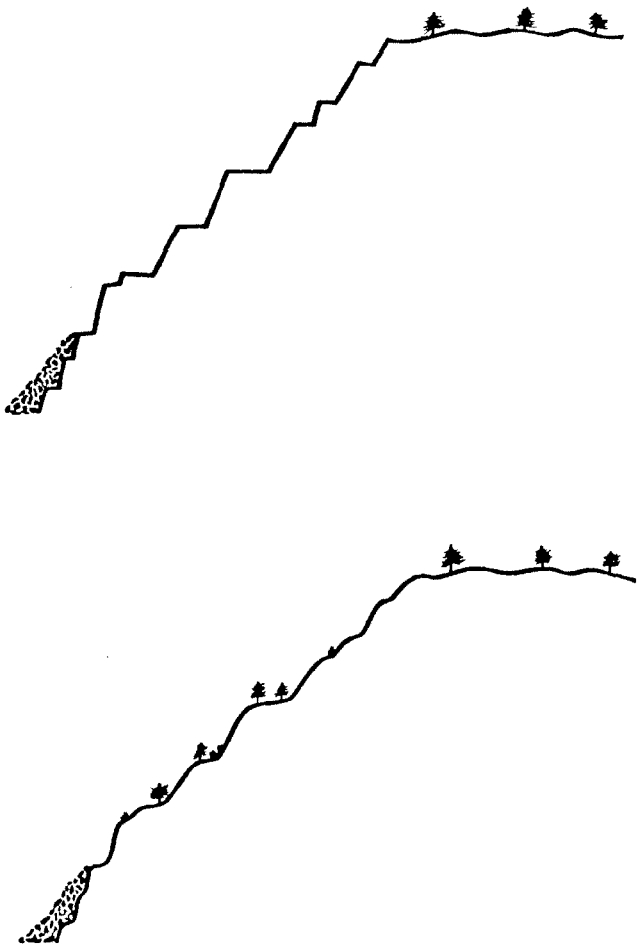


Figure 3. Profile after selected bench blasting (above). Final post reclamation profile (below).

highwalls and benches. (Fig. 3). The product will consist of benches revegetated with woody and herbaceous species and the talus slopes, ledges and crevices created by the selected blasting. We will be working with the companies during pit reclamation to choose sites for blasting that will benefit wildlife. The habitat of ledges, crevices and holes created in the highwalls and the proximity of pits to recently created meadows and forest edges should benefit nesting birds. Although extensive monitoring data of reclaimed pit use by wildlife is not yet available, a temporarily revegetated set of benches has been used by small mammals including rabbits (*Sylvilagus* spp. and *Lepus townsendii*), marmots (*Marmota flaviventris*) and even deer. A Townsend's solitaire (*Myadestes townsendi*) successfully nested in a small crevice of this highwall while it was inactive.

Current permitted wildlife habitat reclamation plans have been derived from agency resource management experience in the Black Hills and from the work of many others in the reclamation field. We feel that, if successful, the habitat produced through mined land reclamation will benefit numerous wildlife species. However, to gain some insight into which species are benefitting, companies are required to monitor vegetative development and associated wildlife use when reclaimed sites of adequate size become available. It is anticipated that monitoring concurrently reclaimed areas will yield habitat and wildlife use data for a period of at least 7 years, probably longer for most mines. Companies will also be monitoring off-site controls for species-use comparisons. The goal is not to duplicate the premining habitat condition, but rather to increase overall diversity and document species that can be expected to benefit.

During the next 5 years, most of the mines will be in the monitoring phases and there will be an excellent opportunity for research to evaluate habitat development and wildlife use, especially for the unique highwall reclamation companies will be employing. It is not enough that reclamation procedures are designed and agreed upon, it is also necessary to take an objective look and determine whether they are meeting the desired goals.

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REGULATORY AND INSTITUTIONAL REQUIREMENTS FOR WILDLIFE HABITAT MITIGATION ON INDIAN LANDS

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Abstract: Pittsburg and Midway Coal Mining Company's (P&M) McKinley Mine was the first, large, operating surface coal mine to be permitted on the Navajo Reservation under the Surface Mining Control and Reclamation Act (SMCRA) of 1977, Permanent Indian Program at 30 CFR 750 et. seq. As the first such permitted mine, there were numerous legal and institutional constraints that had to be addressed, especially in the area of wildlife habitat mitigation. This paper presents a case study of the permitting process and results of that process in the development of P&M's wildlife habitat mitigation plan that was unique at the time of development. The paper also attempts to point out the opportunities that are available in the area of wildlife habitat mitigation when all parties are brought into the negotiations at an early stage.

INTRODUCTION

The Surface Mining Control and Reclamation Act of 1977 (P.L. 95-87) established the Office of Surface Mining Reclamation and Enforcement (OSMRE) as the regulatory agency in the U.S. Department of the Interior with jurisdiction over the permitting and regulation of surface coal mining operations[1] in the United States. OSMRE is required by Section 102 of the Act to, among other things:

> (a) establish a nationwide program to protect society and the environment from the adverse effects of surface coal mining operations;" . . . [and]
>
> (f) assure that the coal supply essential to the Nation's energy requirements, and to its economic and social well-being is provided and strike a balance between protection of the environment . . .

Such diverse goals as stated in Section 102 of the Act led to promulgation of a comprehensive set of regulations contained at 30 CFR Chapter VII. Under the initial program, OSMRE was responsible for regulatory functions on Federal lands, Indian lands, and in States without regulatory programs. Coal-producing States were provided the opportunity, through approval of their permanent programs, to assume primacy for the regulation of surface coal mining within their respective jurisdictions. Approval of primacy did not, however, extend to Indian lands defined as:

> . . . all lands, including mineral interests, within the exterior boundaries of any Federal Indian reservation, notwithstanding the issuance of any patent, and including rights-of-way, and all lands including mineral interests held in trust for or supervised by an Indian tribe;. . .

The Federal government, specifically the U.S. Department of the Interior, retains jurisdiction as the "trustee" of these lands for the various Indian tribes. While SMCRA (Section 710) permits these regulatory duties under Title V to be transferred to the coal-producing tribes through enactment of Congressional legislation, no such legislation has been enacted to date. On September 28, 1984, OSMRE promulgated final permanent rules for surface coal mining and reclamation operations on Indian lands (49 FR 38477).

Therefore, mining companies such as the Indian lands portions of the P&M's McKinley Mine have been permitted and inspected under the jurisdiction of OSMRE's Western Field Operations (WFO). Since issuance of the permanent program permit, McKinley has been regulated under 30 CFR 750 et. seq. Figure 1 shows the "North Mine" over which OSMRE has exclusive jurisdiction, the "South Mine" under the State of New Mexico's exclusive jurisdiction and the areas of contested jurisdiction concerning the application of the definition of "Indian Lands" under SMCRA. The areas of disputed jurisdiction are checkerboard in nature involving a mixture of private coal, Indian surface, and allottee surface over Indian coal.

Portions of the "North Mine" were considered to be significant wildlife habitats by the Navajo Nation's Game and Fish Department and the Bureau of Indian Affairs (BIA) Navajo Area Office. Figure 2 shows the area considered as "significant," which primarily consisted of Areas 3 and 6 in P&M's permit application package.

Portions of the regulations applicable are 780.16 for the permit application requirements, and 816.97 for the performance standards for wildlife issues related to surface coal mining on Indian lands.[2] OSMRE was faced with numerous wildlife concerns expressed by individual allottees, as well as those expressed as Tribal interests by the Navajo Nation. OSMRE's task was to focus on the resolution of the issues, and to this aim, a series of meetings and negotiation sessions were held by a working group consisting of representatives of OSMRE, P&M, the BIA, and the Navajo Nation. The New Mexico Mining and Minerals Division (NM/MMD) was involved indirectly in a commenter's role on target species, mitigation methods, plant species for reclamation, and consistency between the Federal and State permits, where applicable. The intent of these sessions was to reach a common understanding and identify the important

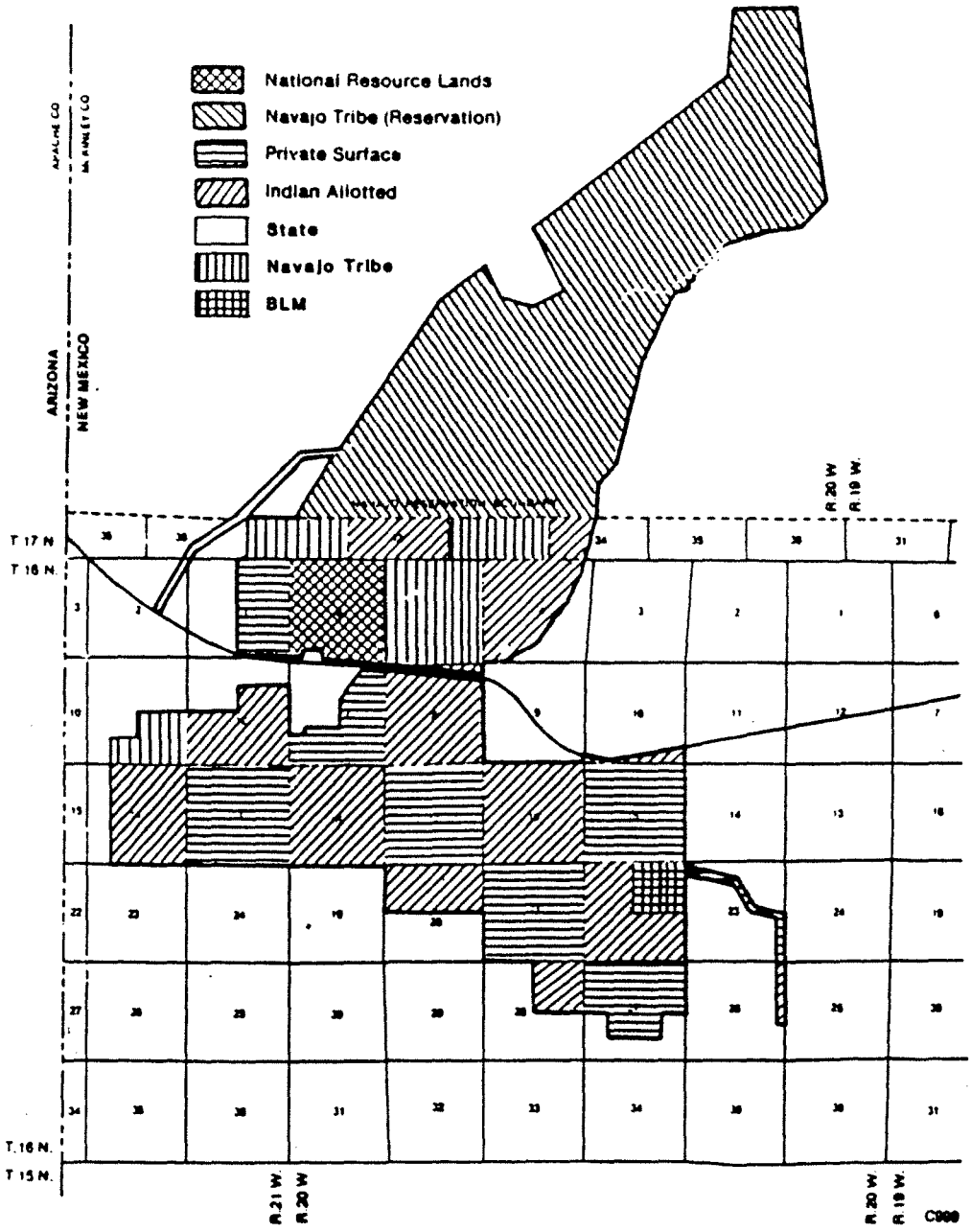


Figure 1. Surface ownership of lands within P&M's McKinley Mine permit area. Above the Navajo Reservation Boundary is the "North Mine," while below is the "South Mine."

issues related to "significant wildlife habitats." To some individuals the notion of reclamation is instant replacement of vegetation types and landforms, the components that define habitat; a difficult task at best.

The working group also was faced with the lack of unanimity between outside interested parties on whether wildlife should be a major or minor component of the postmining land use. P&M was required to include in its permit application:

- Potential listed or proposed threatened and endangered (T&E) species of plants and animals or their critical habitats.
- Habitats of unusually high value such as streams, wetlands, riparian areas, cliffs supporting raptors, areas offering special protection, migration routes or reproduction and wintering areas.
- A protection and enhancement plan used during operations and reclamation to develop aquatic and terrestrial habitat consistent with 30 CFR 816.97.

The regulations required P&M to minimize disturbance of fish and wildlife and related environmental values and to achieve enhancement of those resources where practicable.

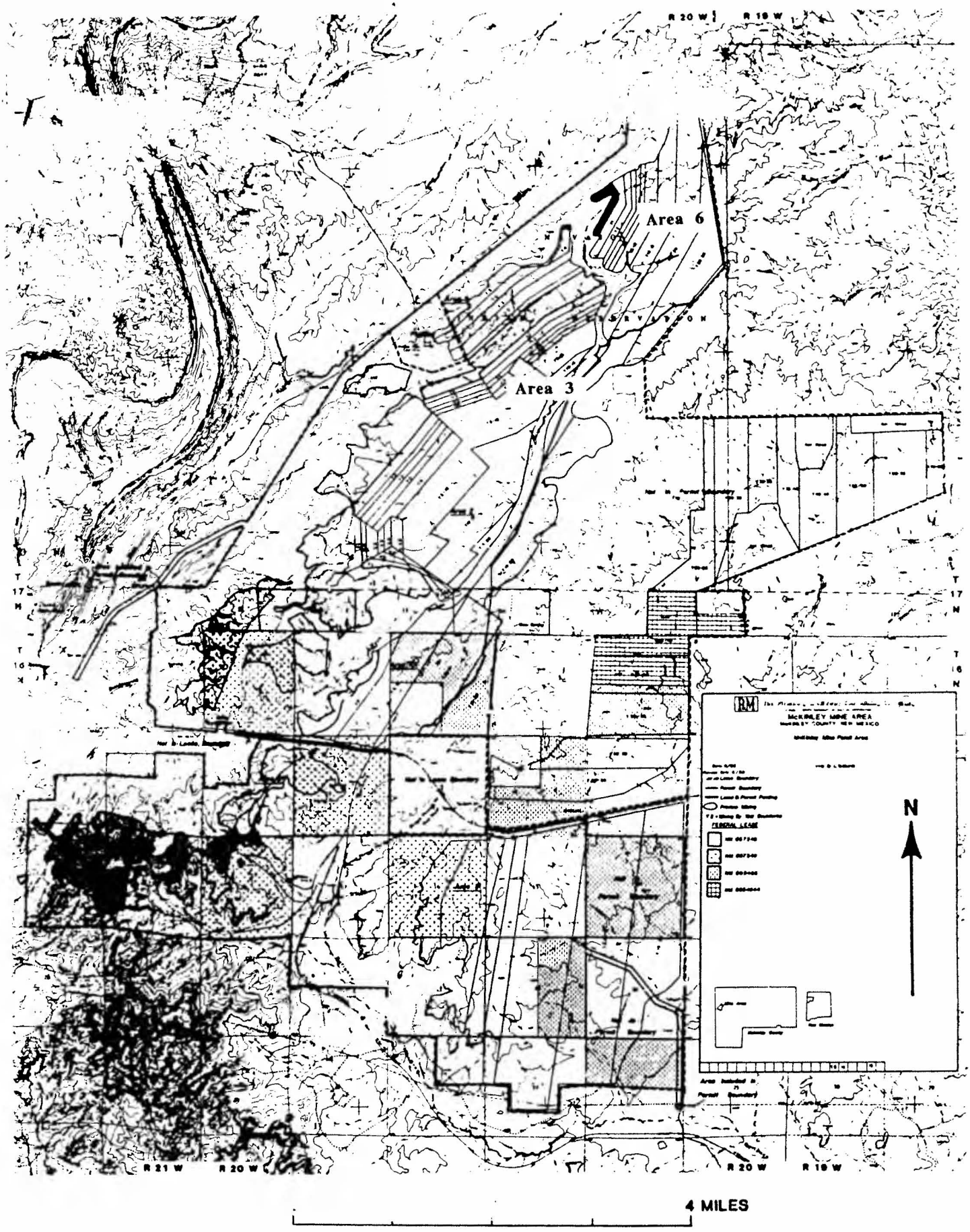


Figure 2. P&M's McKinley Mine lease, permit and operations areas. The areas discussed in this paper as significant wildlife habitat are Areas 3 and 6 in the opper portion of the figure.

With respect to P&M's McKinley Mine, these regulations focused on revegetation and enhancement activities for specific target species; i.e. mule deer and general groups of animals, small mammals, raptors, amphibians, reptiles, etc..

IDENTIFICATION OF WILDLIFE VALUES OF CONCERN

The working group identified one potential T&E species, the black-footed ferret, within and adjacent to the permit area. Consultation between OSMRE and the U.S. Fish and Wildlife Service (USFWS), under Section 7 of the Endangered Species Act, was conducted on the black-footed ferret. The results of this consultation were that the USFWS provided OSMRE and P&M with a declaration that, based on prairie dog town surveys, there were no negative impacts likely to occur to this species. There were several habitats of unusually high value thought to exist within the permit area specifically related to mule deer. It was believed that a major migration corridor between McKinley Mine and the Chuska Mountains (Figure 3) existed as well as potential fawning and wintering areas (Figure 4). There were few water sources available for wildlife in the premining landscape. In order to determine the extent of mule deer use in the permit and adjacent areas, P&M conducted a multiyear study of deer use and movement using neck-banded and radio-collared deer captured at several mine lease locations. Natural sandstone bluffs within and adjacent to the permit area are used by various hunting raptors (Figure 5).



Figure 3. Suspected mule deer migration route from McKinley Mine to the Chuska Mountains in the background.

PROTECTION AND ENHANCEMENT PLAN

P&M, in cooperation with OSMRE, the BIA, Navajo Nation and other interested parties, used the migration data to develop the wildlife protection and enhancement plan. The plan was developed based on the belief that if postmining habitats are provided for the various major groups of animals known to exist in the area, they will colonize them. The mule deer enhancement plan focuses on Areas 3 and 6 shown in Figure 2.

To provide an intensive habitat, islands of mature existing pinon and juniper have been left and will continue to be left within the permit area (Figure 6). These islands provide edge effects that were not prevalent in premining environments and should provide a base for pinon and juniper recolonization of adjacent areas over time.

Initial requests by the BIA for P&M to transplant mature pinon and juniper were considered as a permitting requirement by OSMRE during the permitting process. It was determined that twenty-foot tall trees would not survive such a transplant and that natural reinvasion by pinon and juniper would occur on the reclaimed areas. It was also noted that on a prelaw reclaimed site, there had been an initial invasion of pinon that were not planted and were not in proximity to mature pinons (Figure 7). It is assumed that the seeds were transported to this location by animals. Additionally, P&M would plant large shrub clusters based on the deer use data and the desires of the Navajo allottees to provide additional forage and cover. It is anticipated that these shrub developments will look similar to this mixed shrub community on reclamation of lands conducted prior to issuance of the permit (Figure 8). Many of these shrubs are volunteer.

Massive natural sandstone bluffs exist in the premining landscape throughout the permit area. Figure 5 shows one of the two types of natural bluffs; those that are solitary and surrounded by vegetation. The other type is one that is more or less continuous with scattered vegetation. P&M agreed to reconstruct a small bluff for raptor habitat that has been designed to be stable and to approximate the premining topography. Not only will this bluff provide vertical relief, it will also create microclimates that should retain additional moisture and provide for additional shrub development. A smaller-scale extension of the premise that vertical relief



Figure 4. Potential fawning area in Area 6 of McKinley Mine.



Figure 5. Natural sandstone bluffs at McKinley Mine.

provides raptor habitat has also been incorporated into the protection and enhancement plan. This involves the placement of massive boulder piles on the reclaimed surface that will serve as raptor perches and also serve as habitat to small mammals and reptiles (Figure 9). During observations on November 16, 1988, several larger small-mammals were observed hiding under or basking on these features, and whitewash indicative of raptor use was evident on one of



Figure 6. Example of islands of pinon and juniper left for wildlife habitat at the McKinley Mine.



Figure 7. Example of natural reinvasion by pinon pine on prelaw reclaimed areas at McKinley Mine. Pen in foreground is for scale.

the piles. This colonization has been rapid and is expected to accelerate with maturing vegetation.

P&M has taken upon itself a further significant enhancement of wildlife habitats by the creation of alternate sediment control structures designed to trap sediment as well as to hold water on a seasonal basis (Figure 10). As stated

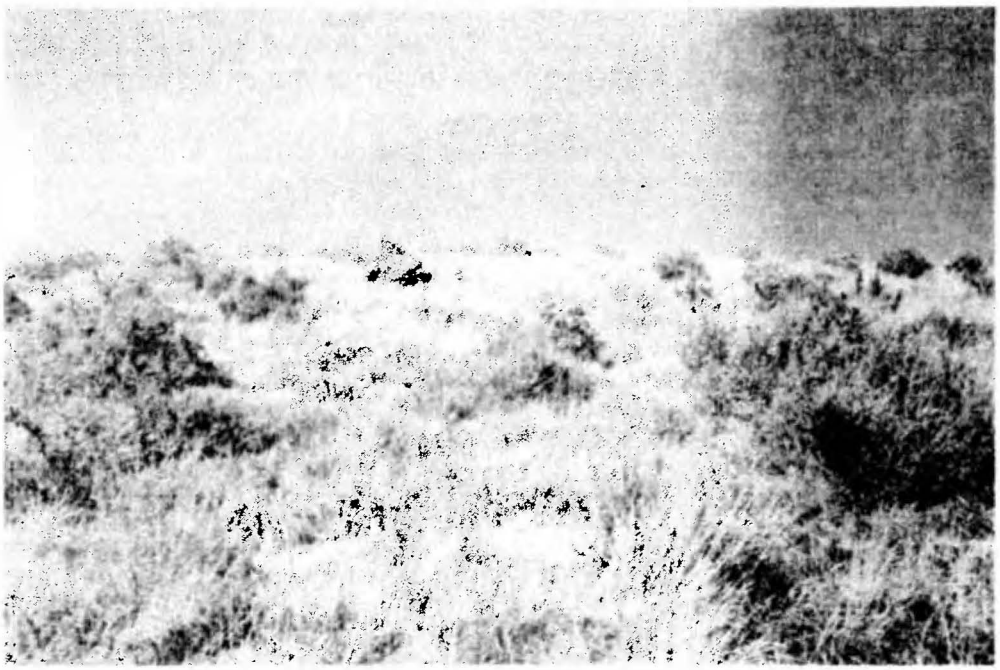


Figure 8. Example of natural reinvasion by shrubs on older reclaimed lands at McKinley Mine.

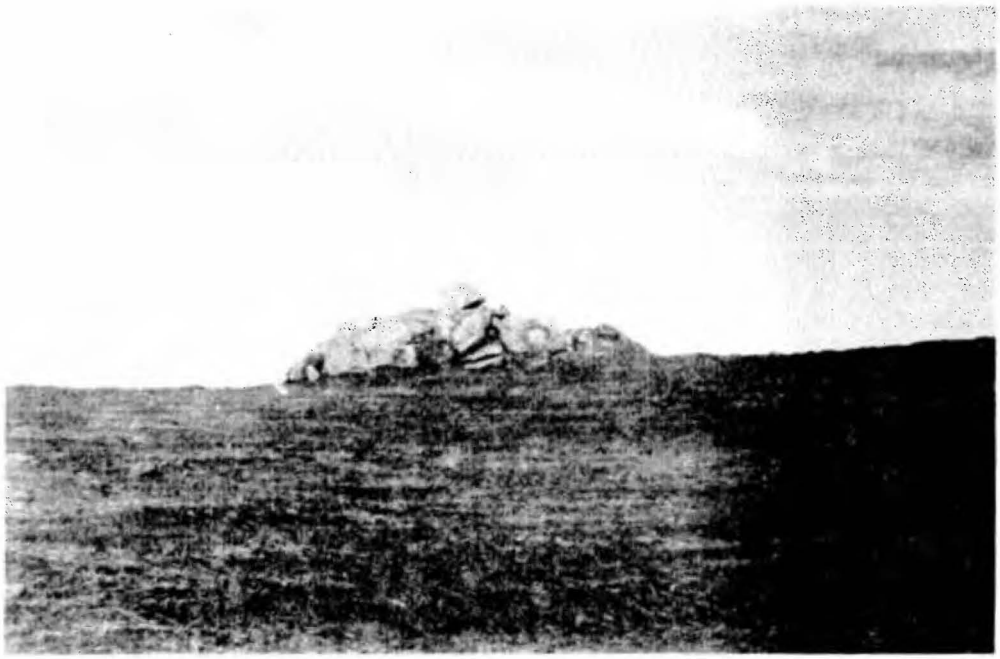


Figure 9. Example of a massive boulder pile placed on new reclamation at McKinley Mine.

earlier, water sources are the limiting feature for wildlife in this part of the arid Southwest. It is planned that a variety of riparian plant species will be planted along the waterways and around the high water line of these erosion control depressions. Species in the riparian planting plan include Fremont Cottonwood, Scouler Willow, *Juncus spp.*, Reed Canary grass, Broadleaf Cattail, Ash and Russian Olive.

In addition to the planned plantings of hydrophilic plants, natural invasion has begun to occur at all of the existing water retention facilities. Figure 11 shows an

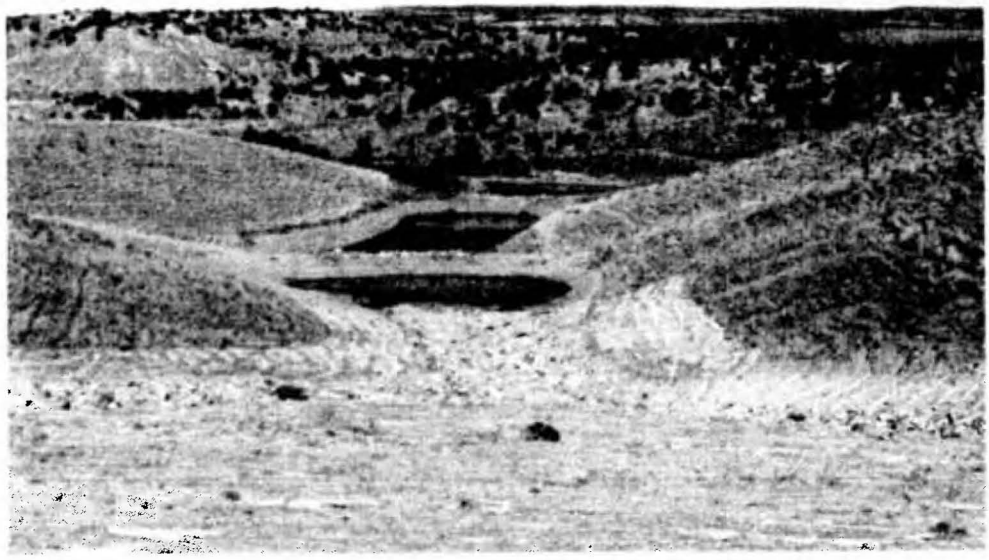


Figure 10. Examples of seasonal water sources planned as a part of reclamation at McKinley Mine.



Figure 11. Example of natural invasion by emergent wetland plant species at McKinley Mine.

example of the affects of natural colonization by cattails. Other species invading the area include the cottonwood, salt cedar (not a preferred species but one that has colonized most of the Colorado river system), and bullrush. One of the larger water bodies also has large boulders that protrude above the high water line and may provide nest and loafing sites for waterfowl. Anecdotal evidence indicates that migrating waterfowl, including important economic species such as Canada geese, are using these ponded areas. Amphibians are also colonizing these water sources

(Erickson personal communication). These riparian zones also will be fenced to preclude intrusion by livestock, a serious threat to riparian zones. Additional water sources will include man-made trickle tanks to further provide water around the permit area.

THE FUTURE

P&M has committed to continued wildlife monitoring efforts and augmented seeding should the shrub community establishment fail initially. The company also expects to use surface manipulations to enhance water harvesting to further assist the establishment of a diverse vegetation community. The ability of P&M to control the future of the protection and enhancement plan for wildlife and attendant liability at the McKinley Mine will end with bond release. At that time, the Navajo Nation will again control the management of these lands. It is expected that with judicious implementation and continued resource stewardship, the results of the P&M wildlife protection and enhancement plan will be present for future generations. All parties involved in the negotiations, development, and implementation of the plan are to be commended for striving to develop a realistic, workable program.

NOTES

1. The term "surface mining activities" refers to open pit strip mining and the surface disturbances associated with underground mining operations.

2. At the time of permitting the McKinley Mine, the most recent final fish and wildlife rules were not in effect, although the contents were similar.

SHARP-TAILED GROUSE LEK (DANCING GROUND) ESTABLISHMENT ON RECLAIMED MINED LANDS

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Abstract: Eastern Montana generally is considered prime plains sharp-tailed grouse (*Pedioecetes phasianellus jamesi*) habitat. Sharp-tailed grouse are described as a "lekking" species (Rippin and Boag 1974). Lekking species gather at specific sites (dancing grounds or breeding grounds) each year to perform annual courtship rituals. The sharp-tailed grouse is a species that adheres to very particular dancing ground sites over long periods of time. One dancing ground documented by Western Energy Company (WECO) has been active for 22 years at one specific knoll. Because of the apparent necessity of these dancing grounds, concerns were raised about the effect on sharp-tailed grouse populations if dancing grounds were removed by mining. Since WECO realized that its future mine plans might conflict with existing dancing grounds, studies were initiated as early as 1975 to investigate these concerns. The studies were designed to answer the following question: Can sharp-tailed grouse be attracted to potential dancing grounds on reclaimed mine lands? This paper is an overview of how dancing ground mitigation efforts developed and evolved at WECO. A discussion of field techniques and equipment is presented. Results indicate that four dancing ground sites show promise.

INTRODUCTION

WECO has been mining sub-bituminous coal at the Rosebud Mine since 1968. The Rosebud Mine is located near Colstrip in southeastern Montana (Fig. 1). WECO mined 16 million tons in 1988; disturbing approximately 350 acres. Fifty percent of the coal was burned in power plants at the town of Colstrip and Billings, Montana. The remainder was shipped to power plants in Minnesota and Wisconsin. The mined land is reclaimed within a three year period following disturbance to a diverse native plant community similar to pre-mining conditions. Topographically, the land-form of the area displays a dendritic drainage pattern that gives the area an abundance of coulees and incised drainages. Open valleys are divided by steep, rugged buttes. The region is within the eastern ponderosa pine formation as described by Kuchler (1964).

Historically, in the Great Plains region, sharp-tailed grouse were associated with prairie brushlands. Today, their most secure habitat is the upland prairie where heavy grazing or cultivation have not completely altered the native grasses and shrubs (Brown 1971). More recently on a much smaller scale, surface coal mining has had the potential to disrupt sharp-tailed grouse habitat, described as excellent in the Colstrip region by ECON (1973).

A "lekking" species (Rippin and Boag 1974), sharp-tailed grouse gather at specific sites (dancing or breeding grounds) annually to to perform courtship rituals. One lek documented by WECO has been active for 22 years on the same knoll. Because of the necessity of these leks to grouse, concerns were raised as to the effect on populations if leks were removed by mining. WECO realized that its future mine plans might conflict with existing leks, and thus, initiated mitigation studies as early as 1975 to research these concerns. These studies centered on the leks and were designed to answer the question: Can sharp-tailed grouse be attracted to potential lek sites on reclaimed mine lands?

Studies of sage grouse (*Centrocercus urophasianus*), their response to artificially created leks, and lek relocation efforts were conducted by Eng (1979) and Tate (1979) with some success.

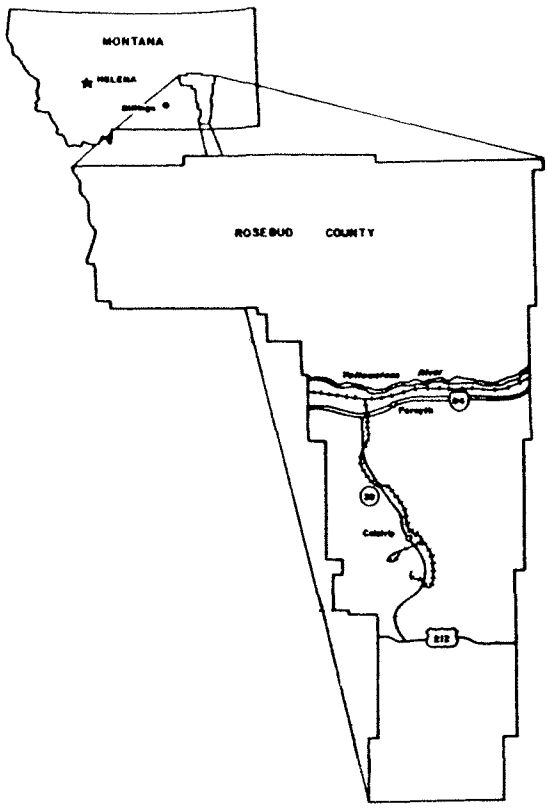


Figure 1. Location of the WECO Rosebud Mine near Colstrip, Montana.

Lek conflicts were an important permitting issue for WECO. At the time, there were no documented leks on any reclaimed mine surfaces. In 1980, the Bureau of Land Management (BLM 1980) invoked unsuitability criteria #14 for the WECO Area C permit, excluding 181 acres containing

7,964,000 tons of coal to protect a lek and to maintain a portion of the available nesting cover. The report stated,

> If it can be shown and the State of Montana agrees that all or stipulated methods of mining will not have significant long-term impact on the area-wide sharp-tailed grouse population and their habitat and that reclamation and management of reclamation areas would provide suitable post-mining habitat, this lek and nesting area could be considered for leasing.

The history of mitigation efforts and results to date of sharp-tailed grouse lek activity on reclaimed mine lands at the WECO Rosebud Mine follows.

METHODS

In 1975, a Crown CX 844 (71 ips, 12-20,000 Hz frequency response), multi-channel tape recorder and Sony ECM were used to record sharp-tailed grouse display vocalizations at a typical sharp-tailed grouse lek. The tape recordings were to be used as a sharp-tailed grouse acoustical lure to stimulate display at a predetermined experimental lek site in the spring of 1976. Experimental lek locations were selected on the basis of topography (modestly elevated knolls) and sparse vegetation. Rogers (1969) found a direct relationship between lek locations and soil types in Colorado; leks were located on dry, solid soils that supported sparse vegetation cover. History of use by sharp-tailed grouse as determined from direct observation also was a criteria in location selection.

Following selections of experimental lek sites, styrofoam decoys depicting displaying male sharp-tailed grouse were constructed to provide additional stimuli at the leks. Decoys were painted to mimic the natural coloration of sharp-tailed grouse. Typically, 12 decoys were placed at each site to simulate a mating center. After 1978, decoy hens in copulatory position were used on decoy sets. Sell (1977) noted considerable response by lesser prairie chickens (*Tympanuchus pallidicinctus*) in Texas to decoys of this type. At experimental lek sites in 1986, skins of sharp-tailed grouse were stuffed and used for decoys.

Sell (1977) noted that female lesser prairie chickens often fed while on the lek. Thus, after 1978, grain was scattered on the ground on the experimental lek sites.

On a typical morning, decoys were placed on the experimental lek along with two speakers with 50' of cord connected to a stereo cassette tape player in a vehicle. Speakers were placed at the edge of the site. The tape was played while a biologist recorded observations from the vehicle. Most attempts were conducted from one hour before sunrise to approximately two hours after sunrise. In addition, some attempts were conducted just prior to sunset. After 1978, an automatic timer system was utilized in which the tape was activated daily by a 12-volt car battery at the appropriate hours. The automatic system avoided additional disturbance to the grouse and reduced manpower requirements.

RESULTS

Attempts to Establish New Leks in Reclamation Areas

There have been eight separate sites in WECO's reclamation areas where attempts to lure sharp-tailed grouse have been conducted. Five sites had positive results (Fig. 3).

Reclamation Site #1—1976

The first attempt at luring sharp-tailed grouse to lek site #1 in the reclamation area (Fig. 2) was on March 23, 1976. there was no response. On March 24, two male sharp-tailed grouse were observed, and aggressive territorial behavior between the two was noted. On March 25, three sharp-tailed grouse were flushed from the site in the pre-dawn hours. Fresh roost sites were located indicating that the sharp-tailed grouse had stayed nearby that night.

Reclamation Site #1—1977

During attempts at luring on March 25, 1977, two males arrived at lek site #1. Unfavorable weather prevented further attempts until April 1. Nine attempts between April 1 and April 15 had marginal results. Between September 26 and November 4, 21 attempts were made to lure sharp-tailed grouse to lek #1. The only noteworthy response occurred October 3 when five grouse flew to a nearby ponderosa pine; one male responded to the tape by displaying in the tree (ECON 1977).

Although the autumn attempt had marginal results, several significant observations were made. A previously unknown lek (#30) approximately 1.2 miles southeast (0.75 mile from the edge of the reclamation area) of reclamation lek #1 (Fig. 2) was discovered by a researcher. Of 23 leks monitored in 1977, this site was the largest in terms of male attendance (33 males) recorded in the study area. Apparently, this site was first attended in the autumn of 1977 as no sounds were heard in the spring of 1976 or 1977.

On October 17, 1977, another new lek (#31) was located one mile northwest of reclamation lek #1 and 700' from the reclamation area (Fig. 2). Whether the sharp-tailed grouse recordings had stimulated the development of leks #30 and #31 is not known, but it is known that in the spring of 1976 and 1977 lek #19 (Fig. 2) was the closest known dancing ground to the reclamation area.

Although the 1977 autumn luring attempts were marginally successful, the time spent in the field resulted in four interesting developments:

1. Leks #30 and #31 were discovered; the closest to the reclamation area.
2. Lek #19, first discovered in 1974 and previously the

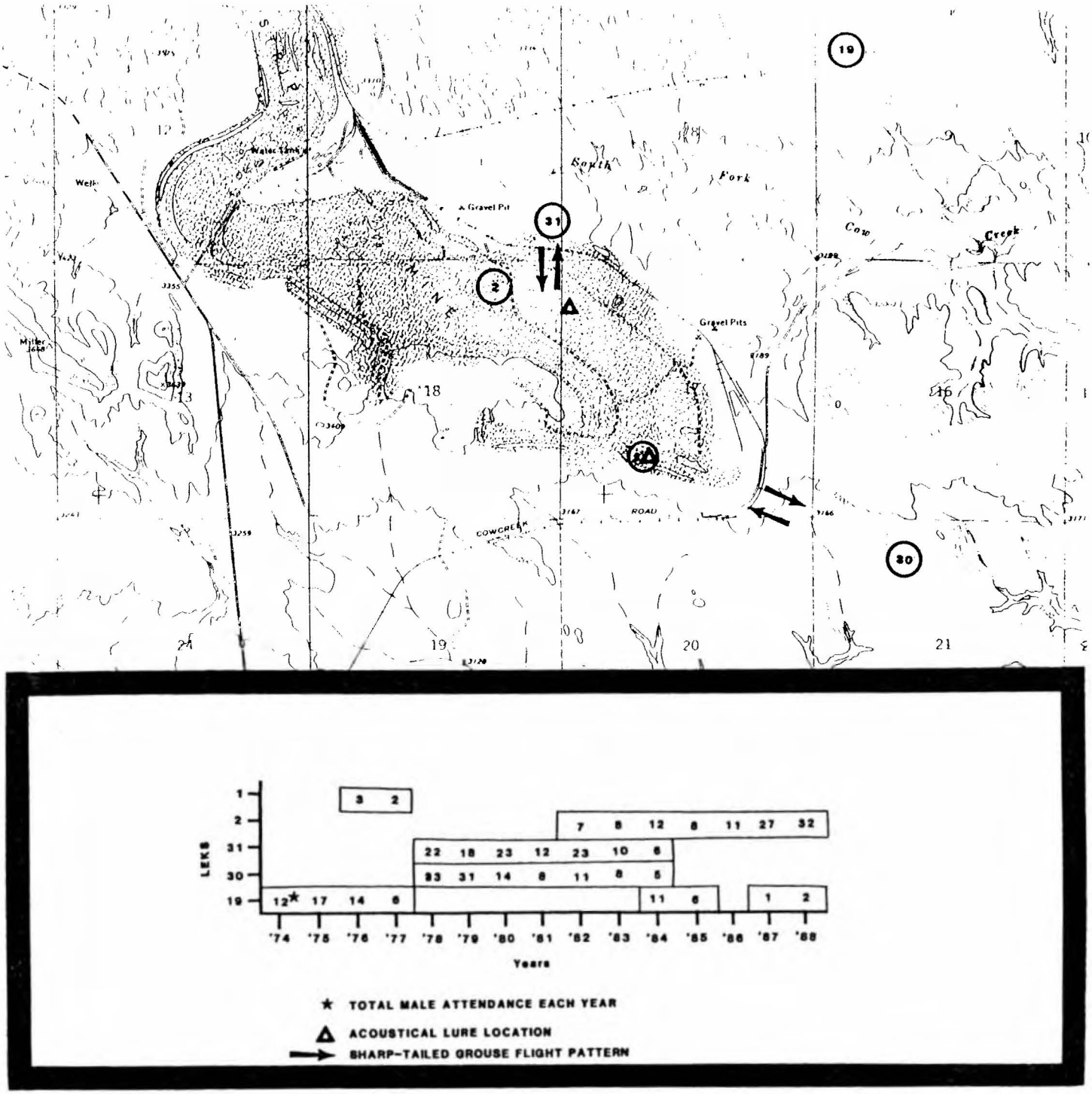


Figure 2. Lek locations and time line of activity for each lek neighboring reclaimed area lek #2.

closest to the reclamation area, became inactive at the time #30 and #31 were discovered. Lek #19 was active from 1974 through 1977 (Time Line Graph, Fig. 2).

3. During research activities at lek #1 in 1977 and in subsequent years, researchers noted flights of sharp-tailed grouse out of the reclamation area at pre-sunrise with return flights after display activity periods. Flight patterns indicated that movement was in the direction of leks #30 and #31. In the case of #31 located adjacent to the reclamation area, birds were directly observed (ECON 1978).

4. Numerous sharp-tailed grouse roosting sites were evident in the reclamation area (ECON 1978). It was obvious that the reclamation area was receiving a great deal of sharp-tailed grouse use.

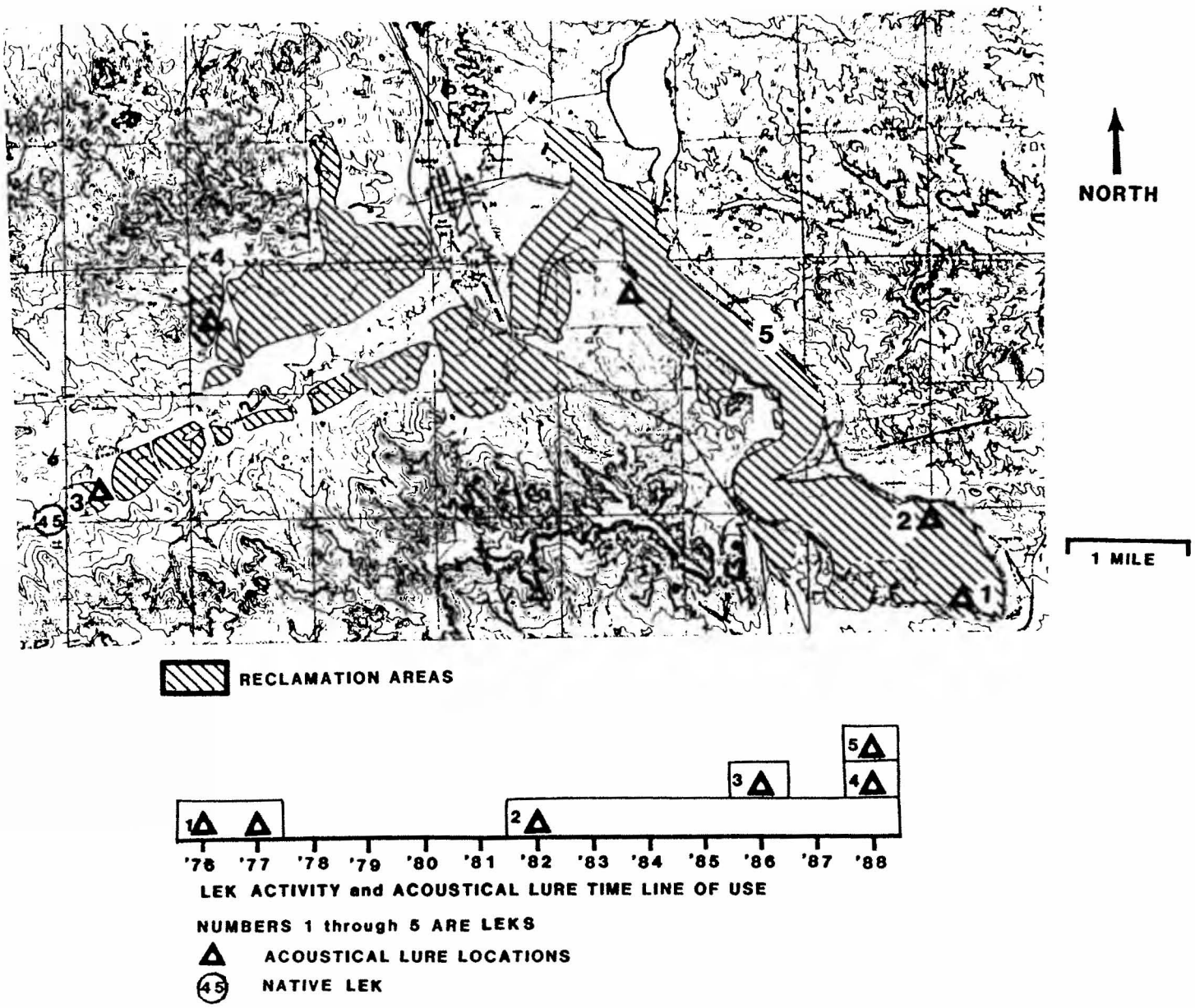


Figure 3. History of reclamation area lek use and acoustical lure locations.

Reclamation Site #2—1982

The high degree of sharp-tailed grouse movement between lek #31 and the reclamation area indicated that luring might intercept and cause these birds to establish a new lek within the reclaimed zone. Such an effort was initiated in late March 1982 on a reclaimed knoll (Fig. 2). Since the luring system was now automatic, less field time was required to monitor the site. Within a short time, a new lek (#2) was being utilized within the reclamation area 300' northwest of the lure site. Seven males and three females were observed on this lek. Lek #2 was located on an elevated knoll with sparse vegetation. In the autumn of 1982, the grouse attended this lek without luring. sharp-tailed grouse have attended lek #2 on their own volition each year since 1982, and male attendance has increased steadily. Since 1986, lek #2 has supported the highest male attendance of 20 active leks being monitored by WECO (Fig. 4). Average male attendance for the past 16 years in the Colstrip area is 12 (Fig. 5). Lek #2 in the reclamation area has averaged 15 males over the last five years.

Reclamation Site #3—1986

On March 18, 1986, luring was initiated at a new experimental site for lek relocation (lek #3). The new location was selected because an existing lek (#45) was located at the very edge of current mining activity and would be part of a future mine permit. The luring system was placed on a knoll within the reclaimed area, 0.3 miles from #45. Two days after the system was installed, a single male sharp-tailed grouse was observed displaying near a speaker.

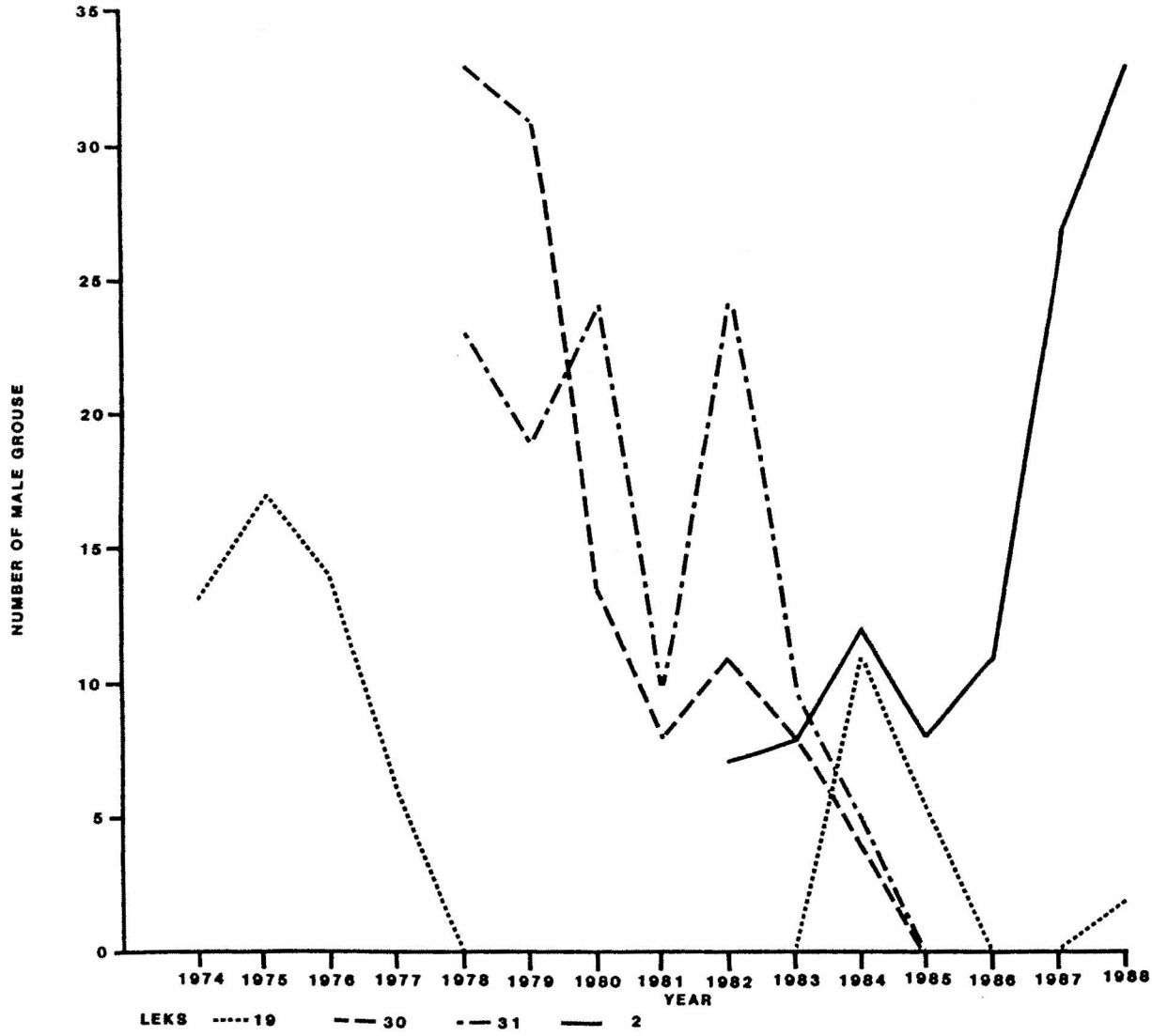


Figure 4. Reclamation area lek #2 compared to its neighboring leks.

From March 20 through April 27, one to three males regularly attended lek #3. One male continually displayed within inches of the front edge of a speaker (possibly indicating the importance of vocal stimulation to the birds).

During the attempts to lure sharp-tailed grouse to lek #3, no use of lek #45 was observed with one exception. On March 26, three males were observed displaying on lek #45, and the usual three males on lek #3 were absent. A speaker that normally was positioned to broadcast in the direction of #45 had been blown around to face the opposite direction.

Even though results at lek #3 were promising, a regionally low sharp-tailed grouse population curtailed the use of this site in 1987.

Reclamation Sites #4 and #5—1988

Two additional experimental lek sites (#4 and #5) were selected (Fig. 3) in 1988, and in early March, luring was attempted. By March 20, seven males were observed displaying 0.3 miles northeast of the luring site at lek #4. seven males regularly attended this lek throughout the mating season. While this lek appears to be established, the spring of 1989 will further indicate the degree of success.

Luring was conducted adjacent to a windmill within the reclamation area where heavy cattle use created sparse vegetation conditions. No activity was observed at this site, but one male was discovered displaying 1.0 miles southeast at Lek # 5. The bird was observed using the site several times, but the establishment of this lek remains to be seen.

DISCUSSION

The prededing analysis has shown that sharp-tailed grouse leks can be established on reclaimed mined lands. Acoustical lure attempts resulted in sharp-tailed grouse display activity being initiated at two designated luring sites

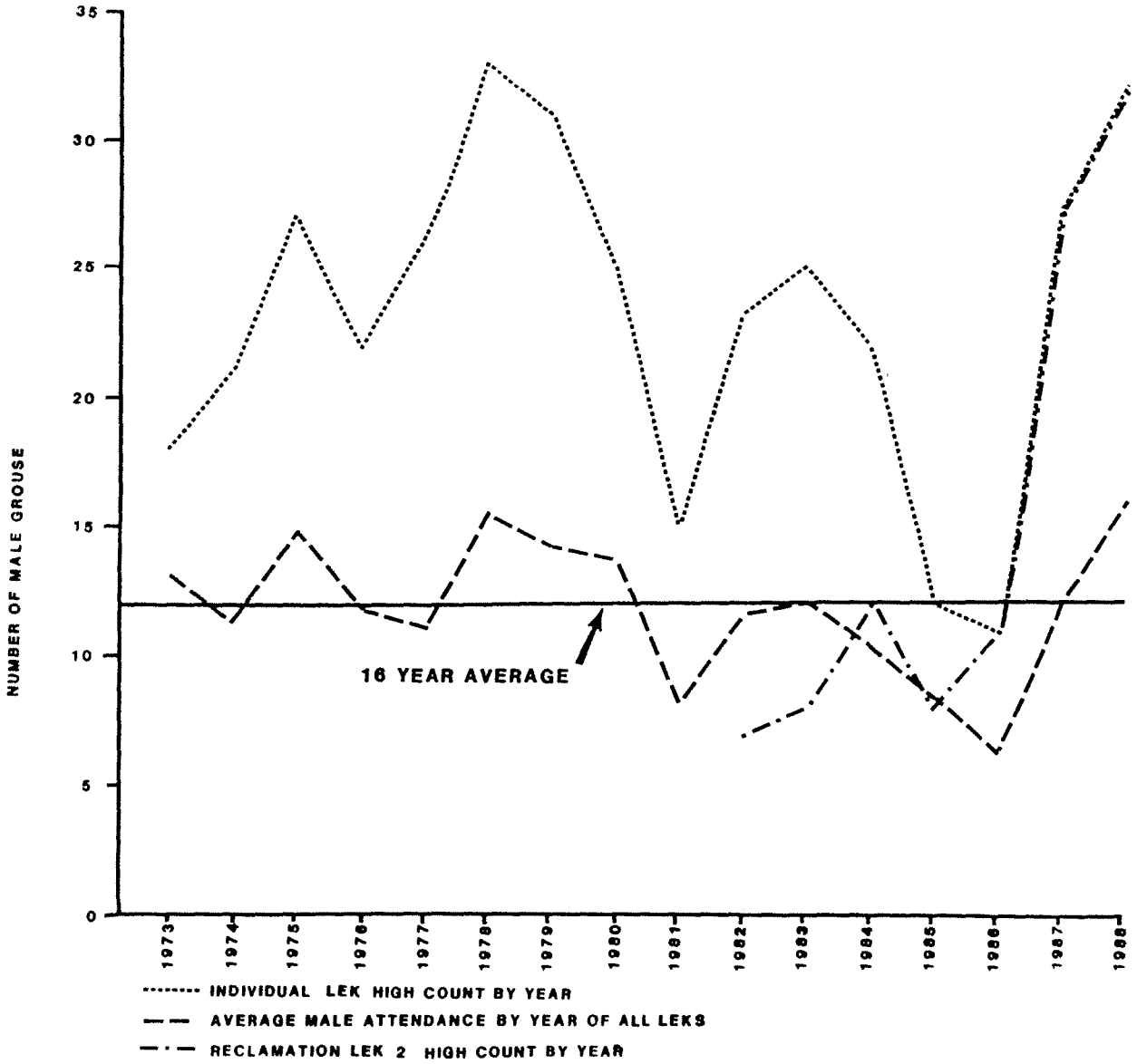


Figure 5. Reclamation area lek #2 compared to Colstrip 16 year average lek attendance and 16 year individual lek high counts.

(#1 and #3) without permanent establishment being achieved.

Three other leks may have been initiated as a result of acoustical lure activity. These sites were within auditory distance of the luring locations. Of these three sites, lek #2 has been active from 1982 with an average male attendance of 15, exceeding the Colstrip area average of 12 (Fig. 5). Furthermore, male attendance at lek #2 has increased to become the highest in the Colstrip area since 1986.

It is apparent that lek #2 within the reclamation area has been very successful. Attendance at this lek has increased dramatically while its closest neighbors (leks #30 and #31) have become inactive, and lek #19 has had intermittent low levels of activity (Fig. 4). The activity time line presented in Figure 2 graphically indicates the movement of sharp-tailed grouse to establish leks adjacent to the reclamation area. This trend culminated in the establishment of lek #2 following one season of acoustical luring. In at least one case, an adult male marked with a numbered poncho was confirmed to move from lek #31 to lek #2 where it was observed displaying in the spring of 1982. This male had been marked during an earlier study on lek #31 (WECO 1982).

The initiation of leks #30 and #31 in close proximity to the reclaimed area, and the establishment of lek #2 within the reclamation area is believed to have occurred for several reasons. Lek #2 is located in one of WECO's earliest reclamation areas. This area was mined prior to current reclamation laws. These pre-law sites were seeded to cool season grasses such as crested wheatgrass (*Agropyron cristatum*), smooth brome (*Bromus inermis*), and intermediate wheat-

grass (*A. intermedium*). It is apparent that these grass species provided increased cover, having vertical growth forms that remain very rigid. This may provide a greater residual cover value, particularly during the early spring. Structure and density of grasses may be more important than species composition in determining sharp-tailed grouse habitat quality (West 1961). Others also have noted the importance of residual cover from the previous year growing season (Schwarty 1945, Baker 1953). Cover can have a profound effect on sharp-tailed grouse lek locations as indicated by Kirsch (1969) in his study on the government soil bank program in North Dakota during the 1950's and early 1960's. Kirsch noted that active leks were directly associated with individual tracts of soil bank cover. Leks moved adjacent to the new cover. Eleven of 14 sharp-tailed grouse leks were within 180 meters of a retired land area.

New leks were established in Montana following substantial increases of residual cover. The largest leks were located in areas surrounded by dense stands of residual vegetation (Brown 1966).

It is also obvious that grazing has a profound effect on sharp-tailed grouse cover. Movement of grouse into reclamation areas may be a response to intensive grazing practices on adjacent areas as opposed to limited grazing within reclaimed areas where a rest-rotational grazing system has been employed since 1980, preserving residual cover.

Grouse have established leks on reclaimed lands at densities that meet or exceed pre-mined conditions. WECO controls approximately 4.7 square miles of reclaimed lands. Using the three leks active in 1988, this translates into a lek density of 0.6 per square mile. Native lek densities reported for the region have been 0.12 per square mile in Colstrip (Schwarzkoph 1980), 0.22 per square mile for the Otter Creek drainage (Martin 1980a), and 0.09 per square mile in the Sarpy Creek drainage (Martin 1980b).

Amstrup (1976) found that when the distance between leks was used as a radius in calculating the area per lek (3.86 square miles), the density of displaying males was 3.28 per square mile. If the number of displaying males in the reclamation area in 1988 is divided by the reclaimed land area, a male density of 8.5 per square mile is derived. It should be noted, however, that this number would tend to be high as birds are utilizing a land area greater than just the reclamation boundry.

As more mined lands are reclaimed at Colstrip and monitoring programs continue, WECO will have a larger sample to support the results comparing sharp-tailed grouse lek populations on reclaimed versus native areas.

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SESSION IV:

IMPACTS OF NATURAL RESOURCES DEVELOPMENT ON WILDLIFE

FERRUGINOUS HAWK NESTING ON THE U.S. DOE HANFORD SITE: A RECENT INVASION FOLLOWING INTRODUCTION OF TRANSMISSION LINES

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Abstract: Ferruginous hawks were an uncommon nesting raptor on the U.S. DOE Hanford Site prior to 1987, with only one or two pairs nesting each year. In 1987, four pair were found nesting on transmission towers. In 1988, seven pairs were observed nesting on the towers. This recent increase in nesting pairs may correspond to an acceptance phenomena related to age of the transmission towers. The increase may also be due to an overall increase in the population of ferruginous hawks in Washington.

Key words: Buteo regalis, ferruginous hawk, population, raptors, transmission towers, Washington

The use of man-made structures has enabled a number of different raptor species to increase their densities within their historical range and in some instances, to even expand their range (Newton 1979). Artificial nesting substrates are sometimes immediately accepted for nesting, but in other instances, acceptance occurs only after many years (Newton 1979) or not at all. The factors associated with acceptance are not well understood and acceptance time is not well documented.

Since 1973, birds of prey have been studied on the U.S. Department of Energy (DOE) Hanford Site. The use of nesting substrates has been observed and recorded annually (Fitzner et al. 1981). Red-tailed hawks (*Buteo jamaicensis*), Swainson's hawk (*Buteo swainsoni*), great horned owl (*Bubo virginianus*) and the common raven (*Corvus corax*) have all been observed nesting on transmission towers (Fitzner et al. 1981). Generally, over 50% of the red-tailed hawk nests have been situated in transmission towers during each year of the study. No ferruginous hawks have been observed nesting in transmission towers. In South Dakota, transmission towers serve as an important nesting structure for ferruginous hawks (Gilmer and Wiehe 1977). Olendorff (1973) felt that large areas of the U.S. DOE Hanford Site were devoid of nesting raptors simply because nesting opportunities were not available. He speculated that the creation of nesting structures in these areas would increase the density of nesting raptors on the Hanford Site. He did not speculate as to the rate of invasion of nesting raptors given the creation of new nesting substrates.

In this manuscript we provide an historical overview of an area of the Hanford site that was once devoid of nesting structures but today contains many transmission towers that provide for raptor nesting. The rate of invasion by the ferruginous hawk, red-tailed hawk and common raven is presented. Factors that may affect this invasion are also discussed.

This study was funded by the U.S. Department of Energy under contract DE-AC06-76RLO-1830 with Battelle Memorial Institute.

STUDY AREA

The study was conducted on the U.S. DOE Hanford Site in the Columbia Basin of southcentral Washington state in Benton and Franklin Counties (Fig. 1). The site is bordered by the Columbia River to the East and North, and the Yakima River to the South. In 1943, the site was established as a national security area and was closed to agriculture, grazing and unofficial travel.

The most prominent topographic feature of the site is Rattlesnake Mountain, on the western boundary, which rises to 1100 m above mean sea level. The Saddle Mountains rise in elevation to 925 m to the north. The Saddle Mountains and Rattlesnake Hills are separated by the Columbia River and a wide expanse of lowland topography generally less than 150 m in elevation. This lowland topography is interrupted by an alignment of basaltic ridges (Gable Mountain and Gable Butte) that run east-west near the middle of the Hanford Site.

Annual precipitation averages 16.5 cm, ranging from 7 to 30 cm over the past 30 years (Stone et al. 1972). On average, 60% of the precipitation occurs between October and February. Precipitation decreases after January but increases again to a secondary maximum in June. The climate can thus be described as consisting of hot, dry, summers and moderately cold, wet winters. July is the hottest and driest month while January is the wettest and coldest (Thorp and Hinds 1977).

Vegetation on the Site consists of three major vegetation associations. The higher elevations are dominated by big sagebrush (*Artemisia tridentata*) and bluebunch wheatgrass (*Agropyron spicatum*). Lowlands contain plant associations consisting of cheatgrass (*Bromus tectorum*), big sagebrush, with antelope bitterbrush (*Purshia tridentata*) replacing sagebrush on sandy substrates.

Trees occur sporadically along both banks of the Columbia River from near shoreline to a few kilometers inland. Many of these trees were planted for shade or orchards by early settlers and were abandoned over 35 years ago with the creation of the Hanford Site. Trees also occur

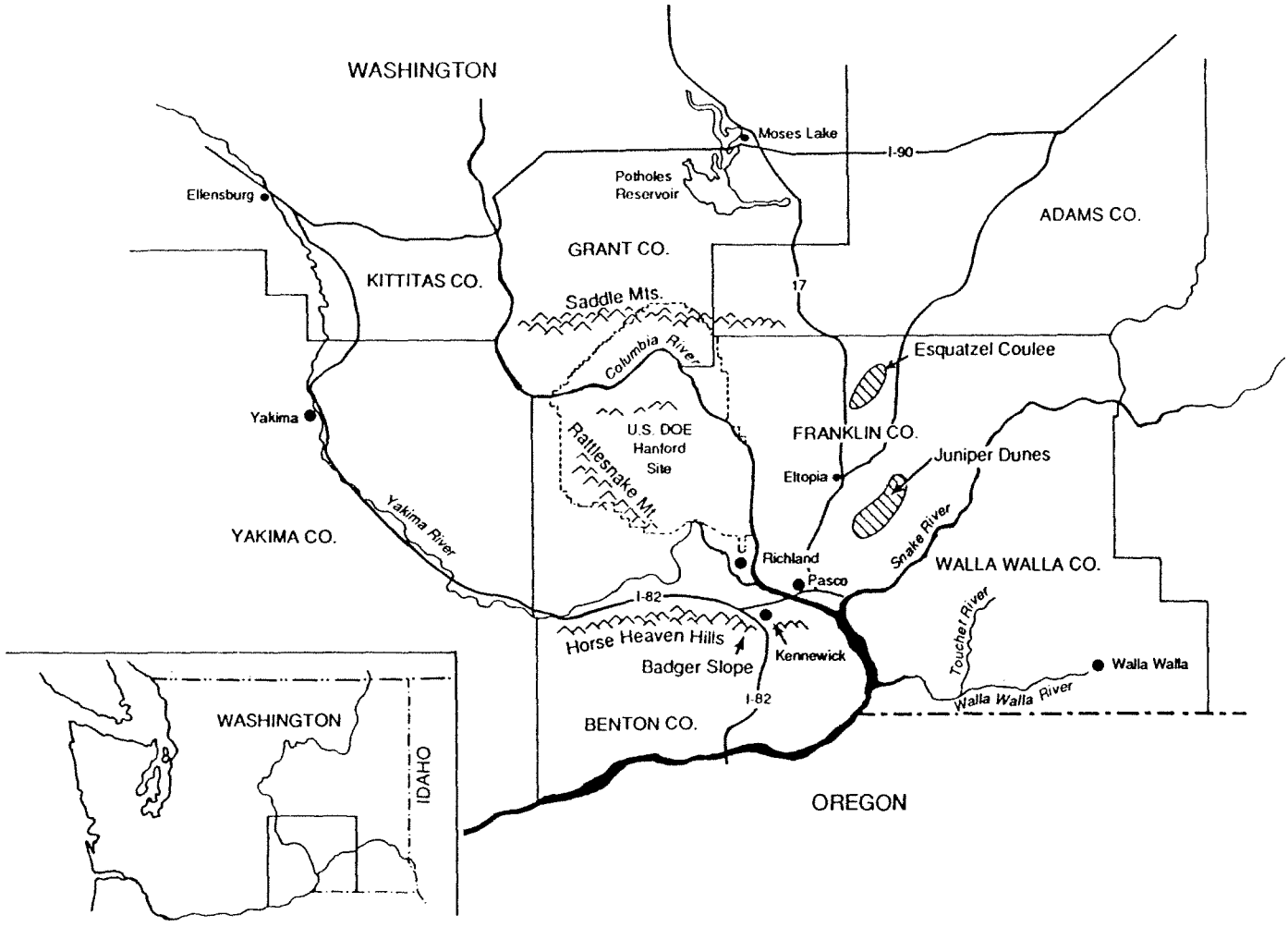


Figure 1. Southcentral Washington and the U.S. DOE Hanford Site.

in isolated spots around the site where they were planted as shade for industrial facilities and military installations now decommissioned. Black locust (*Robinia pseudoacacia*), cottonwood (*Populus* sp.) and Chinese elm (*Elmus* sp.) provide nest sites for several raptor species.

METHODS

Nest surveys were conducted yearly from the ground, by foot, vehicle and from the air by single engine aircraft. Surveys were generallly conducted twice each year, once during egg-laying (April–May) and once during the prefledging period (June–July). Species, location, status and type of nesting structure were recorded for each nest site.

RESULTS

Fitzner (1985) reported on nesting densities, habitat utilization and nesting substrates utilized by raptorial birds on the Hanford Site from 1975 through 1984. Figure 2 provides a summary of the number of nesting buteo hawks on the site since 1985. Ferruginous hawks have clearly increased from the usual one or two nesting pairs in the mid-1970s and early 1980s to four in 1987 and eight in 1988. Red-tailed hawk populations have remained relatively stable over the past decade but Swainson's hawks have increased since 1987. The Swainson's hawk seldom nests in transmission towers (Fitzner 1978). The recent increase of this species on the Hanford Site is related to an increased use of existing trees and the exploitation of trees that naturally invaded irrigated areas two decades ago and are now of an age and size capable of supporting the nests.

The increase in abundance of ferruginous hawks coincides with the influx of nesting birds around the Washington Public Power and Supply Systems (WPPSS) nuclear power reactors. Transmission towers erected to carry electricity from one of the completed reactors to the power network provided new nesting opportunities for the birds.

Construction of the transmission towers associated with the WPPSS reactors began in 1976. The ASHE-WHITE BLUFFS 230 Kv line and the ASHE-TAP TO DOE MIDWAY HEW No. 2, 230 Kv line were energized in

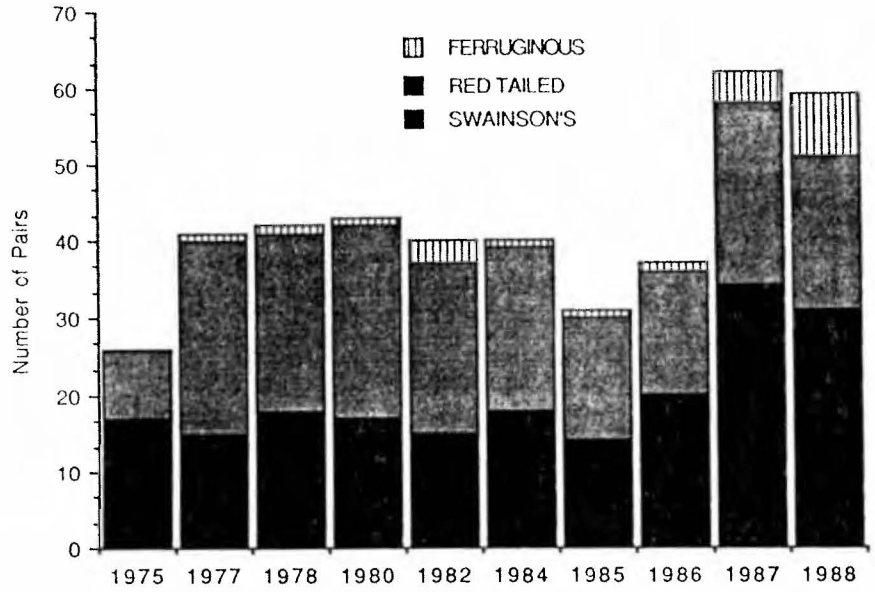


Figure 2. Territorial pairs of buteo hawks on the U.S. DOE Hanford Site 1975–1988.

December of 1976 . The LOWER MONUMENTAL ASHE 500Kv line was energized in December of 1978. The ASHE-SLATT 500Kv DOUBLE CIRCUIT was energized in December of 1980. A final line associated with the WPPSS reactors, the MIDWAY BENTON NO. 1 230 Kv was energized in July of 1981. Figure 3 provides a map showing the location of these transmission lines and Figures 4 and 5 are photographs of the 230 Kv and 500 Kv towers respectively. The 230 Kv towers are 84 feet high, with bases 24 feet across. Five horizontal- cross member supports occur at 35 feet above ground and form a platform 20 feet across. The 500 Kv towers are 136 feet high with one primary crossarm 51 feet 8 inches long occuring 95 feet above ground and two secondary crossarms.

The first nesting by raptors on any of these towers occurred in 1979 when a red-tailed hawk nested on the ASHE-WHITE BLUFFS line. This was three years after that line had been energized. By 1982, two pair of red-tailed hawks were found nesting on the same line. Another pair of red-tails were found nesting on the HANFORD-ASHE-TAP Line in the same year. The first raptor nesting to occur on the HANFORD ASHE 500KV line occured in 1983, five years after the line had been energized. The first raptor nesting (a pair of red-tailed hawks) on the LOWER MONUMENTAL-ASHE 500Kv line occured in 1984, six years after it was energized. The first ferruginous hawk nesting in a transmission tower occured six years after that line had been energized. Another nest was found at year 10 post-energization and three new nests were found in towers 11 years post-energization. Figures 6 and 7 provide a summary of the number of red-tailed and ferruginous hawk nests found in the transmission towers in relation to the age of the lines (i.e., years since energization). Table 1 provides a summary of the total number of red-tailed hawks, ferruginous hawks, Swainson's hawks and ravens nesting on transmission towers each year since 1979.

The 230 Kv tower used for nesting by the ferruginous Hawks is shown in Figure 8. Figure 9 demonstrates the typical arrangement of a stick nest on the five crossmember supports. All ferruginous hawk nests but one were built in the same location on the same type of tower. The nests were built 35 feet above ground in an 84 foot high tower on crossmembers that were 20 feet across. The odd nest constructed on a 500 Kv line was situated within a crossarm that was six feet wide and six feet high by 52 feet long, 100 feet above ground (Fig. 5).

DISCUSSION

Nesting of ferruginous hawks in Washington has primarily been associated with basalt cliffs and outcroppings and western juniper trees (*Juniperus occidentalis*) (Fitzner et al. 1977). Their presence on the U.S. DOE Hanford Site has been limited in the past to basalt outcroppings on the sidehills of Rattlesnake Mountain (Fitzner et al. 1981). It was not until 1987 that the first nesting was recorded at elevations lower than 2000 ft. In that year, four nests were located in transmission towers associated with the WPPSS reactors. All nesting occurred in 230 Kv towers and all nests were built in precisely the same location on the same type of tower (Figs. 8 and 9). In 1988, three more nests were found in transmission towers, and one was found in a tree, bringing the total number of nesting pairs to eight. The tree-nesting pair possibly tried to build a nest earlier in a nearby 230 Kv transmission tower, but abandoned it after high winds blew the nesting material from the tower.

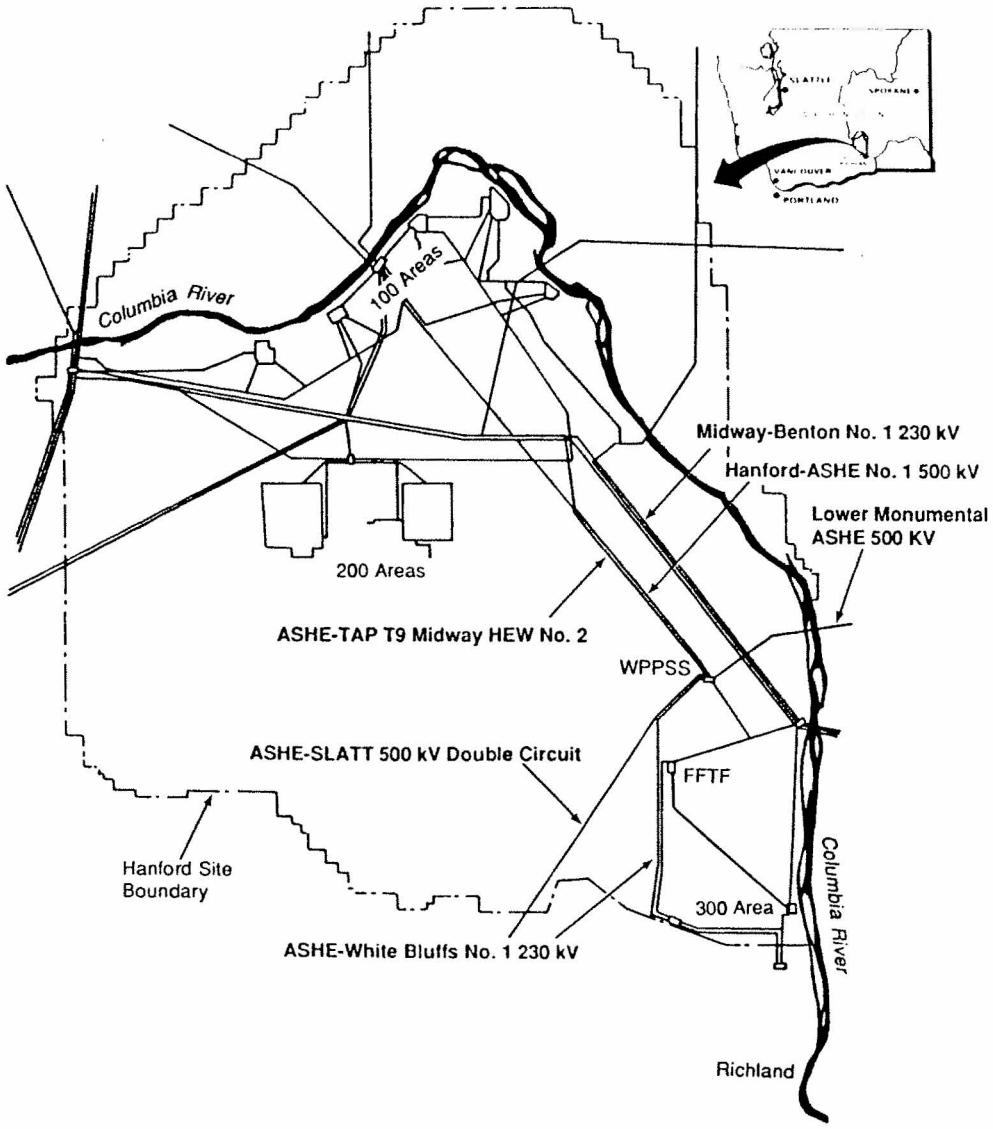


Figure 3. Hanford Site electrical transmission lines.

The increase in nesting pairs of ferruginous hawks may be related to an influx of birds that previously nested in nearby areas. Esquatzel Coulee and the Juniper Dunes in Franklin county and Badger Slope/Horse Heaven Hills in Benton Country (Fig. 1) could have supplied the stock populations from which the Hanford pairs emigrated. The Esquatzel Coulee and Juniper Dunes populations have both undergone recent population reductions. In 1985, five pairs of birds were found on territories in Esquatzel Coulee (Kelly McAllister, Personal Communication 1989). In 1988, only two pairs were found in the Coulee. In 1986, seven pairs of birds were found nesting in the Juniper Dunes (Lou Jurs, Personal Communication 1989). There were nine pairs found in the Juniper Dunes in 1987 and only five pairs in 1988. The influx of birds to Hanford corresponds to a drop in nearby populations.

The argument could also be made that the influx of ferruginous hawks to Hanford is simply due to an overall increase in population density of ferruginous hawks in Washington. Populations in the state have reportedly increased; however, this change may also represent an increase in survey effort. In 1981, 31 pairs of birds were found during intensive statewide surveys, 39 pairs in 1987, and 63 pairs in 1988 (Kelly McAllister, Personal Communication 1989). The birds now nesting on Hanford could be the young that were produced elsewhere and are now of breeding age. The evidence is more supportive of a local influx of adult pairs from adjacent areas. One piece of evidence for this claim is the presence of two pairs of dark-phase adults nesting on the Hanford Site. The dark phase is very rare in Washington and the only dark phase birds reported for the state have been from the Juniper Dunes.

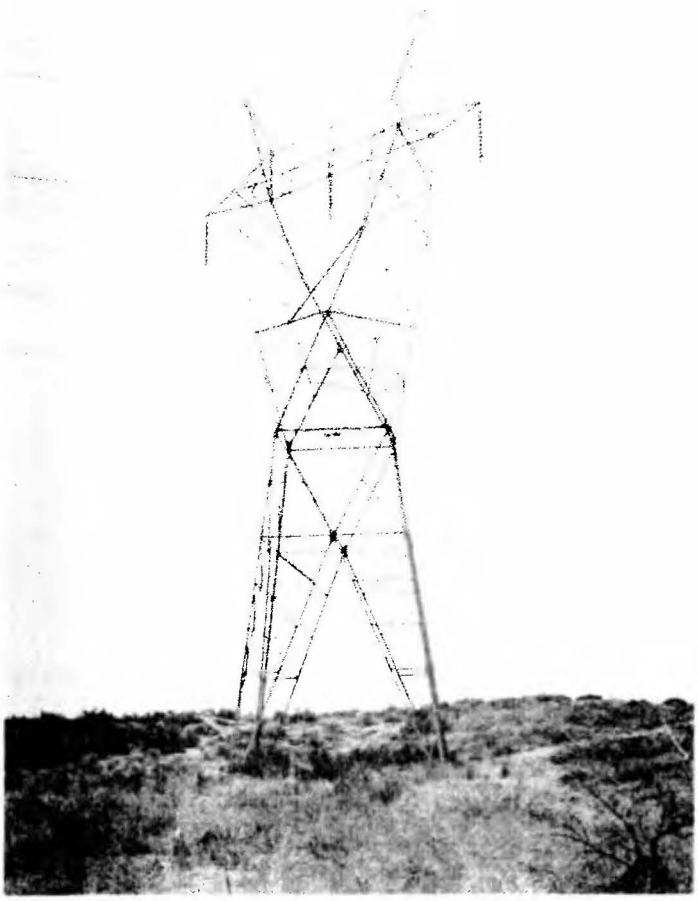


Figure 4. 230 Kv transmission tower used for nesting by ferruginous hawks.

Considering the rareness of this color morph in the population, it is likely that the dark birds at Hanford originated from the dark adults known from the Juniper Dunes.

It is likely that young produced in areas remote from Hanford would return to areas near their original nest site. Newton (1979) states that individuals normally return to breed near their hatching sites and that knowledge of the natal area is gained during the post-fledging period. This phenomena is the main premise behind the reintroduction of peregrine falcons (*Falco peregrinus*) to specific hack sites (Newton 1979).

Adults nesting in outlying areas would be imprinted to their ancestral nest site. Their movement to transmission towers on Hanford would require that they abandon their ancestral nest site, likely a cliff or tree, for an artificial situation. Transmission tower nesting is very scarce in Washington, and none has been reported even though intensive surveys have been conducted throughout the bird's range in Washington. The use of transmission towers may demonstrate that ferruginous hawks will readily accept these man-made structures if the tower configuration provides an adequate base for a large nest of sticks. The 230 Kv towers associated with the WPPSS reactors seem to provide a nest-site configuration acceptable to birds that previously nested in cliffs or trees. The occurrence of four pairs of ferruginous hawks nesting on Hanford transmission towers in 1987 and three more in 1988 is interesting indeed. Since ferruginous hawks and most large buteos probably don't reach breeding age until their third summer of life (Newton 1979), the three

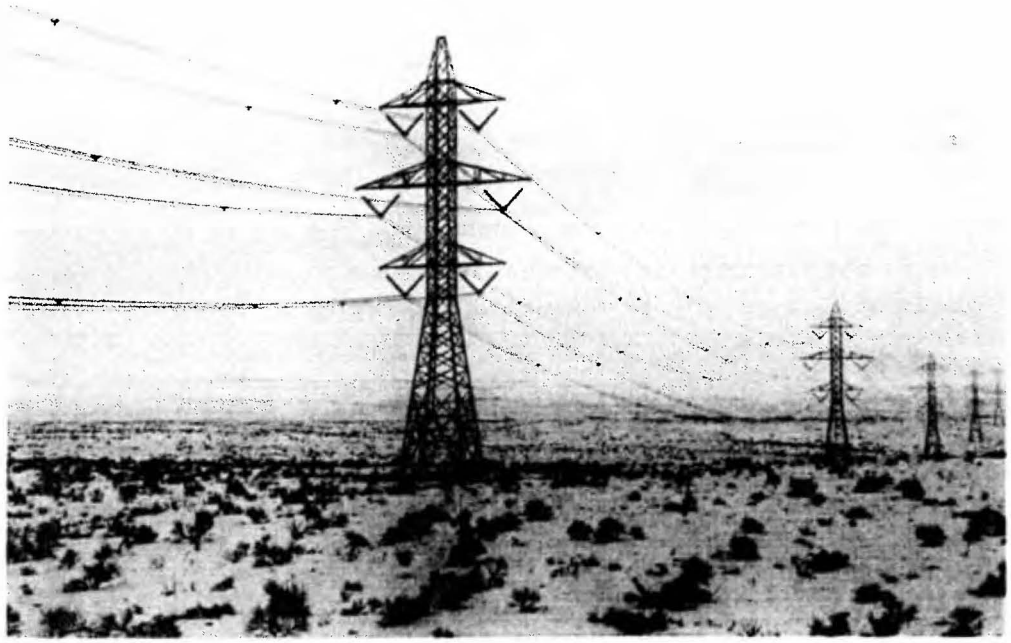


Figure 5. 500 Kv transmission tower.

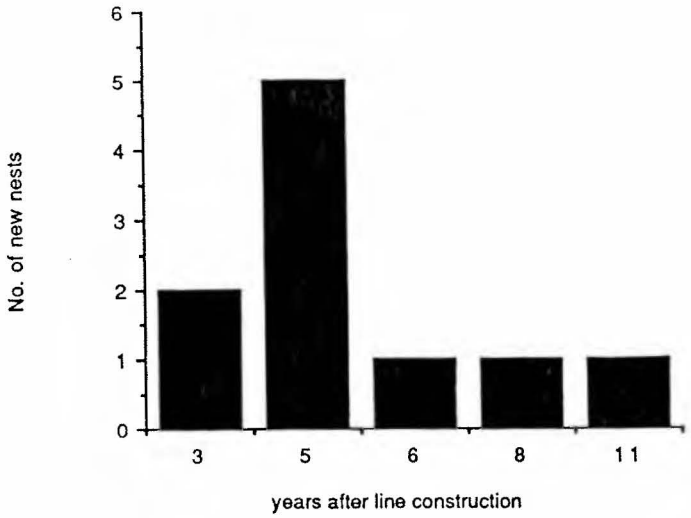


Figure 6. Number of new red-tailed hawk nests on transmission towers.

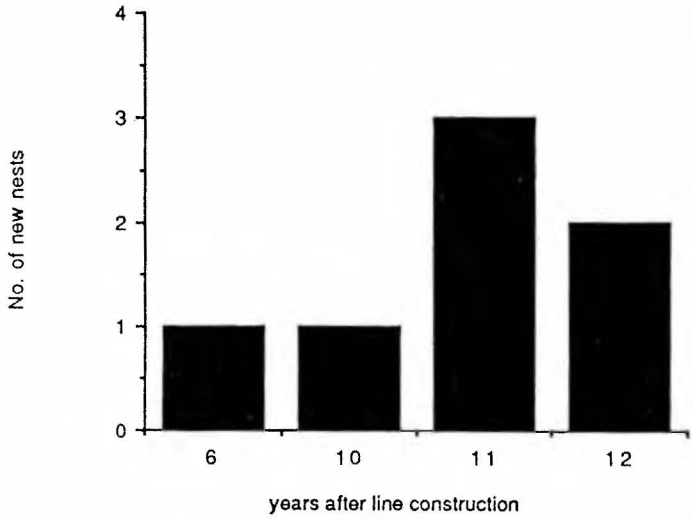


Figure 7. Number of new ferruginous hawk nests on transmission towers.

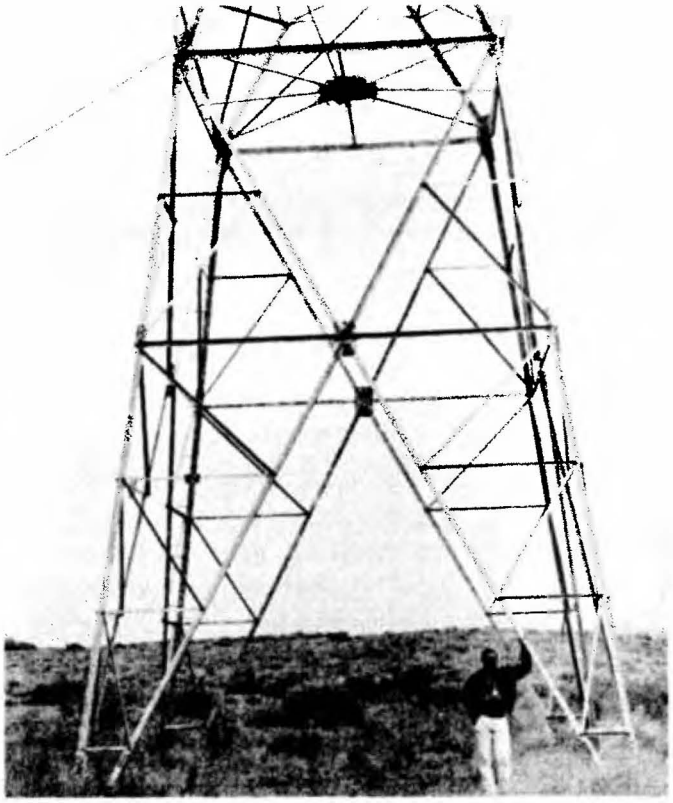


Figure 8. 230 Kv tower showing placement of a ferruginous hawk nest.

additional pairs nesting on towers in 1988 may represent an influx of outlying birds, not young produced on Hanford that would have been imprinted to tower nesting.

Perhaps the most interesting feature of this study was the finding that a definite lag period seems to exist between the time a transmission line is energized and the time that a raptor will nest in the associated towers. Figures 6 and 7 clearly demonstrate that red-tailed hawks, and ferruginous hawks don't immediately invade newly erected transmission towers for nesting. There is a lag time between energization

Table 1. Numbers of pairs of raptors and raven nesting on transmission towers associated with the WPPSS reactors.

Species	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Red-tailed hawks	1	0	5	3	5	6	6	10	11	6
Ferruginous hawks	0	0	0	0	0	0	0	0	4	7
Swainson's hawk	0	0	0	0	0	0	0	0	0	1
Common raven	0	0	2	2	1	1	3	3	6	5

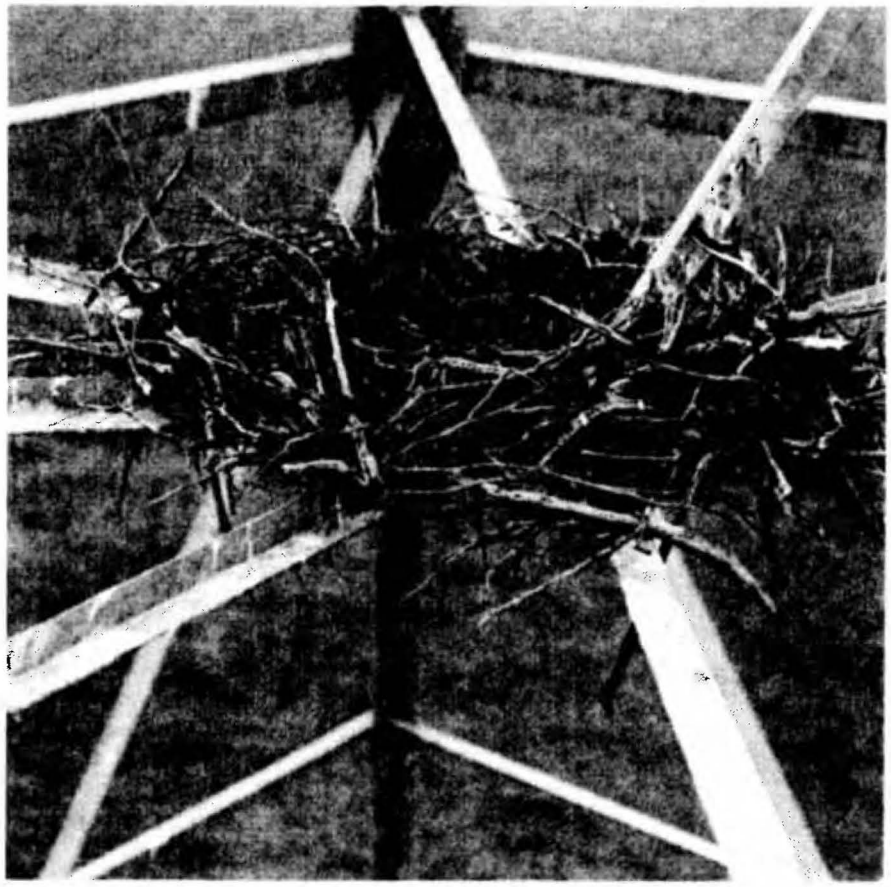


Figure 9. Typical arrangement of a ferruginous hawk nest on the crossmembers of a 230 Kv tower.

and acceptance of the towers. For red-tailed hawks, the time period varies from a minimum of three years to an average acceptance time of about five or six years. The minimum time between energization and use for nesting by ferruginous hawks was six years with three pairs moving into the lines at 10 years post-energization and two more pairs moving in at 11 years post-energization.

The 230 Kv towers are apparently attractive as nesting sites for ferruginous hawks. Only one problem is associated with the use of these towers. Even though the crossmembers forming the support for the nests provide a sturdy base, they don't provide any vertical supports to hold the nests in place during high winds. The addition of a nest basket, firmly anchored in the center of the crossmembers would insure that the nest would not blow out. Also, if a pre-constructed nest was provided in the nest basket, this would likely attract birds to nest in the future. In areas where construction projects remove or destroy wildlife habitat, transmission towers (properly altered) may prove to be a useful tool to help mitigate effects of human activities on raptors.

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THE EFFECT OF RECREATIONAL ACTIVITY ON ELK USE AND DISTRIBUTION ALONG A PIPELINE RIGHT-OF-WAY

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Abstract: The response of elk to recreational activity along a pipeline right-of-way was studied from September 1984 to December 1985. The study area is located in west-central Alberta, approximately 80 km northwest of Rocky Mountain House.

Seven elk were trapped and fitted with radio collars and monitored by ground triangulation and aerial location from September 1984 to March 1985. Five Super 8 mm movie cameras were modified to expose a single frame every three minutes and were placed along the right-of-way to record human activity as well as elk utilization. Track counts were used to determine habitat preference by elk and also to determine the influence of human activity along the right-of-way on elk distribution.

Data indicate that elk use of habitats adjacent to the right-of-way was affected only marginally by human activity along the right-of-way. However, elk use of the right-of-way declined dramatically during periods of intense recreational activity. Elk used the right-of-way as a feeding area during all times of the year and showed a preference for areas where human activity was lowest. People used the right-of-way as an access route and as a staging area from which they ventured into areas remote from the right-of-way. People activity was greatest in the fall period and was centered on the hunting season. Elk distribution in relation to activity along the right-of-way is affected by the type of cover available, weather conditions, time of year and the duration and intensity of human activity.

It is suggested that pipeline rights-of-way provide elk with unique high quality feeding areas. The availability of these areas to elk during elk during critical periods of the year is affected by human activity along the right-of-way. If elk are to take advantage of these areas without high expenditures of energy, the wildlife managers should develop means of controlling use of these areas by humans.

Key words: Recreational activity, elk, distribution, pipeline, habitat.

INTRODUCTION

In the mid 1970s concern was expressed regarding the impacts of oil and gas development on wildlife populations, particularly in northern environments. Research into the effects of disturbances specific to the petroleum industry is limited. Klein's (1973) review of the impact of oil development on northern environments showed that the construction of pipelines, roads, and railroads pose threats to the free movement of caribou. Development of temporary winter roads have been known to disrupt normal migration movements of caribou. This is particularly serious as traditions in movement of caribou are maintained by learning in young animals as they accompany older animals in their migration. Obstructions to movements resulting in delays or failures of animals to reach calving or seasonal ranges can affect future distributions, result in range abandonment, and reduce the overall population level. Geist (1975) provided a detailed review of available literature on the effects of harassment of large mammals related to energy development in the arctic region of North America.

Bergerud et al. (1984) have shown that many of the presumed impacts of oil and gas development on northern caribou herds have not occurred. Their study of demography of eight caribou herds revealed increasing populations despite intense oil and gas development. Declines in specific caribou populations were a result of overhunting and predation. The presence of roads, pipelines, power lines, and other man-made features did not affect caribou population numbers. Increased harvest, as a result of improved access, and predation appear to be the key factors regulating caribou populations.

Every activity involved in oil and gas development is contingent on the development of access, either temporary or permanent. Access and associated activities have been identified as major factors in alienation of habitat and over-exploitation of some wildlife populations (PRISM 1984, Hershey and Leege 1976). Increased elk (*Cervus elaphus nelsoni*) harvest and the subsequent decline in elk populations have both been directly linked to increased hunter success as a result of road development in important elk habitat (Leege 1976, Thiessen 1976). Similar findings have been reported by Lynch (1973) for moose (*Alces alces*), and by Pendergast and Bindernagel (1977) for mountain goat (*Oreamnos americanus*).

The access problem is a complex issue involving licensed hunters, year-round native hunting, and recreational use of access routes for off-road travel with trail bikes, ATVs, 4x4s, and snowmobiles. These factors result in increased disturbance of wildlife and a higher wildlife kill, both legal and illegal. The increasing network of roads, seismic liens and pipeline rights-of-way (RsoW) and the uncontrolled use of them by the public remains a major problem in wildlife management (PRISM 1984). In many instances, wildlife managers have been forced to adopt special regulations to govern hunting (Stubbs and Markham 1979), or to implement land-use regulations that require companies to regulate use of their access routes (Bromley 1985, PRISM 1984, Stubbs and Markham 1979). To date there is no published literature on the success of these measures in protecting wildlife.

This research investigated the response of elk to recre-

ational activity along a pipeline right-of-way (RoW) using three different approaches: telemetry, time-lapse photography, and track counts. Elk were chosen for this study because they are the most abundant ungulate species in the study area, and when disturbed, travel long distances (Altmann 1956, Geist 1982). Consequently, they provided more information on the affect of human activity on their movements and distributions, than deer, for instance. Their numbers provided for greater opportunities for successful trapping and collaring of study animals. There are approximately 15,000 elk in Alberta, with a management goal of increasing this population to 30,000 (AENR 1984). Elk are also a highly sought-after and economically important big game animal. In Alberta during 1981, elk hunters spent 357,000 person days and an estimated 13 million dollars in pursuit of this animal (Adamowicz and Phillips 1984).

Pipeline RsoW provide a means of access into relatively remote portions of wildlife range, and provide a unique component of elk habitat that is not used by elk because of high levels of human activity. One of the objectives in expanding the elk population in Alberta is to eliminate or minimize killing and harassment outside of the hunting season (AENR 1984). One way of meeting this objective is to determine the influence on elk of increased access caused by pipeline development in remote portions of elk range.

This project was fully supported and financed by NOVA Corporation of Alberta (NOVA). The Alberta Fish and Wildlife Division provided certain equipment for the field portion of the study. The support of both these organizations is gratefully appreciated. Dr. A. W. Fedkenheuer deserves special recognition for encouraging and supporting this study. B. Lunseth, M. Thornton, J. Townsend, and B. Andrews assisted in the collection of field data.

STUDY AREA

To meet the objectives of this study it was necessary to find a study area that: had a limited amount of road access; was transected by a pipeline RoW; was located such that it could be easily accessed by a large number of people; had a resident elk population; and had hunting that was not restricted by special license or season.

The study area, located at latitude 52°30' and longitude 115°50', is centrally located within a 2 to 2.5 h drive of Edmonton or Calgary (Fig. 1). It is transected by a wide RoW owned by NOVA and has a resident elk population, with hunting not restricted by special license or season. Road access is limited to a single road.

Vegetation within the study area consists of the following cover types: coniferous dominated (44%), deciduous dominated (9.2%), mixed coniferous/deciduous (24.9%), treed muskeg (18.3%) and grasslands (3.6%).

NOVA's pipeline was originally constructed 1965 and subsequently looped in 1970. The RoW is approximately 38 m wide by 8,900 m long. Since the original construction,

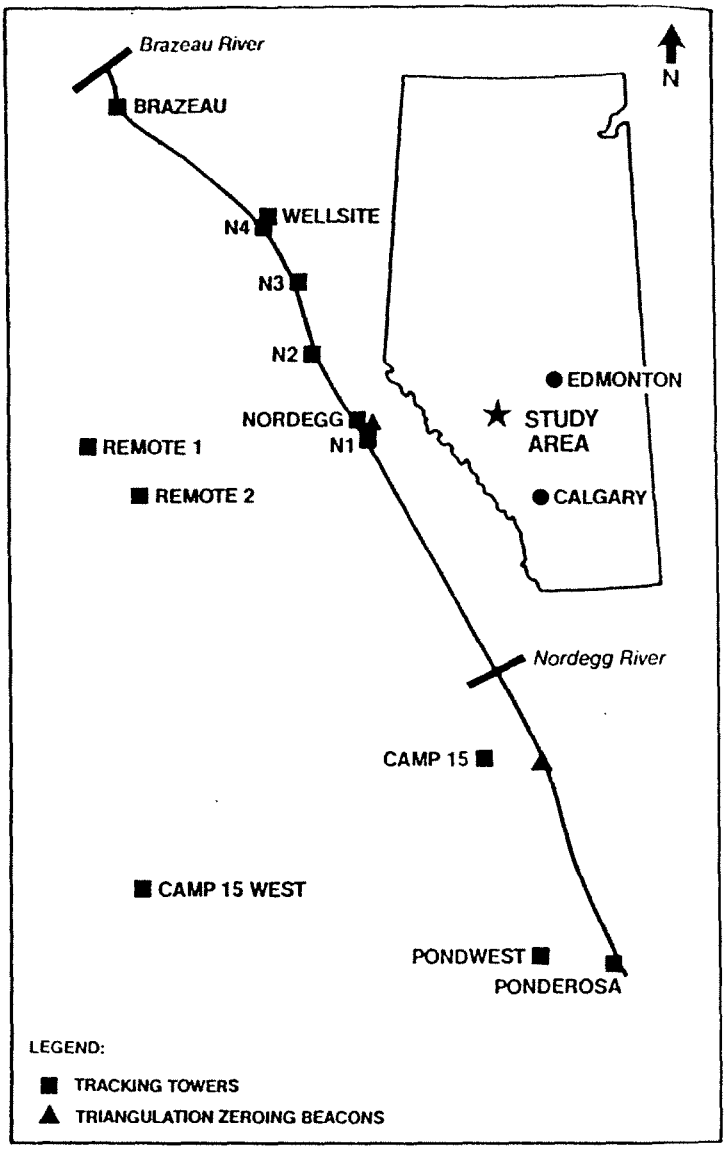


Figure 1. Study area location and detail of RoW with tracking tower locations.

the study area has been subjected to timber harvest, seismic activity, wellsite development and pipeline construction. In 1965 only two seismic lines crossed the RoW, but by 1984 the number of lines had increased to 11. In addition, two wellsites have been constructed within 400 m of the RoW. This increase in oil and gas activity has resulted in the development of access routes into this previously inaccessible wildlife habitat. The development of seismic lines and wellsites has modified the habitat within the study area by increasing the amount of edge and the availability of highly palatable agronomic grass species. These changes in habitat may have changed elk numbers and distribution within within the study area.

The study area lies within Wildlife Management United (WMU) F328, and utilization of the wildlife in this area is

mainly in the form of hunting. The hunting season for ungulates generally opens in mid-September and closes at the end of November. Black bear (*Ursus americanus*) are hunted in the spring and fall seasons, while grizzly bear (*Ursus arctos*) are hunted only in the spring.

Little information is available on recreational use of the study area. Hunting, fishing and camping occur during the spring to fall period. Winter recreational activities are snowmobiling and cross-country skiing (personal observation). Undoubtedly other activities such as berry picking and woodcutting also occur.

METHODS

Seven elk were trapped in four clover traps baited with salt, placed near the RoW. Captured elk were immobilized with an injection of Xylazine Hydrochloride (Rompum, 100 mg/L), administered through a dart fired from a Pneu-dart rifle. Once elk were captured and immobilized radio-transmitter equipped collars (150-151 MHz, Wyoming Biotelemetry) were fitted around the neck of the animals.

Ground telemetry of radio-collared elk was done using Telonics Inc. RA-NS Precision DF Antenna Systems. Antenna arrays were pairs of two-element H antennas, and four or five element Yagi antennas mounted on 10.7 meter-high towers located throughout the study area. A portable 3.7 meter-high tower was mounted in the box of a 3/4 ton 4x4 truck.

Once the antenna systems were built and installed on the towers, the systems were zeroed to a reference beacon and all subsequent readings were in relation to this beacon. The transmitted signals were received using Telonics TR-2 receivers.

Transmitted signals were received simultaneously from either two or three tracking-tower locations. Readings were taken every two hours, starting at 0500 hours and terminating at 2100 hours on Friday and Saturday. From September 18, 1984 until October 31, 1984 two tower locations were used. Three tower locations were utilized November 1 to December 1, 1984 and during the once-monthly tracking periods from December 1984 until March 1985.

Time-Lapse Photography

Five Sankyo EM-40XL Super 8 mm movie cameras, power by six-volt batteries, were modified to expose a single frame approximately every three minutes. Built-in light meters switched the cameras "on" and "off." The cameras switched on 10 minutes past sunrise and shut off when light conditions were unfavorable, generally about one-half hour past sunset.

Eight locations were chosen for collecting data on human and elk activity along the RoW (Fig. 2). Initially, cameras C6, C7 and C8 were to be alternated on a two week basis between locations 3 and 6, 4 and 7, and 5 and 8, respectively, but equipment and batter failure made it impossible to continue this format. Instead, cameras were set up at locations 1, 2, 6, 7, and 8. In 1985 a sixth camera was added so that camera location 5 could be sampled over the same period as in 1984.

Developed films were viewed using a Lafayette Instrument Company Model 925 single frame analyzer. The number of people, vehicles, ATVs and elk observed on each frame were counted and recorded on data sheets.

Track Counts

Six transect lines were established perpendicular to, and placed systematically along, the RoW. The first transect was chosen randomly within the first 500 meters of the RoW and subsequent transects were spaced every 1600 meters on alternate sides of the RoW. The transects were originally planned to be 1000 meters in length. The Nordegg and Brazeau rivers prevented transects 1 (700 m) and 6 (925 m) from being this length. Transect 5 was only 925 m because of an error in measurement.

Each transect line was subdivided into 25-meter sections. Within each section the major forest cover types were classified as conifer, mixed conifer/deciduous, deciduous, grassland or treed muskeg. Ungulate tracks were recorded for each 25-meter section, and if possible, tracks were identified to species. Where species could not be determined the tracks were assigned an unclassified rating. Only tracks crossing a transect were counted, although no attempt was made to determine the fate of a set of tracks. Consequently, an animal could easily be counted more than once should it cross the transect again, or cross another transect. If a group of animals crossed the line and the number of animals could not be determined, then the crossing was classified as a trail. After each set of tracks were recorded they were obliterated to prevent counting on subsequent sampling dates.

Three sampling periods were established to coincide with periods of high and low recreational activity. Track counts were done on November 28, and 29, 1984 to correspond to the period of high recreational activity, while track counts were done on January 24, 1985 and March 5 and 5, 1985 to correspond to the period of low recreational activity. There was no attempt to conduct track counts within a specified period after a snowfall, although this would have been ideal.

Data Analysis

All data were tested for normality using the Kolomogorov-Smirnov one-sample test (Zar 1984). The data were found not to be normally distributed. Consequently, nonparametric statistical procedures were used for subsequent data analysis, namely the Mann-Whitney U-test (M-W), the Kruskal-Wallis (K-W) test, the Kolomogorov-Smirnov two-sample test (K-S 2) and the chi-square (χ^2) test (Siegel 1956, Zar 1984).

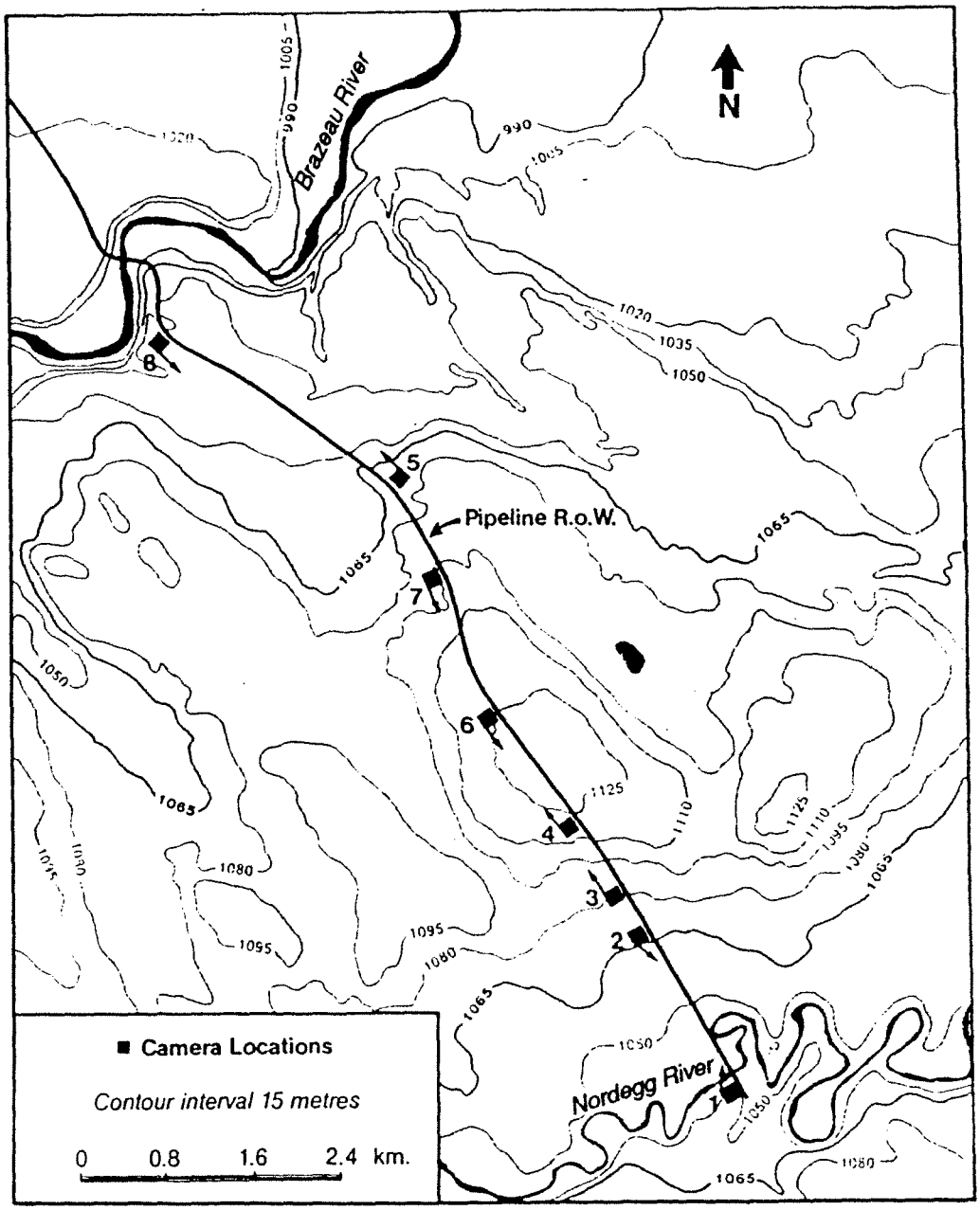


Figure 2. Camera location and direction of view along the RoW.

Triangulation Data

Telemetry data reduction was done using a triangulation and mapping program developed by the Computer Services Department at the University of Calgary. The triangulation data were also grouped into disturbed and undisturbed categories. The disturbed category corresponded to the period of greatest human activity, September 16 to December 2, 1984. The undisturbed category was from December 11, 1984 to March 21, 1985.

Time-lapse Photography Data

Observation time was defined as the camera exposure interval for each frame multiplied by the number of elk, people, vehicles or ATVs observed on each frame. Observation time was expressed as a ratio of observation time for each activity for a specified period divided by total exposure time for that period. Because of variations in day-length between days, months and seasons it was necessary to make comparisons between sunrise and sunset periods. Comparisons of time-lapse photography ratios were made between disturbance categories.

Track Count Data

Only track data recorded within the first 700 m from the

RoW were used for comparative purposes and for statistical analysis. In addition, the length of time between sampling periods was not equal, consequently, the November and January data were multiplied by 0.9524 and 0.8163, respectively, to adjust the data to an equal length of time between sampling periods. In conducting the track counts in this manner the following assumptions were used: (1) there were no snow falls between sampling periods that obliterated elk tracks, (2) the number of tracks observed is an accumulation of tracks over an equal time period, and (3) the number of tracks observed are randomly distributed throughout the time period between sampling dates.

RESULTS

Time-Lapse Photography

The use of cameras at six different locations during this study resulted in exposure of 279,753 frames of film, and a total observation time of 15133.70 hours. Camera 8 (C8) accounted for the highest percent of the total observation hours. At this camera location people, vehicle and ATV activities were lowest, while elk activity was highest. Camera 5 operated for the shortest period but recorded the highest levels of people, vehicle and ATV activity and the second highest level of elk activity along the RoW.

People, vehicle, and ATV activity accounted for 0.34, 1.94, and 0.09% of total observation hours, respectively, while elk activity accounted for 0.30%.

Periods of greatest human use of the RoW occurred during the fall (September 15 to November 30) hunting seasons of 1984 and 1985 and during May 1985. Approximately 91% of the people activity, 88% of the vehicle activity and 89% of the ATV activity occurred during these periods at camera locations C1, C2, C6, C7, and C8. Sixty-four percent of the people activity, 74% of the vehicle activity and 71% of the ATV activity recorded during these dates occurred at the C1 location.

Table 1. Comparison of the ratios of observation time for elk, people, vehicles and ATV's to total observation tiime between disturbed (Sept. 16 to Dec. 2, 1981, and Sept. 16 to Nov. 30, 1985) and undisturbed (June 1 to Sept. 15, 1984, Dec. 3, 1984 to Sept. 15, 1985, and Dec. 1 to 31, 1985) categories by camera location.

Camera location	Disturbed vs. Undisturbed Categories (P-values)[1]			
	Elk	People	Vehicles	ATV
C1	0.6681	0.0001	0.0001	0.0001
C2	0.1155	0.0001	0.0001	0.0001
C5	ND[2]	ND	ND	ND
C6	0.0372	0.0001	0.0001	0.1041
C7	0.0025	0.0001	0.0001	0.0097
C8	0.0001	0.0002	0.0007	0.8231

[1]Mann-Whitney U-test using each day's data.
[2]ND indicates that no data were available for comparing disturbance categories.

Observation times for people and vehicles were higher in the disturbed period and were significantly different between disturbance categories (Table 1).

Higher levels of ATV activity were not observed at all camera locations as might have been expected based on the observations for people and vehicle activity. Significant differences observed at locations C1 and C2 are probably related to these areas being near the only access point along the RoW, consequently human activity is likely to be greater at these locations.

People and vehicle observation times were greater in the disturbed versus the undisturbed period for most activity periods at all camera locations. The differences observed suggest that hunters spend a considerable amount of time hunting on foot or driving along the RoW. Since the use of ATVs for hunting is prohibited by law before 12 noon during the hunting season, it was not surprising to find any difference between disturbed and undisturbed categories for sunrise activity period at all camera locations.

Observed elk activity along the RoW was classified into feeding, standing/walking and bedded activities. Feeding accounted for 71%, standing/walking 8% and bedded 21% of the elk activity.

There was no difference between disturbed and undisturbed categories for elk observation time at locations C1 and C2. Elk observation time at locations C6, C7, and C8 was significantly different between disturbance categories with elk use being higher in the undisturbed period. The higher levels of elk use at these locations in the undisturbed period may be related to the relatively low levels of human activities during this period recorded on the RoW.

The high level of elk use recorded at location C8, may reflect the physical condition of the RoW at this location. The pipe through this section of the RoW is not buried in a trench but has been placed on the soil surface and then covered with soil. Consequently, there is a high pipeline roach that has been seeded to a mixture of grasses and legumes. Elk may have been attracted to this area because of the grass/legumes growing on the roach and the fact that it is almost snow free during the winter due to heat loss from the pipe, melting the snow. Elk were observed feeding along the pipeline roach during spring and winter seasons.

Elk Movements

The triangulation data were categorized into observations occurring within 1600 m and greater than 1600 m from the RoW. This distance has been suggested as the maximum distance at which elk are likely to be affected by human disturbance (Marcum 1975, Perry and Overly 1976, Ward 1984, Ward et al. 1980).

Locations of radio-collared elk at distances greater than 1600 m accounted for 56.5% of all locations. Sixty-eight percent of the locations of elk were obtained from September to December, 1984, while the remaining 32% occurred during the period January to March, 1985. Locations within 1600 m of the RoW during the period of greatest human activity (September 16 to December 2, 1984) accounted for 41.3% of all the readings taken during this period. Elk were located within 1600 m of the RoW 50.5% of the time during the period of least human activity (December 11, 1984–March, 1985).

The triangulation data were grouped into disturbed (September 16 to December 2, 1984) and undisturbed (December 11, 1984 to March, 1985) categories. Three of the six elk were significantly different between disturbance categories in distance from the RoW, indicating that all elk were not affected by the higher levels of human activity during the disturbed period (Table 2).

Table 2. Comparison of distance from the RoW between disturbed (Sept. 16 to Dec. 2, 1984) and unidsturbed (Dec. 11, 1984 to March 21, 1985) categories by individual radio-collared elk.

	Disturbed vs Undisturbed[1]
Animal	P>|Z|
Cow elk 1	0.0527
Cow elk 2	0.0001
Cow elk 3	0.0625
Cow elk 4	0.0001
Cow elk 5	0.9804
Cow elk 6	0.0001

[1]Mann-Whitney U-test, using each day's data.

Track Counts

A total of 598 tracks of all ungulate species were recorded during the sampling periods, of which elk accounted for 65.7%. The highest percentage of elk tracks occurred during the January and March sampling periods (Table 3).

Table 3. Number of elk tracks observed during sampling periods from November 1984 to March 1985.

Sampling Date	Number of Tracks			
	elk	other ungulates	total tracks	elk (%)
November 1984	102	18	120	85.0
January 1985	145	147	292	49.6
March 1985	146	40	186	78.5
Total	393	205	598	

The distribution of distance of elk tracks from the RoW in the November sampling period was not different from the January sampling period but was significantly different from the March sampling period (K-S 2, $D_{max} = 0.2753$, $P < 0.05$). The distribution of elk tracks in January was significantly different from the March sampling period (K-S 2, $D_{max} = 0.2792$, $P < 0.05$).

The track data were grouped into the number of elk tracks occurring within 0 to 350 m and 350 to 700 m from the RoW for each sampling date (Table 4). If elk were responding to lower levels of human activity by moving closer to the RoW, then the number of elk tracks observed should be greater at closer distances to the RoW during the January and March 1985 than November 1984.

Table 4. Summary of the number of elk tracks observed within 0 to 350 m and 350 to 700 m from the RoW for each sampling period.

Distance from RoW	November (1984)	January (1985)	March (1985)
0 to 350	58	84	53
350 to 700	44	61	93
Total	102	145	146

The distribution of elk tracks was independent of the two distance categories when November track data were compared with January data ($\chi^2 = 0.024$, $P > 0.05$). When the November data was compared with the March data, the distribution of elk tracks was different between distance categories ($\chi^2 = 10.27$, $P < 0.001$). It appears that the greater frequency of elk tracks at distances beyond 350 m in March contributed to this difference. A comparison of January data with March data revealed that the distribution of elk tracks was different between distance categories ($\chi^2 = 13.60$, $P < 0.001$). The high number of elk tracks observed within 350 m of the RoW in January and the greater number observed at distances greater than 350 m in March may account for this difference. Cover was considered an important element in determining the distribution of elk in relation to the RoW. Determination of percentages of cover types on all transects combined showed that conifer accounted for 42.8, deciduous 3.0, grassland 5.4, mixed conifer/deciduous 32.1 and treed muskeg 16.7.

The mixed cover type showed a steady increase in the percentage of elk tracks observed for the November, January and March sampling periods (33.3, 42.1, and 45.9%, respectively). The grassland cover type showed a significant change in number of elk tracks among sampling dates (K-W, $H = 15.10$, $df = 2$, $P < 0.0005$). All other cover types showed fluctuations in the number of elk tracks observed among sampling dates, but none were significant (Fig. 3).

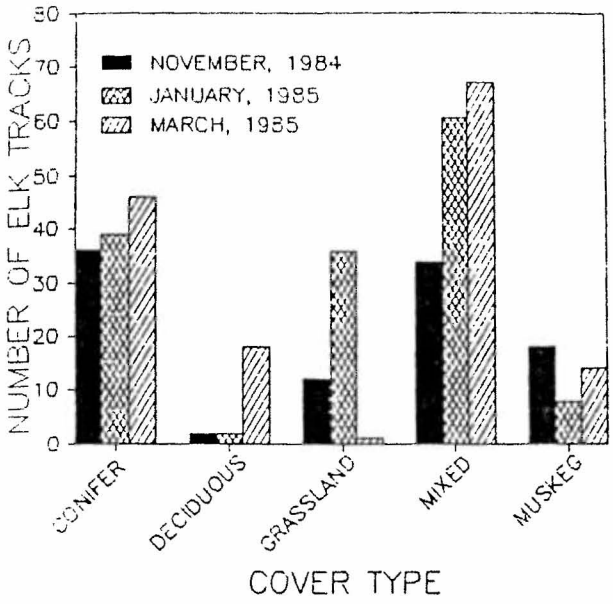


Figure 3. Total number of elk tracks observed, within 700 m of the RoW, by cover type for individual sampling periods.

The distribution of elk tracks in the November, January and March sampling periods was dependent on cover and location ($\chi^2 = 12.076$, $P < 0.007$; $\chi^2 = 35.297$, $P < 0.001$; and $\chi^2 = 8.118$, $P < 0.044$, respectively). Some caution must be used in interpreting the results of the January and March chi-square tests as 25% of the cells had expected frequencies of less than 5.

Elk use (% of total elk tracks, Table 5) of individual cover types was in proportion to the availability of each cover type in November ($\chi^2 = 3.92$, $P > 0.43$) but not in January ($\chi^2 = 34.06$, df = 4, $P < 0.001$) or March ($\chi^2 = 23.14$, df = 4, $P < 0.001$).

Table 5. Comparison of percent expected elk use versus percent observed elk use of cover types for November, January, and March track transect sampling periods.

Cover Type	%(A)[1]	November %(U)[2]	January %(U)[2]	March %(U)[2]
Conifer	42.8	35.3	26.2	31.5
Deciduous	3.0	2.0	1.4	12.3
Grassland	5.4	11.8	24.8	0.7
Mixed	32.1	33.3	42.1	45.9
Muskeg	16.7	17.6	5.5	9.6

[1]Percent of total area represent expected elk observation values as if elk occurred in each cover type in proportion to availability.
[2]Percent of utilization of each cover type by elk.

DISCUSSION

Human Activity along the Pipeline Right-of-Way

The difference observed between disturbance categories was related to the high levels of people, vehicle and ATV activity associated with the fall hunting seasons. Hunters appear to spend a considerable amount of time either walking or driving along the RoW. The Wildlife Act prohibits the use of ATVs during the hunting seasons prior to 1200 h, thereby contributing to the lower levels of ATV use observed. In addition, RoW ground conditions during the fall allowed for travel with either two or four wheel drive vehicles. Consequently, the need to use ATVs was reduced. Hunters appeared to use ATVs for accessing areas away from the RoW rather than actually travelling the RoW.

The more accessible portions of the RoW (locations C1, C2, C6 and C7) were subjected to high levels of people and vehicle activity throughout the day during the hunting seasons. The least accessible portion of the RoW (location C8) received relatively low levels of people and vehicle activity, with people observation time being more in the sunset activity period and vehicle activity being greater only during the sunrise activity period.

No statistical comparisons could be made between locations along the RoW since camera exposure, field-of-view and operational period were not the same for each camera. However, some general observations can be made. Location C1 was confirmed as a major entry point into the study area and gives an idea of the number of hunters that use the RoW as an access corridor through the study area. The majority of human activity occurred at locations C1 and C5 accounting for 93% of the recorded human activity. Location C5 appeared to be a major staging area from which hunters dispersed into areas remote from the RoW. Location C8 received the lowest amount of human activity because it was the least accessible point along the RoW. This also indicates that hunters used the RoW as a base from which they hunted adjacent habitats rather than actually hunting along the RoW.

Elk Distribution

All of the radio-collared elk used in this study included the RoW as part of their home range. However, some animals stayed closer to the RoW than others. Fifty-six percent of the locations of radio-collared elk were at distances greater than 1600 m from the RoW. Aerial tracking of the radio-collared elk showed some to be located as far as 12 km east of the RoW.

The distance radio-collared elk stayed from the RoW was highly variable for individual elk, and the distance kept from the RoW between disturbed and undisturbed periods was significantly different for only three of the six elk. A very

high proportion of recordings of radio-collared elk were from only two tower locations. These were assumed to be at the intersection of two bearings, but they were actually located somewhere within an error polygon. Consequently, the radio-collared elk could be closer or farther from the RoW than indicated. Furthermore, the size of the triangles formed from three tower locations were highly variable both for observations within 1600 m and greater than 1600 m from the RoW. Since elk response appeared variable, and a high proportion of recordings were from two tower locations, and the size of triangles formed from three tower locations were quite large, the hypothesis that the distances of radio-collared elk from the RoW are independent of the level of people, vehicle or ATV activity was accepted.

Analysis of the track data showed that the distribution of elk tracks was not different between the November and January sampling periods but was different between November and March, and January and March. If elk were responding to lower levels of human activity along the RoW in January and March then the distribution of elk tracks would be expected to be different compared to the November sampling period. Since only November to March comparisons were different, elk distribution was probably being influenced by other factors besides human activity along the RoW. Cover type was likely an important element in determining the distribution of elk tracks. During the November sampling period all cover types were used in proportion to their availability. With the high levels of human activity observed in November, cover types providing escape, such as conifer and treed muskeg, would be expected to show higher levels of use (Lyon et al. 1985, Ward 1984, Redgate 1978). Other factors such as snow depth, air temperature, wind and predators may also be contributing to elk use of conifer and treed muskeg cover types (Burbridge and Neff 1976). These were used almost in proportion to their availability. During the January period, elk use of the conifer and muskeg cover types was lower than November, suggesting the elk may be responding to lower levels of human activity by using escape cover less frequently. Also, the high levels of use observed for the grassland cover type suggest elk were more willing to use open habitat types in the absence of human activity, although other factors may also be involved. The very low levels of use for the grassland cover type in March, 1985 were probably a response by elk to a change in snow conditions. Chinook weather during February melted the snow surface, causing a hard crust to form. That may have made feeding difficult, resulting in elk abandoning this cover type for more easily accessible forage.

Other studies have found highly variable responses by elk (Lyon 1979, Perry and Overly 1976, Schultz and Bailey 1978, Thomas 1979, Ward 1976, 1984, Ward et al. 1980) to people and vehicle activity on roads and adjacent habitats within important elk range. In these studies, elk response to human activity has been shown to be influenced by cover, snow and the type of human activity. In this study, it seems that human activity may have influenced elk use of different cover types (Table 5). With the high levels of human activity observed during the fall, elk preferred to use cover types providing escape. In the absence of human activity (January, 1985), elk use of habitat types that provided escape cover decreased (Table 5).

Elk Activity along the Pipeline Right-of-Way

Elk activity observed along the RoW was not equal at all locations. At locations C1 and C2 elk activity was low during most times of the year. Elk activity was lowest in the disturbed (fall) period compared with the undisturbed period (winter, spring and summer combined) at all locations along the RoW.

Observation time of elk use of the RoW was less at locations C6, C7, and C8 during the disturbed period compared with the undisturbed period. Elk may be responding to increased levels of human activity along the RoW by abandoning or limiting their use of the RoW. Other authors have also found that elk abandon habitats when human activity increases (Batcheler 1968, Hershey and Leege 1976, Marcum 1975, Morgantini 1979, Morgantini and Hudson 1979, 1985, Perry and Overly 1976).

Effects of Human Activity on Elk

The data indicate that the radio-collared elk did not respond to increased human activity along the RoW by moving farther away. Human activity appeared to influence the level of elk activity observed within various cover types, but other factors may have also been influencing elk activity. The distribution of elk was not significantly different between disturbance categories, and evaluation of the track data showed that distribution of elk tracks was not different between a period of high human activity (November 1984) and low human activity (January 1985). It appears from the data that elk in this area accepted human activity by using cover types that provided security, while still allowing access to food sources. In the absence of human activity (January 1985), elk no longer needed the security offered by the conifer and treed muskeg cover types. Their use of them decreased, while use of the grassland cover type increased dramatically.

As the winter seasons progressed the mixed cover type became increasingly more important. In January and March, elk use of this cover type increased by 31.2 and 43.0% over the November levels. This increase in use was probably weather and habitat related. This cover type may offer: thermal protection during cold days and nights, protection against body heat loss from winds, and forage (Houston 1982, Nelson and Leege 1982).

Crusting of snow can be an important factor in determining elk use of different cover types, especially in

Alberta, where late season chinook winds cause snow melt and crusted snow on open grasslands. These winds in February caused a crust to form on snow in the grassland cover type, resulting in elk abandoning this area for more readily accessible forage. In March, 1985 elk use of the mixed cover type was highest, while the next preferred cover type was the conifer. The preference for these cover types in March may be related to the modifying effect of this cover type on climatic conditions. These cover types should offer protection for the animal from winds, while lessening the effect of snow melt and crusting caused by chinook winds. Overall, these cover types may reduce the daily metabolic maintenance costs for elk, resulting in a preference for them.

The data indicate that elk used the RoW as a feeding area, suggesting that it may be an important, although unnatural, component of local elk habitat. The data also indicate that elk show a preference for grassland cover types at particular times of the year. In the study area, grasslands comprise only 98.1 ha, of which the RoW accounts for 34.5%. This further emphasizes importance of the RoW as a component of elk habitat in the area. The RoW provides a unique and potentially high-quality feeding area for elk. During the rut, bull elk use up a large portion of their fat reserves since they reduce food intake during this time of the year (Houston 1982). Areas such as the RoW may provide important forage on which physically drained bull elk can feed to replenish fat reserves prior to the onset of winter. Increased human activity activity in the form of hunting may cause elk to abandon the RoW as a feeding area for other areas. Disturbance by humans, particularly hunters, has caused range abandonment in sheep (*Ovis dalli stonei*) (Geist 1971), and also within other populations of elk (Hershey and Leege 1976, Marcum 1975, Morgantini 1979). How detrimental this abandonment would be to the elk population in the study areas is pure speculation since there are no data on the amount or quality of other foraging areas. Presumably other sources of forage would be available to the elk during this period. Since human activity is primarily confined to the fall season, then the vegetation along the RoW would be available to the elk during other seasons of the year. Therefore, the consequences of human activity on elk use of the RoW in the fall may be unimportant to the overall health of the elk population in the area.

For cow elk to provide energy resources to ensure healthy development of the fetus, energy costs in excess of those required for maintenance must be minimized (Geist 1978a) Any activity by pregnant cow elk beyond the metabolic rates required for maintenance can potentially cause the animal to bankrupts its energy reserves. This is particularly true during the gestation period, as energy costs increase until parturition (Geist 1978b, Houston 1982). Therefore, any activity caused by man that requires the cow elk to move from or abandon favorable habitats has the potential to affect the health of a population.

The high levels of hunter activity observed during this study has the potential to cause changes in the local elk population. Hunting has the potential to interrupt the mating process thereby reducing the number of pregnant cow elk. Elk may be forced into less productive habitat types, resulting in lower birth rates and reduced calf survival. These effects may not manifest themselves immediately but might appear several years later resulting in reductions in local elk populations. Results of Yarmoloy et al. (in press) for mule deer and Batcheler (1968) for red deer support these ideas.

The extremely high levels of human activity along the RoW observed in this study emphasize a major problem in successful wildlife management, which is the control of public access and use of the network of trails (seismic and pipeline RsoW) created as a result of oil and gas exploration and field development. Improved access and the subsequent increased hunter activity resulting in higher harvest has been found to be the main reason for declines and sometimes elimination of local ungulate populations (Pendergast and Bindernagel 1977, Lynch 1973, Bergerud et al. 1984, Leege 1976, Thiessen 1976, Hershey and Leege 1976). Compulsory registration of elk killed within the WMU F328 indicates that elk harvest has more than doubled since 1980. This level of kill may be too high considering there is no accurate information on the number of elk from which to base decisions on allowable kill necessary to maintain or increase the elk population within this WMU.

To maximize the value of the RoW to elk, control of vehicle access and subsequently the level of people activity in the area would appear to be of benefit. Access control may reduce the potential for localized over-harvest, while reducing the potential for excessive disturbance of elk during the fall period. Several methods exist for potentially controlling human use of the RoW. Physically blocking the RoW with a gate or other barrier would reduce the amount of 2- or 4-wheel drive travel thereby reducing the level of human activity. However, there is still the problem of ATV travel, which is presently restricted to some degree during the hunting season by the Wildlife Act. Regulations restricting the use of ATVs to designated trails would further reduce human activity. These regulations are now in place in some areas of the Province (e.g. Kananaskis Country). Most oil and gas companies require ground access for operation and maintenance of the facilities. Consequently, making the RoW totally impassible for vehicle travel is not practical. Therefore, regulations may be required that allow companies to legally restrict public use of the RsoW. During the hunting season, the number of hunters using this particular WMU could be controlled through the use of a limited license draw system, whereby the number of hunting licenses available for each species would be strictly controlled.

The challenge to the wildlife manager will be to arrive

at a balance between providing secure habitat for elk as well as hunting opportunities for Alberta sportsmen. This RoW, along with others, provides excellent opportunities to develop high quality feeding areas for elk and other ungulate species. This can only be achieved if measures are taken both by industry and government to control the use of RsoW as access corridors by the public. With the continued pressure for more oil and gas development, habitat security for elk and other ungulates will become more important as the number of access roads, seismic lines and RsoW increase.

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WILDLIFE ENHANCEMENT ON DISTURBED LAND: A CASE STUDY

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Abstract: Enhancement of wildlife populations was used as the success criterion for retaining a massive land slide at a Colorado coal mine. Wildlife and vegetation composition were compared in a normal reclaimed area of a coal strip mine to about 100 landslide acres of reclaimed land that formed a broken landscape of exposed rock, steep slopes, crevices and deep channels in the soil. Recommendations of the survey resulted in small changes in the landslide area rather than costly reclamation.

Key Words: Case study, wildlife, enhancement, disturbed land.

INTRODUCTION

Diverse topography increases abundance and diversity of wildlife and vegetation. At The Pittsburg & Midway Coal Mining Co. Edna Mine near Oak Creek, Colorado, the rugged topography of 40-year old unreclaimed spoil piles, patches of dense vegetation, some seeps, and sparsely vegetated slopes and valleys, support wildlife numbers equal to those in undisturbed habitat types, such as aspen woodlands and mountain brush (Steele and Grant 1982).

METHODS

A landslide occurred at the Edna Mine in 1983. An area of land covering appoximately 100 acres that had been reclaimed with topsoil and vegetation began to slide. The area, known as the South of Shop Slide, eventually stabilized resulting in a broken landscape of exposed rock, steep slopes, crevices and channels in the soil, and patches of dense vegetation. Because this area had already been reclaimed prior to the landslide, at issue is whether the area continues to meet the post-mining land use criteria for wildlife and grazing. This study was conducted to determine the wildlife values of the slide area, in particular, whether the area equaled or exceeded wildlife values on undisturbed reclamation.

To determine whether the slide area was beneficial to wildlife, a survey of birds, mammals, and nocturnal rodents was conducted at the Edna Mine in June 1987. Two line transects (Emlen 1971), 600 m in length, were measured and marked in areas with reclaimed topsoil that were adjacent to aspen woodlands. One transect was established in the landslide area (87SLIDE) and the other was located in an undisturbed area (87TOP). Each transect was walked in the morning for birds (dawn to 0900 hr) and in the evening for mammals (1930 hr to sunset) during June 1987. All wildlife observed on the transect line were recorded by species, number of individuals, and location in habitat type for five consecutive mornings and evenings. Abundance was expressed as number observed by sight divided by total kilometers walked (3 km). We did not adjust counts based on perpendicular distances of observations from the transect lines because direct counts and adjusted counts are reported to be highly correlated (Steele et al. 1984). Species richness was the number of species seen on the transect, and species diversity was calculated according to Shannon and Weaver (1964). Biomass was based upon estimated weights of birds and mammals derived from a variety of sources.

A rodent trap grid was placed in each of the two reclaimed habitats (87SLIDE and 87TOP). Each grid covered 2.72 ha and was arranged in a 12x12 configuration with 144 Sherman live traps placed 15 m apart. Each trap was baited with rolled oats. For five consecutive days, each rodent captured was marked with a numbered ear tag, aged (adult or juvenile), sexed, weighed on Pesola scales to the nearest gram. In the case of microtine captures, head, body and tail were measured to the nearest mm. The grid location of the capture was recorded and the captured animal was then released. Density was expressed as number of individuals divided by 2.72 ha.

Birds were surveyed using line transects in July 1979, and mammals were trapped on 12x12 grids in September 1979 at Edna mine sites (Steele and Grant 1982). One study site was in reclaimed habitat with no topsoil (79NOTOP) and the other was in habitat containing unreclaimed spoils (79SPOIL). In addition, rodents were sampled in September 1979 using a 12x12 grid located in habitat with reclaimed topsoil (79TOP). The 79TOP grid corresponds to the same grid used in 1987 on the undisturbed area (87TOP). In 1979, vegetation was also evaluated at this site and at the 79NOTOP grid established north of the slide area (Harner 1980).

Vegetation cover values in each habitat were measured using the point intercept method to compare 1987 sites to sites sampled in 1979. Fifty points along a 50 m tape were taken at 10 random locations in each habitat. Cover estimates were based on mean values. Diversity (Shannon and Weaver 1964) was calculated for locations and for summary value by habitat.

RESULTS AND DISCUSSION

Avian population characteristics in both habitats during 1987 were similar. However, the slide area supported slightly more species, higher diversity, and a more even

Table 1. Avian population characteristics in four habitat types at the Edna Mine near Oak Creek, Colorado.

	Habitat Types			
	Reclaimed Topsoil, 1987		1979	
Characteristics	Undisturbed (87TOP)	Disturbed (87SLIDE)	Reclaimed No Topsoil (79NOTOP)	Unreclaimed Spoils (79SPOIL)
Abundance, No/km	20	19	3	28
Species Richness, n	10	12	4	19
Diversity, H'	1.84	2.16	0.94	2.20
Evenness, J	0.80	0.87	0.68	0.75
Biomass, Kg	1.17	1.02	2.30	29.29

Table 2. Mammalian population characteristics in four habitat types at the Edna Mine near Oak Creek, Colorado.

	Habitat Types			
	Reclaimed Topsoil, 1987		1979	
Characteristics	Undisturbed (87TOP)	Disturbed (87SLIDE)	Reclaimed No Topsoil (79NOTOP)	Unreclaimed Spoils (79SPOIL)
Abundance, No/km	26	2	1	76
Species Richness, n	2	3	2	7
Diversity, H'	0.12	1.01	0.64	.97
Evenness, J	0.17	0.92	0.92	0.50
Biomass, Kg	16,054.00	513.50	7.22	13,584.86

Table 3. Rodent population characteristics in four habitat types at the Edna Mine near Oak Creek, Colorado.

	Habitat Types				
	Reclaimed Topsoil, 1987		1979		
Characteristics	Undisturbed (87TOP)	Disturbed (87SLIDE)	Reclaimed Topsoil (79TOP)	Reclaimed No Topsoil (79NOTOP)	Unreclaimed Spoils (79SPOIL)
Density, Ind/ha	3	31	52	98	67
Species Richness, n	2	4	4	3	6
Diversity, H'	0.41	0.69	0.12	0.14	1.11
Evenness, J	0.59	0.48	0.09	0.13	0.57
Biomass, Kg	0.61	1.73	2.51	4.76	4.07
Species					
Least Chipmunk					
Density	–	–	–	–	6
Golden-mantled Ground Squirrel					
Density	–	–	–	–	<1
Northern Pocket Gopher					
Density	–	<1	–	–	–
Deer Mouse					
Density	11	22	51	96	43
Age Ratio, Adults	55%	62%	86%	74%	79%
Sex Ratio, Males	41%	43%	54%	48%	42%
Weight ± SD (g)	16±4	18±5	17±4	18±4	16±4
Northern Grasshopper Mouse	2	<1	–	–	–
Bushy-tailed Woodrat	–	–	<1	–	1
Montane Vole	–	–	<1	3	7
Long-tailed Vole	–	8	<1	–	10
House Mouse	–	–	–	<1	–

Table 4. Vegetation characteristics in three habitat types at the Edna Mine near Oak Creek, Colorado.

Characteristics	Habitat Types: Reclaimed Topsoil, 1987 — Undisturbed (87TOP)	Reclaimed Topsoil, 1987 — Disturbed (87SLIDE)	1979 — Reclaimed Topsoil (79TOP)	1979 — Reclaimed No Topsoil (79NOTOP)	1979 — Unreclaimed Spoils (79SPOIL)
Cover, %					
Plant	55±6	46±12	30±10		32±11
Litter	30±8	19±8	4±1		10±11
Bare Ground	12±6	28±8	50±19		50±14
Rock	3±2	7±4	16±23		8±6
Diversity, H'	1.43	1.81	1.84		1.83
Species, n	10	20	16		11
Grasses					
Smooth Brome	11±5	8±3	2±1		2±2
Western Wheatgrass	3±4	4±4	–		–
Pubescent Wheatgrass	–	<1	10±8		9±10
Fescue	2±2	1±1	<1		<1
Timothy	–	<1	–		–
Crested Wheatgrass	–	–	4±4		9±5
Intermediate Wheatgrass	–	–	3±5		4±4
Japanese Brome	1	1	<1		–
Winter Rye	–	–	7±10		2±3
Kentucky Bluegrass	–	–	<1		–
Bristlegrass	–	–	<1		–
Forbs					
Alfalfa	20±17	22±19	–		–
Milkvetch	18±8	3±2	<1		<1
Yellow Sweetclover	–	3±2	1±1		2±4
Houndstongue	–	1±1	<1		–
Thistle	<1	<1	–		<1
Forb 1 dis	–	<1	–		–
Blazingstar	–	<1	–		–
Dandelion	–	<1	–		–
Forb 1 und	<1	–	–		–
Forb 2 und	<1	–	–		–
Forb 2 dis	–	<1	–		
Forb 3 dis	–	<1	–		–
Prickly Lettuce	–	–	–		<1
Chenopodium	–	–	<1		–
Polygonum	–	–	1±2		–
Vetch	–	–	<1		–
Russian Thistle	–	–	<1		4±3
Shrubs					
Big Sagebrush	<1	<1	–		–
Rubber Rabbitbrush	<1	<1	–		–
Wood's Rose	–	1±2	–		–
Snowberry	–	1±1	–		–
Chokecherry	–	<1	–		–
Diversity, H'	1.17±0.33	1.42±0.47	-		-
Summary, H'	1.43	1.81	1.84		1.83

distribution of species (Table 1). Compared to the 79NOTOP site, both the 87SLIDE area and 87TOP area surpassed previous wildlife values, and both were approaching the values found in the 40-year old unreclaimed spoils (79SPOIL). Typically, avian activity declined during the evening to 13 birds/km, 7 species, and 1.47 H' on the 87TOP site. Compared to mornings, evenings at the 87SLIDE site had greater abundance (21 birds/km), equal richness (12 species), and higher diversity (2.10 H'). The 87SLIDE area provided an evening food source for birds nesting in adjacent aspen woodlands.

Nesting species on the 87TOP site were vesper sparrow (*Pooecetes gramineus*) and western meadowlark (*Sturnella neglecta*). On the 87SLIDE site, vesper sparrow, mourning dove (*Zenaida macroura*), and rock wren (*Salpinctes obsoletus*) nested in the broken landscape. The remaining species foraged in reclaimed areas and nested in aspen woodlands or mountain brush.

Characteristics of the 87TOP site definitely favored mammalian populations in terms of abundance and biomass (Table 2), and more specifically, use by elk (*Cervus canadensis*). The 87SLIDE site supported a higher diversity and even species distribution of mammals. In 1979, the 79SPOIL site supported a high mammalian abundance due

to a high density of yellow-bellied marmots (*Marmota flaviventris*). A few marmots established dens on the 87SLIDE site.

The low number of elk viewed on transects in the 87SLIDE area was due to two factors: (1) the unpredictability in the elk's use of any given area; and (2) the terrain of the disturbed reclamation area, which limited viewing distance from the transects. At the initiation of this survey a minimum of 40 elk were observed foraging and bedded down in the 87SLIDE area. As transects and grids were placed in the area, the elk moved into the adjacent aspen woodlands. Since the terrain was not conducive to rapid movement, few elk were subsequently observed during transect counts on the 87SLIDE site. On two of the five evenings, no elk were observed in the 87SLIDE area. Nevertheless, elk use of the 87SLIDE area exceeded elk use of the 87TOP area because of the higher number of bedding sites within 1 m of the transect. Two fresh elk beds were counted in the TOP87 area, whereas 14 beds were found in the 87SLIDE area. The varied topography of the landslide area was therefore favored by the elk when human disturbance was minimal.

Rodent populations were favored on the 87SLIDE site in terms of density, richness, diversity, and biomass (Table 3). Compared to 1979 results at the 79TOP site, density and biomass declined by a factor of 4 and richness declined by a factor of 2. But diversity and evenness, both indicators of community stability, increased by magnitudes of 3 and 6, respectively. Comparing the age of the disturbed reclamation (4 yrs) to the unreclaimed spoils (40 yrs), the wildlife values for the 87SLIDE area are increasing much more rapidly than values for 79SPOIL area. In a relatively short period of time, the wildlife values at the slide area should be similar to those values for the unreclaimed spoils.

Deer mice (*Peromyscus maniculatus*) were the dominant rodents in all habitats. Long-tailed voles (*Microtus longicaudus*) apparently preferred the broken landscape at both the 87SLIDE site and the 79SPOIL site. Notably, an ermine (*Mustela ermina*) was also trapped on the 87SLIDE area. Northern grasshopper mouse (*Onychomys leucogaster*), captured at the reclaimed sites, was the first record of this species for Routt County (Armstrong 1972).

Vegetation cover values for both current reclaimed areas are presented and compared to previous values (Table 4). Cover values at the 87SLIDE site and the 87TOP site exceeded cover values for the 79TOP site. Notably, there was less bare ground at the 87SLIDE site than at sites sampled previously. The 87SLIDE site supported more shrubs than other habitats, exceeded the 87TOP site in diversity, and was equal to overall diversity from prior sampling periods.

Based on the results of this study, we conclude that the slide area meets or exceeds the wildlife values in the undisturbed reclamation area. The slide area offers wildlife, vegetation, and a varied topography or "niche space" that should continue to increase in value. We predict that the slide area will eventually be as valuable to wildlife as unmined land and that these wildlife values will be attained at the slide area before they are reached on undisturbed reclamation areas. As a result of this survey, Colorado's Mine Land Reclamation Board allowed the mine to remove the topsoil from the upper escarpment, level it, and reclaim the small area. The original cost estimate for smoothing out the slide area was $607,000.00. The actual cost was less than $7,000.00. And some people think that wildlife doesn't pay.

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PANEL DISCUSSION:

FIRE MANAGEMENT AND WILDLIFE

PANEL ON FIRE MANAGEMENT AND WILDLIFE

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WILLARD: Fire Ecology from an alpine ecologist's point-of-view includes a long-range perspective and an attempt to understand the role of fire from a scientific standpoint. Most terrestrial ecosystems experience fire, some more frequently than others. Benefits of fire are: (1) consumption of dead material, so nutrients are put back into the system to be reconsumed more rapidly than by decay; (2) effects (usually positive) on insect balance; (3) assistance to plants that need additional heat for seed germination (e.g., lodgepole pine); (4) changes in physical structure of the system; and (5) changes in species composition, usually resulting in more diversity.

There is a human element of the ecosystem in that we as people place our sense of value in regard to fire on the ecosystems of the Earth. Since fire is usually devastating from the human viewpoint, we think that all fire is damaging. Fire is *not* usually damaging to the ecosystem. In Yosemite, 25% of fires are natural and 75% are manmade. "Smokey Bear" was created to make us think about the 75%, but we have projected the idea that all fires are bad in all ecosystems. This is not good thinking.

For example, chaparral ecosystems in California burn naturally on an average of once every eight years. The severe Santa Barbara fire of 1969 was caused by six missed cycles, allowing an excess amount of fuel build-up. It had not burned for 50 years due to fire protection by humans.

Another example is the giant sequoia, which needs open sunlight and bare mineral soil in order for the seeds to germinate. Sugar pine and incense cedar were overtopping the sequoia due to the lack of fire. These latter two species could germinate in the litter. The sequoia could not.

It is hoped that this ecological view of fire will generate meaningful discussion and thinking as we go forward with our exploration of fire management policy.

ROBERTS: In Region 2 of the U. S. Forest Service, all wildfires are suppressed using the most cost-efficient means considering the values at risk. Suppression strategies range from using natural features such as rock cliffs or streams as fire breaks, to constructing hand or tractor lines, to extinguishing the fire completely. In wilderness areas, policies for fire suppression restrict the use of mechanized equipment. The direction and the resource values in the Forest Plans are used to guide the suppression efforts.

All prescribed fires require an approved plan for both planned and unplanned ignitions. In Region 2, there are no approved prescribed fire plans for utilizing unplanned ignitions at the current time. Trained and qualified personnel are required to execute the approved prescribed fire plans. The policy allows only unplanned ignitions from lightning to be used to restore wilderness ecosystems, but planned ignitions may be used to reduce hazardous fuel accumulations. When a fire exceeds the prescription and cannot be returned to prescription within the project budget, it is declared an escaped fire (wildfire) and suppressed until out.

The role of "Smokey Bear" in preventing *human-caused* fires is just as important today as ever. We cannot tolerate the loss of human lives and property from wildfires caused

by humans. Although some have attacked this program, we still strongly support its validity.

In Region 2, suppression of wildfire has caused very unnatural fuel accumulations, particularly in the frequent-fire types such as ponderosa and lodgepole pine. These fuels often produce more than 1000 BTUs per foot per second along the flaming front of the fire and exceed our ability to control them directly by *any* means. Such was the case this summer in the Yellowstone area. Barring changes in the weather or fuels, these conflagrations can only be stopped by the skilled application of fire, yet there are very few who are experienced in conducting burn-outs on such a large scale.

The average age of lodgepole pine in Region 2 is well over 100 years and is extremely decadent. Along the Front Range and high country in Colorado, the mountain pine beetle attacks bear witness to the enormity of the problem. The insects are not the problem; the old, overmature trees are. In F. E. Clements' *The Life History of Lodgepole Burn Forests*, published in 1910, a 242 year old lodgepole pine was the oldest tree he could find in the vicinity of Estes Park, CO. We now have a number of lodgepole pines well in excess of 300 years of age.

The best opportunity we have to correct the situation is to regenerate these decadent forests by the most cost-efficient means at our disposal. In most of Region 2, that would be prescribed fire. In 1985, approximately 17,000 acres were prescribed burned in this Region. In 1988, the plans to burn approximately 50,000 acres were interrupted by the Yellowstone fires. We actually need to treat about 300,000 acres each year in order to maintain the ecosystems we have in a healthy condition. Our options to treat these are limited to mechanical (harvesting), chemical (herbicides), prescribed fire, or no treatment. The "no treatment" alternative will result in massive insect and disease attacks followed by large, catastrophic wildfires, and will probably have the worst impact of all our alternatives. It is many times cheaper to prescribe burn an area than to fight a wildfire of the same size on the same area.

The forest resources (wildlife, range, recreation, water, soils, air and timber) are all benefited by a healthy forest ecosystem. For a better job of land management, ecosystem management should be the common focus of *all* disciplines. Wildlife biologists must participate in the broad arena of land management if they are to have maximum influence on the decisions.

Managing vegetation is the key to managing ecosystems. The greatest public benefit is derived from healthy forests with a rich diversity of successional stages, age classes, and genetic pools from which to respond to catastrophic changes. The best way to mitigate habitat losses is through restoration of vegetation diversity on the millions of acres of overmature forest, shrub and grass communities.

BISHOP: There is *no* "let burn" policy. There *are* fire management plans. A great deal of research went into the present fire policy in Yellowstone. There were big fires in Yellowstone in 1700 and 1850, (a big-fire cycle of 150 years).

Books and publications that might be helpful in further understanding the role of fire are: *Fire in America* by Stephen Pine of Western Arizona University (A Cultural History of Wildland and Rural Fire); Proceedings of the *National Wilderness Research Conference* (1986) in Ft. Collins, CO; and the *National Park Service Symposium on Wilderness Fire* (1983) in Missoula, MT.

The Fire Management Plan for Yellowstone National Park was evolved by 1972 and revised in 1976. In 1987, the Wildland Fire Management Plan was completed.

After the Yellowstone fires of 1988, a Consortium was immediately held in Bozeman, MT involving Montana State University, the University of Montana, the University of Wyoming, and others. The theme was the Ecological Consequences and Public Opportunities of the Yellowstone Fires of 1988.

Some immediate necessary action, for example, was to restore the fire lanes that had been cut. It was noted that a bulldozer wider than the Grand Canyon of the Yellowstone would have been needed to stop some of the fires from jumping, especially when the winds were blowing at 50-60 mph. It was determined in the Fall of 1988, that 25.3% of the Park had canopy burn and 16.8% had surface burn as a result of the fires. A useful pamphlet is called *Questions and Answers: Yellowstone Fires of 1988*. Don Despain clarified how and when prescribed burns could be used in the Park.

There were no overall ecosystem studies (no bringing together of all the processes) that had been proposed for Yellowstone, even after the fires, except by Linda Wallace of the University of Oklahoma, who reviewed all of the research proposals and realized the need. She has applied to the National Science Foundation (NSF) for funding of such research.

KILPATRICK: *Fire Impacts to Wildlife and Wildlife Habitats*. The Wyoming Game and Fish Department provided input and support to the U. S. Forest Service Wilderness Fire Management plans from their inception through finalization in the 1970's. Conceptual support for allowing fire to act as a natural catalyst in altering vegetative communities was driven by basic and historic wildlife habitat needs. Vegetative communities (wildlife habitats) are a product of local climate as well as catastrophic events such as avalanches, volcanic eruptions and fire. Historical evidence strongly supports the fact that fire has been a part of the natural Yellowstone ecosystem for many thousands of years, and all wildlife species are a product of and have depended on their environment for just as long.

Wildlife habitats are not stable entities that can be preserved behind a fence or protected from climatic and/or catastrophic events. They are constantly changing and need some form of maintenance to remain suitable for most species. Natural fires have historically influenced and assisted with the maintenance of such habitats.

Due to topography, inconsistent fuel sources and variability in fuel moisture, the 1988 Yellowstone fires generally burned in a mosaic pattern, directly impacting approximately 40-60% of the surface area within delineated fire peripheries. Intensity and completeness of burning varied considerably from site to site. Such fire behavior is considered normal within the Rocky Mountain area, is beneficial for most wildlife species and creates an overall mosaic of seral and climax vegetative communities (over time), considered the preferred habitat for the greatest diversity of wildlife species.

The resulting habitat mosaic from the fires of 1988 will have longterm benefits for a variety of big game species, including elk, moose, deer, bison, black bear and grizzly bear. There may be some localized problems associated with a significant reduction in escape cover for elk. The loss of forage on seasonal ranges for big game was minimal, especially where winter ranges are concerned. Nearly all of the impacted areas were late spring, summer and fall ranges. Only in the case of the Clark's Fork Sheep Herd Unit and the Crandall Moose Herd Unit have crucial ranges been impacted to an extent exceeding 10%. The long-term impacts on big game populations are expected to be positive. Existing winter range carrying capacity has been reduced primarily because of drought conditions, not because of fires. As of January 20, 1989, mild winter conditions had prevailed in these areas with all big game species well distributed on winter ranges and animals appearing in normal physical condition. It is anticipated that Summer and Fall distribution, as well as migration routes, will experience some changes in the future. The extent of these is not known at this time and may require several years to document.

Fire is widely accepted as a means of improving bear habitat. Over most of the Greater Yellowstone, ecologists predict that the burned areas will be changed from that of mature lodgepole pine monocultures to ones rich in early successional shrubs, forbs and grasses that should provide better forage for grizzly bears than the original older pine forests. It is felt that a large enough area of whitebark pine forest did not burn to significantly change the overall mast available to bears in either poor or good pine nut production years. Bears normally using the upper North Fork and Crandall areas in the late summer and fall seasons, however, will need to find new foraging areas due to fire intensity and extensiveness. Areas of important whitebark pine stands that burned are anticipated to be poor spring range for one to three years, and poor summer and fall foraging areas for anywhere up to fifteen years for berries, and perhaps as long as 100 years for pine nuts.

There will be negative impacts on species such as pine squirrels (chickarees), some seed-eating birds and pine martens, primarily dependent on mature conifer forests. Survival of small mammals within a burn depends upon the uniformity, intensity, size and duration of the burn. In general, burrow-dwelling mammals survive fires well. Resulting dramatic changes in habitat will usually cause a decrease in the number and diversity of small mammal populations for one to three years following a fire. In mosaic burns, populations recover more quickly.

Forest and shrub habitats in the middle successional or preclimax stages generally have the maximum diversity and numbers of birds. The fires of 1988 occurred after the peak of nesting and fledging seasons, allowing for escape of most birds. Longterm benefits are expected, since the absence of fire usually results in a decrease in habitat diversity, which in turn reduces bird niche diversity and species richness. Woodpeckers and other cavity-nesting species are expected to increase in numbers as a result of standing dead snags left by the fire. These also provide additional sites for raptor nesting and perching (while foraging in the newly-created open areas).

Confirmed fire-related mortalities in the areas of the Huck-Emerald-Mink and Clover-Mist fires include 83 elk, 9 moose, 4 black bear, 30 mule deer and 7 birds and small mammals. In addition, 1 moose and 1 black bear were destroyed because they were severely burned. A majority of the mortalities in the Bridger-Teton Wilderness were a result of animals being trapped between advancing fire fronts and human-ignited backfires. This is also reportedly true for many of the mortalities in Yellowstone National Park.

COMMENTS ON FUTURE FIRE MANAGEMENT POLICIES

The Secretaries of the Departments of Agriculture and Interior assembled a Fire Management Policy Review Team on September 28, 1988 to review national policies and their application for fire management in National Parks and Wilderness Areas, and to recommend actions to address the problems experienced during the 1988 fire season. They published their Report on Fire Management Policy on December 14, 1988. The following comments are made relative to the Review Team's findings and recommendations.

Review Team's Finding #5

"Prescribed natural fire programs do not adequately consider the impact on other interagency programs and resources."

The impacts to wildlife habitat is of great importance to the Wyoming Game and Fish Department, especially if fire occurs within delineated crucial winter ranges. We need adequate input in such cases to insure that an acceptable amount of a winter range is impacted by a prescribed natural

fire. Usually fire effects on big game winter ranges will be positive if not more than 20% is burned within a given five-year time frame. If the majority of a winter range is burned in too short of a time frame, an adequate amount of forage may not exist for wintering wildlife, resulting in public outcry and possible supplemental feeding programs. On the other hand, total lack of fire will result in a reduction of carrying capacity due to ecological succession continuing to a climax stage. Optimum big game winter range habitat conditions will generally occur if a mosaic of early to mid-successional vegetative stages is provided on big game winter ranges.

It is recommended that both the Forest Service and the Park Service consider the impacts of different fire suppression techniques in fire management planning. Backfires set can result in some wildlife mortalities. Location of backfire ignitions and importance of structures saved should be weighed against the value of potential wildlife losses.

Review Team's Finding #6

"The severity of the 1988 fire season in some areas of the West (the most severe on record in the Greater Yellowstone Area) revealed the risks inherent in managing wildland fires."

Although there are significant risks involved when dealing with fires during severe conditions, it should be realized that some vegetative communities require such conditions before they will burn, initiating their rejuvenation process. A prime example is the rapidly disappearing stands of aspens, which generally occur on relatively moist soils. It is common knowledge that aspen is fire-dependent (or disturbance-dependent) for its existence, yet will not burn unless conditions are severe from a prescription standpoint. The Bridger-Teton Forest alone estimates that approximately 5,000 acres of aspen will have to be treated on an annual basis over the next ten years in order to maintain existing stands. These stands are a very important component of wildlife habitat and need to be maintained within the ecosystem even though risks may be higher than we like.

Such risks of prescribed natural fires within Wilderness Areas appear to be minimal, as evidenced by the Review Team's Report. In Regions 1 and 4, the Forest Service allowed 503 prescribed natural fires to burn inside Wilderness Areas from 1972 to 1988. Only 23 of these (4.7%) resulted in wildfires, better than 95% success.

Review Team's Finding #11

"Inconsistent dissemination of information . . . the primary message communicated by agencies continued to be the biological value of prescribed natural fire to vegetation and wildlife even after the fires had been declared to be wildfires."

The public continued to express their concern for the wildlife resource, especially after fires were classified as wildfires. It was necessary and appropriate, therefore, to communicate the above message to assure the public that faunal and floral resources were not going to perish due to reclassification of fires from natural prescribed to wildfires. The long-term response of flora and fauna to fire will not differ significantly as a result of our fire classification system!

Review Team's Recommendation #4

"Current fire management plans must be strengthened by: . . ." (criteria listed).

The comprehensive set of criteria developed to guide the use of planned ignitions and natural prescribed fires should take into account that some plant communities require rather severe conditions in order to burn. Many of these are dependent upon fire for their existence as indicated by historic fire records and research. Constraints on prescribed fires need to be flexible enough to allow for the perpetuation of such communities. Examples of these are willow bottoms and aspen clones, important components of an ecosystem and wildlife habitat in that they provide niches for a large array of faunal species.

Review Team's Recommendation #7

"Agencies must re-evaluate the opportunities to use prescribed burning (by planned ignitions) to achieve management objectives and complement prescribed natural fire programs."

We strongly agree with the concept of using planned ignitions in addition to prescribed natural fires. Historic fire suppression has placed the Forest Service and Park Service in a "catch up" mode. The "natural process" has been severely interrupted in recent history. Waiting for natural prescribed fires to occur will undoubtedly result in additional fuel loading in areas already exceeding historic fire frequencies. The fact that only those natural fires occurring within prescription will be allowed to burn, will further contribute to the fuel loading problem, since under natural conditions fires obviously burned outside of human prescriptions. These nonprescription fires were very effective at reducing fuels and providing diversity within the forest ecosystem. Intensified use of planned ignitions will help offset the fuel-reducing function of these nonprescription fires, which will no longer be part of fire management plans.

Use of prescribed fires in forests of the intermountain west has been accepted rather slowly due to associated risks. This is understandable due to Forest Service and Park Service personnel having experienced devastating stand-replacement fires. Fire ecology experts, however, are confident that the risks are becomming more serious with time, and the western states will need a massive prescribed burning program to solve the problems of fuel buildups, stagnation,

monocultures, disease, and insect damage, which, when combined, create the potential for catastrophic fires.

From a wildlife habitat standpoint, planned ignitions are very desirable in that timing and amount of surface area treated with fire are predetermined and more controlled. This is especially desirable for treatment areas containing crucial habitat (e.g., big game winter and parturition areas). In addition, identified sites with excessive fuel loading generally possess a very low wildlife carrying capacity as a result of conifer stands succeeding more palatable shrubs, forbs and grasses. Implementation of additional planned ignitions should create a mosaic pattern of floral communities of differing age classes. Such conditions will enhance wildlife carrying capacity, diversity and species richness.

Over time, fire suppression coupled with the lack of planned ignitions within wildernesses has allowed succession of conifer stands into historic big game winter ranges, reducing carrying capacity and restricting bighorn sheep migration. It has also contributed to the fuel loading problem. A lot of big game populations are experiencing an all time low in winter forage, while waiting for a "natural" fire within human prescriptions to revert the range to historic and more productive successional stages. Many large ungulate populations are having a difficult time coping with current climax vegetation conditions prevalent in modern day wildernesses. Ignited prescribed fires in these areas are a "must" for the perpetuation of historic crucial wildlife habitat, and they will reduce the ever-building fuel loads resulting from suppression of natural fires not within prescription. The Fire Management Policy Review Team reported only four ignited prescribed fires totaling 4,424 acres were conducted on Forest Service wildernesses. All four were within the past two years. An assertive prescribed burning program is equally applicable and necessary in wilderness as well as non-wilderness areas if the deficit between current natural prescribed and historic natural (non-prescription) fires is to be overcome.

Review Team's Recommendation #11

"Interpretation and public information before and during fires will be improved."

The importance of public education relative to fire ecology (before fires are initiated) is critical, especially if an aggressive prescribed burning program is initiated. Fire is a part of natural ecosystems and is a catalyst for diversity. It has resulted in longterm stability of ecosystems, including their wildlife resources. Not until recently (since the 1960's) has the public been told that protecting all plant communities from fire can be bad.

Since the science of fire ecology, which includes prescribed burning (planned ignition and natural), is so new, an all-out public education program is paramount. Most of the past fire-related education has been of "Smokey Bear" content. In many cases public naivete in regard to fire ecology has resulted in political involvement. This has often forced federal agencies to waste massive sums of money to either fight fires that they could not stop, to put out fires that would go out naturally, or to put out fires that would have resulted in substantial resource enhancement. During the 1988 fire season, 30,000 fire fighters were used to combat 70,000 different fires in the United States. Suppression expenditures were $600 million for 3.7 million acres within fire perimeters. This amounts to $162 per acre compared to $7 to $70 per acre for ignited prescribed burning of conifers.

The public and political segments will continue to demand unnecessary fire suppression actions until they are deprogrammed through an educational effort by the federal agencies. The most effective approach would be to educate the public prior to natural or ignited prescribed fires. Trying to educate them after fires are started is difficult due to the state of hysteria to which most of the public is conditioned as a result of historic "total-suppression" type education.

CARRIER: The reason for writing "Letters From Yellowstone" while reporting on the fires this past summer (1988) is that they were more widely read than if a scientific series of articles had been written. I know what I see and what I sense. Yellowstone was an ecological triumph but a political disaster. As Vietnam was the first TV war, Yellowstone was the first TV forest fire. The "fallouts" are very similar. The American public, it seems, does not want anymore "Vietnams" or "Yellowstones." The mistake they made was having fires in an election year! (Laughter).

The press, for the mostpart, probably blew it out of proportion, especially with headlines like: "Fire Roars Toward Old Faithful, or "Blazes Char Yellowstone," or "Million Acres Burn," (which turned out not to be true), and finally, "Will They Ever Cease." Even Audubon Magazine on the cover had "The Incineration Of Yellowstone."

Fire maps put out daily by Yellowstone Park itself had "blackened in" completely the perimeters of the fire areas. This really gave a sense of "out-of-control." Media is especially "color conscious" since flame reproduces well, therefore TV and newspaper reporters looked for flames even on days of low fire activity. This added to the "incineration" feeling. The media, however, mirrored pretty much the feelings of a majority of the people in the Park. The firestorm at Old Faithful was indeed a very scary situation. When one was actually there in person, one lost perspective. Coming back in September, one found it looked rather benign.

When you put fire and wilderness together, you get social and political reactions. During the fires there was a lot of howling from tourist organizations and from the Wyoming Congressional Delegation. It is hard to educate people's "hearts" as opposed to their "heads." Fire strongly

effects us emotionally. "Little baby ducks burning in their nests" is more effective in "grabbing" people than all the talk about aspen regeneration.

This symposium is really about the manipulation of nature and the way we think about nature. Why should we expect less in Yellowstone? It probably had one of the purest of the natural regulation systems going for it (fire) . . . a tremendous hands-off (laissez-faire) attitude about it. We manipulate the grizzly bear, for example, almost like a chess game . . . using nets to take the pieces around by helicopter! The wolf could be the same.

Yellowstone has become a sort of "environmental proving ground." Fire is really now considered less a tool of nature and more a tool of mankind as a result of the 1988 fires.

QUESTIONS, ANSWERS, AND DISCUSSION

QUESTION: Are there plans for any follow-up articles?

CARRIER: Yes, media has already followed up on after-effects, focused mainly on the ecology.

QUESTION: Since a lot of federal funds were expended to communities surrounding Yellowstone, to what degree did that reflect election year politics?

ROBERTS: A significant income was indeed spent in local communities: 26.4 million overall, 12.8 million in Wyoming and 8.5 million in Idaho, for example.

BISHOP: Revenue for gift shops was down, but hardware stores were really booming!

CARRIER: Because it was Yellowstone, whatever was needed was spent.

QUESTION (V. GRANT): What was the extent of fires in other areas besides Yellowstone in the summer of 1988 and was there any media coverage of them?

ROBERTS: Yes, for example there was some media attention to fires in late June in Custer State Park in the Black Hills. During the Yellowstone fires there were fires in north central Wyoming in the Big Horn National Forest that had little or no media attention. In the former case, the residents of Buffalo, WY were briefed each evening by U. S. Forest Service officials and others and they had much good public support and understanding. The residents of Buffalo threw a party for the firefighters afterwards.

GRANT: We had extensive fires (in Utah), but the Yellowstone fires took all the publicity away. Is the Forest Service looking at getting the people in the states to understand what the fire is doing right close to home (in the sense of lessening negative response to the Yellowstone fires)?

ROBERTS: We are a pretty decentralized organization. It depends on the Forest Service administration in each area and how they react . . . it is not a uniform approach.

DAVIS: Trying to put this in perspective, in the summer of 1987, the Forest Service and Bureau of Land Management (BLM) were fighting fires in California and the Pacific Northwest. Do you know what acreage was burned that summer?

ROBERTS: No, I don't know. I do know we sent more forces and resources out of our Region than we ever did in history. That was also true in 1985 and 1986.

QUESTION: Are any criminal charges pending against people who started fires, albeit accidentally, this past summer?

ROBERTS: I do not have specific information. We investigate all fires where the causes are felt to be suspicious (human-caused). As far as prevention is concerned, we are trying to get compliance with the laws. We enforce regulations against malicious or negligent human-caused starting of fires. For example, fires on the north side of Yellowstone Park were investigated for being started by outfitters.

BISHOP: That outfitter's permit has been rescinded. That is the penalty.

CARRIER: Four men were charged by the U. S. Attorney for dropping of cigarettes, but that is only a misdemeanor. They were not charged specifically with starting that fire.

ROBERTS: It is difficult to prove. One way is through criminal laws or civil suit in a court of law to try to regain damages. Another is through administrative action (e.g, revoke a permit . . . we just do it).

WILLARD: Do you think you have enough legal recourse the way the laws are now?

ROBERTS: I feel comfortable with the laws we have now. They give adequate protection to the public. My philosophy is that you exert the minimum amount of control necessary. I do not want to go overboard with rules and regulations, particularly at the expense of having to enforce all of them.

CARRIER: The other side of that, for example, is that these

men who were charged (in Idaho) have no property except an old pick-up truck, and they have a $40 million fire on their hands (or heads!). You could take civil action against them, but that is not a very practical answer.

QUESTION: Does the Forest Service have any plans to expand "Smokey's" horizons in regard to the message for the public about the ecological advantages of fire?

ROBERTS: "Smokey" has been losing ground for the past 15 years, i.e., less name recognition and purpose than 15 years ago. There have been so many people who have jumped on the bandwagon that "Smokey's" message has become diluted. His main purpose and the focus of his message has always been *prevention of human-caused fires.* Apparently this has not gotten through too well to the public.

COMMENT: It was noted that a Fish and Game Department ranger (in the summer of 1988) at a campfire program in Oregon talked only about the negative aspects of fire. The wife of an ecologist, angered by this, lectured the ranger afterwards on the positive aspects of fire. It was felt that perhaps more public awareness could be gained if "Smokey" were to become "a more ecologically aware bear."

ROBERTS: "Smokey" is not our only problem. Academia, which is the genesis of our professional training, has put us in separate little boxes in each functional area and has not given us the broad ecological background to interface these functions. So we sit around and argue with each other and expend energies, activities and monies that often gain us nothing. But we have four ways to deal with vegetation: (1) *mechanical,* which has certain applications a small percentage of the time, (2) *biological,* a hailed approach, where insects or disease come in, and eventually leads to fire, (3) *chemical,* usually not socially acceptable, especially since Rachael Carson, and (4) *fire,* when there are fuel accumulations, which can be 1000 BTU's per foot per second on the flaming front when the wind is 40-60 mph. We have no means of fighting that kind of situation. You can have "spotting" (where the fire jumps 1-2 miles) under those circumstances.

WILLARD: But fire is a biological tool if allowed to burn a little at a time; for so long we have prevented that from happening.

ROBERTS: I consider it an ecological tool.

WILLARD: Biology is part of ecology!

KILPATRICK: I challenge you in the Forest Service to change the tone of "Smokey" ads. Ideas need to be qualified, because people go into hysteria when they hear about fire.

ROBERTS: You are overestimating my abilities! (Laughter).

COMMENT (J. GELHORN): To say that the biological method is a failed approach shows human impatience. We forget Nature's way of doing business, which may be very slow at times in a sense of ecological succession. We want everything to be pristine . . . the way *we* want it . . . right now.

ROBERTS: What I really meant is that when we remove ecological fire from an environment, we produce a situation that is ripe for the spread of insects and diseases beyond what would occur in a natural system. In that sense, the case I mentioned was a failure.

GELHORN: It is important that we put fire as part of the natural biological/ecological approach.

QUESTION: Given the vast lodgepole acreage, even with major shifts in policy, is controlled burning going to make a dent in reducing the huge amounts of fuel?

KILPATRICK: We are so far behind that we will not get caught up unless we have more catastrophic fires. Prescribed burning will at least enhance wildlife values.

ROBERTS: Prescribed burning has some problems we all need to address. Prescribed fire is *not* a fire function, it is a *land management* function . . . a tool of the biologist. It is too often left to non-professional technicians who do not truly understand its function. If one is concerned about air quality regulations (in relation to burning), emmission standards will *not* allow intense burning. More frequent intense burning is a "catch-up" ecologically. One can burn at a time when you can get better dispersion at less cost.

WILLARD: Can you tell us what we as citizens can do to change regulators' feelings about fire?

ROBERTS: I think when the Environmental Protection Agency (EPA) is holding hearings on PM 10 and PM 2 1/2 standards, which are visibility regulations, that land managers need to get our thinking expressed in regard to fire.

QUESTION: What do you suggest can be done to change the public's perception of fire?

KILPATRICK: Be sight specific. People *do* listen to radio and TV. Qualify "Smokey's" stand to say which fires are bad and which are good. Get the U. S. Department of Agriculture (Forest Service) ad makers to change their message.

BISHOP: Yellowstone National Park (Park Service) has a three-person interpretive team that talks to service clubs in regard to the biological and bio-political aspects of the fires.

CARRIER: It is a difficult road to hoe when you are dealing with peoples' attitudes about fire, which are pretty instinctual.

But a lot of things are possible through ads. One is intrigued with the idea of having "Smokey" *manage* a fire as opposed to putting it out. Most of the time if one wrote about fire, nobody would read it. Yellowstone, however, is a large "2x4," of which we can take advantage.

QUESTION: Are you under pressure to write about fires in a certain way or are you able to write the way you wish?

CARRIER: No pressure . . . except people wanting to see pictures of flames. There were many evenly-stated articles.

QUESTION (D. FINCH): What research will be done (on the fires) and will it be in-house, by universities or what?

BISHOP: A combination of both. There was an incredible outpouring of eagerness to jump on the Greater Yellowstone Ecosystem from a research point-of-view because of the fires. Working groups at the Montana State University meeting suggested interdisciplinary and fire history studies. Also suggested were studies of lakes, streams, run-off, soils, seed dispersal, sediment transfer, chemistry, geology, habitats, mammals, birds, vegetation, etc., always stressing the interdisciplinary.

FINCH: How about longterm monitoring and succession studies? Will funding dry up after five years, like it did at Mount St. Helens?

BISHOP: Sedimentation studies will be continued. It is hard to predict longterm funding. The public gets excited about an event (and we have funding). Who knows, 15 years from now?

WILLARD: This points out a major problem. I spent four years on the President's Council on Environmental Quality (CEQ) trying to get an ecological survey, but failed. This is because we elect congresspersons for two years, presidents for four years and senators for six years. Their scope of interest is mostly in those election periods and they have very little interest beyond, unless they are exceptional persons. We as citizens, managers and scientists need to demand something much better. The National Science Foundation (NSF) is sometimes an exception, but it is funded the same way. There are occasionally a few funds for longterm research, but not nearly enough. We need to look at landscapes over 10, 25 or 100 years continuously before we can really understand some ecosystems. But we are unfortunately more political animals than we are biological.

CARRIER: The grizzly bear is a case in point. 5% of the budget in Yellowstone is spent on them because they have more "sex appeal" as a study animal (in relation to public opinion) than other animals. The National Parks and Conservation Association feels that the Park Service does not ask for enough dollars in general. In the National Parks, we have a billion dollars of physical structures, yet Congress would rather create new parks than do work on old ones. In regard to Yellowstone, the scientific consortium can now say that this is a once-in-a-lifetime opportunity.

WILLARD: An agency can provide information, but by its nature it is *not* an advocate organization. For a long time, there was almost no research going on in National Parks; there was no funding. With the addition of more parks over the past 20 years we have increased this aspect, but our "sights" need to be raised even more. If we as citizens want National Parks well-supported, then *we* are the ones who must push Congress.

CARRIER: The Yellowstone Deputy Park Director told me they were not asking for more research money than they have now.

FINCH: What about the National Science Foundation (NSF)? Are they setting aside any funding for Yellowstone?

BISHOP: There is a grant proposal into NSF right now entitled: "The Subsystem Linkages and Ecosystem Level Responses to Largescale Fire in Yellowstone National Park."

FINCH: What is the status of the Montana State Consortium at this point?

BISHOP: We continue to get reports.

QUESTION (R. JUDY): How do we get the ecological message out to the American people?

CARRIER: Take every opportunity you can. Suggest story ideas, especially ones that will appeal to the public, if you can. I feel that biologists are often reluctant to do this. Forge on ahead and talk to us anyway. In this country it is possible to sell anything if enough savvy is put into a campaign. I think you *can* convince people that fire is our friend.

BISHOP: You just said the slogan: *"Fire is our friend!"* Hold on to that!

CARRIER: "Bambi" was shown in Gardner, MT (just north of Yellowstone) during the height of the fires. Maybe "Bambi" ought to meet "Godzilla." (Laughter).

JUDY: It is hard to overcome public prejudice when we as scientists are used to dealing with the facts and figures of science instead of some mix of science and politics.

CARRIER: Next Spring, Yellowstone will be overrun with media looking for green shoots . . . a positive story. But if the fire season starts again in August, I am not sure whether or not you will feel any different about fire, given the crisis it creates. I do have faith in education . . . that you can teach people intellectually. We have advanced ecological awareness through crises (the "Green Revolution"). It has been a gradual 25-year process.

WILLARD: You are really speaking to much bigger prescribed burns, so that we will not have evacuation and disruption of people's lives. When I was in Yellowstone Park in late September (1988) with Don Despain, we found a very small fire buring. I said that we could put it out easily with our water bottle, and Don said "Don't you dare touch that! That's the most valuable thing we have in this Park!" So our instincts come out, even though we are ecologists. He had to remind us.

I would say in answer to Bob Judy's question that we need much more education of elementary and secondary teachers, and also university people and practicing scientists, so that they understand the role of fire, because we are all ingrained with the horror of fire and not the understanding of its positive role in our lives.

KILPATRICK: I like the idea of "Smokey the Bear" turning his tables. Kids and adults identify with him. For example, during the Yellowstone fires, a Bureau of Land Management (BLM) biologist in Rock Springs, Wyoming, who believed in the positive role of fire, was forced by his boss to put on "Smokey's" costume and appear at the County Fair. People came up to him and said "What are the fires doing? Poor bears!" He said, "Oh no, you don't really understand. I'm going to have more berries, etc." I think we *can* use "Smokey," since we already have him in place (rather than "Flower the Squirrel").

GELHORN: I would like to follow up on that. I think education is the *real* tool. I take students and teachers out into the fire burn area at Ouzel Park in Rocky Mountain National Park, burned ten years ago, and they all agree that it is a much more interesting area than it was before. It is not until you take them into the field and point out the positive aspects that they really realize the truth. I think there is a lot of hope in that fact. The trouble is that at my school (and most others), I can only have one field trip per semester.

JUDY: To bring up a similar problem, when I was with the Biological Sciences Curriculum Study (BSCS) and we were developing environmental education programs for grades K through 12 (as well as for introductory biology classes at the university level) . . . and they were excellent programs . . . the response we got from teachers was "We already have all this other stuff we have to teach. How can we devote four or five days or two or three weeks to another layer? We have to supervise lunch room, etc. We just don't have time to do it." This was from teachers in Colorado, a progressive State when it comes to environmental affairs. So I do not know how you break down that barrier. Inside this room, we are all believers. Outside this room there are many who just do *not* know about the benefits of fire.

CARRIER: People who came back to Yellowstone in October 1988 were amazed and expressed astonishment that the place was still there and functioning. The Park Service is doing a lot of good things, for example, a children's trail through burned areas. The tactile sense of being out in burned areas would be good. People who were in the Park during the fires were fascinated by them, but they were also torn. I was torn between the feelings of "This is good" vs. "I've got to get out of here."

QUESTION: Does the U. S. Forest Service have a communication system going on within your operation whereby Regional staff will be at local meetings to make comments, and do you see that as an important tool to enable legislation?

ROBERTS: We *do* have a person on staff (unique to our Region) who deals specifically with air quality issues, and he does a lot of work with the Environmental Protection Agency (EPA) and the local/state regulatory agencies in gaining recognition of the depth of the problem with which we are dealing. I do not see, however, the same degree of participation at the National level in the Forest Service. I also see the resource fields saying "Let someone else do it." But it is *our* collective responsibility. I think we are going

to have to do more in that area, otherwise we are going to end up with our hands tied to the point where we cannot do our job and do it well.

It is exciting to talk about the possibility of when we do land management planning to first define what we want that vegetation to do, in a way that it can perpetuate itself in cycle after cycle, and then go from there to develop our land management plan that will fit within that scheme. If we do that, then a lot of the dissension that we have now and the infighting among resources will suddenly dissolve and will pull us into a single-focus cause. Then we will be more effective internally and externally in dealing with the programs.

WILLARD: I would like to underscore that concept, because it was my observation, when I was on the Council on Environmental Quality (CEQ) in Washington, that we are as a government much too much *reactive* and not looking at the management of forests as a longrange process . . . toward an ideal. We always wait for a crisis and then do something, and that is the worst time because then you have a narrow band (of what you can do). Whereas, if you are planning 25, 50 or 100 years out, with the best knowledge you have at the time, then you can bring these plans constantly under the review of more recent science. If you do that, then you are really looking at it the way the ecosystem does, *not* the way the politics or the economics do. We desperately need that approach.

QUESTION: Shifting from the National Parks for a moment, what are the feelings about fire suppression in the National Forest areas, since we are dealing with the economics of recreation, timber harvest, etc.?

ROBERTS: The Forest Service usually reflects the wishes of the public in general. We have people within the Forest Service who oppose our policies, those who support our policies and those who really want to change our policies. In our implementation of fire suppression policies, right now we are looking at the most *cost effecient* way we can do that, but frequently that is not the most politically expedient (because of the way the public feels about fire). It is not effective to go to the public with a lot of technical jargon. They need to feel confident about what we are doing. They need to see sincerity from us . . . .that we are trying to do the best job of land management that we can do with their tax dollars. If we get that across, we will get public support. Beyond that, we do not have enough people with the expertise to use fire. Suppressing fire and using fire are two entirely different things, and the level of expertise is light-years apart.

COMMENT: Speaking from experience in Northern California (Six Rivers National Forest), a huge timber-producing area, the loss in 1987 was in terms of board feet (not watershed or wildlife losses). The emphasis then was only on what logs they could get out. I feel that the Forest Service has not budgeted enough for stream and watershed restoration.

ROBERTS: I have a problem with your stream restoration comment. If your talking about events that have naturally occured in that particular environment in the past, salmon require *clean* gravel in which to spawn. A lot of streams in the Pacific Northwest are not as productive as they could be because we have eliminated fires . . . stand replacement fires that resulted in high water events. These recut the stream channels and scoured them, producing clean gravel at periodic intervals. So when we talk about restoring watersheds, we better look carefully at how that fits with the *natural* ecosystem, and *not* take some manifestation of our own feelings about turbidity and other matters, and superimpose this on that particular watershed.

COMMENT: Good point!

KILPATRICK: In regard to the *cost effective* approach, I would challenge the Forest Service to *not* just look at the economics, but also evaluate the *ecological* benefits to the plant and animal communities (or to the economics of the State) of, for example, letting a fire go to Point B instead of putting it out at Point A. In other words, do not always take a pure cost effective approach.

WILLARD: But that is just what the Park Service was doing (during the fires) and they got "knocked" (publically and politically) for that decision.

ROBERTS: You must realize that the Forest Service operates under legal constraints, one of those being that when we use emergency fire money, we *cannot* use these funds to accomplish any land management purpose . . . and that is a dictate from Congress!

KILPATRICK: We at the Wyoming Game and Fish Department would like to see more aggressive use of prescribed fire (including planned ignitions) in Wilderness Areas. Only four have been used and burned just 4000 acres.

ROBERTS: We cannot have these in our Region due to low staffing available to respond.

KILPATRICK: You do not allow planned ignitions in Wilderness Areas.

ROBERTS: I hope that changes.

KILPATRICK: We have to sit and wait for lightning to strike.

ROBERTS: We have a lot of *internal* education to do, because many of our wilderness managers feel that early Spring or late Fall is the only time to burn, when there is little chance of "escape" fires, yet these ecosystems were never adapted to burn at those times of year, and it messes them up when we do that.

CARRIER: There is a more fundamental question here, and that is whether or not Wilderness Areas are to be manipulated at all, and that is what argues against planned ignitions in such areas.

KILPATRICK: They were manipulated for the last 100 years through fire suppression. Now what are we going to do?

BISHOP: I have to take issue in terms of number of years. It has only been since the 1950's that we have been effectively able to suppress wildfires in Yellowstone, so we are only talking about one tenth of one fire cycle (if a fire cycle is 250-400 years), so the amount of change that humans have wrought on that system is minimal at best. On the Northern Range (of Yellowstone) it is a different story, since the normal fire cycle there is 20-25 years, and there we had the Army (since 1886) vigorously stomping out fires . . . so there *are* vegetation changes. The "Catch 22" is that you cannot have the kind of fires that will cause the changes we want to achieve unless you get the kind of fires going like we had the Summer of 1988 . . . and what manager will do that on July 15th in a drought year when the wind starts blowing!

KILPATRICK: To comment on fire suppression and our effectiveness at it, I think we *were* effective before the 1950's because we put out so many small fires *before* drought would have allowed them to eventually get big.

BISHOP: Don Despain pointed out to me a report that suggested that a certain percentage of fires were contained within less than one acre in a certain number of our National Forests. Then in the last 16 years they were allowed to burn. More or less the same number of fires then burned roughly about the same acreage. It just depended on when a storm came and put them out.

ROBERTS: In the chaparral area around Palomar, CA, fires were larger and more intense because there had been suppression for many years, compared to areas that had been allowed to regularly (naturally) burn.

BISHOP: Chaparral is quite different from lodgepole pine, and both are quite different from spruce/fir. That is to say, each ecosystem has its own "recipe." Natural fire cycles are much shorter in some areas than in others.

ROBERTS: My vegetation inventories indicate that we have natural fire cycles at much more frequent intervals than what is stated in the literature.

CARRIER: As a disseminator of facts, I can tell you this is really a confusing argument to me! In the Summer of 1988, I may have been one of the *only* journalists *not* to talk about the accumulation of fuels, largely because of the time I spent with Don Despain. He stressed that if one considers even an 80-year period of suppression in Yellowstone, that you are only talking about 20% of fuel accumulation over a natural cycle, which he said was insignificant. So as an example of blowing things out of proportion, most journalists writing about (and people talking about) the fires said that the accumulation of fuels has and continues to be the significant factor. I do not know what the facts are, whether Despain is right, or your two or three missed cycles are correct. I think the facts *are* important in deciding what we end up doing from a management viewpoint.

QUESTION: What about feeding elk in the Cody, WY area?

KILPATRICK: Wyoming Game and Fish Department has taken an administrative stand against feeding wildlife. As a result of the fires (and other factors), the public is in the state of hysteria. The problem in Northwest Wyoming is much more the result of a two-year drought, which will be the main factor if there is any winterkill, and will *not* be a result of the fires.

QUESTION: Are there more elk showing up at the Jackson Hole refuge?

KILPATRICK: No, about normal (9500 on feed). Southern Yellowstone elk normally vacate toward Jackson in winter. The fires did not hurt any winter range in the southern area. As a matter of fact, we are proposing to burn between Yellowstone and Jackson this year to improve habitat.

QUESTION: Addressing air quality in the Pacific Northwest, most problems are related to clearcut (slash) burning. How does that relate to wildlife?

ROBERTS: The Pacific Northwest is a difficult situation. The Cascades are essentially the break between a temperate

rain forest on the west side and a dry, high dessert on the east side. The Douglas-fir region on the west side is generally managed by even-aged 40-acre clearcuts, resulting in tremendous accumulation of residue on the ground. These have typically been burned in the past, otherwise it is difficult to replant or reseed the area. Severe fires used to be the natural way that old stands of Douglas-fir were prepared for new growth and regeneration of a healthy forest. By not burning the clearcut slash, the phytotoxins in the dead vegetation accumulations have had a slowing effect on the new growth. This is known as "Allelopathy," which is the deleterious effect of chemicals being released on the new vegetation that is trying to become established. I do not know the complexities of it, but studies have shown that there is a strong suppression of regeneration from the decomposing matter.

Field burning in Oregon has resulted in restrictive air quality regulations. Forest burning has been "caught up" in these. It may take some years before prescribed burning is again allowed in this area. It will take recognition by the public and a change in the law. People think of timber production as a big factor in the Pacific Northwest, but only 55% of the land there is actually managed for timber. About 45% is not managed at all, and the use of fire is the only way to keep it healthy.

Prescribed burning is a critical issue in practically any place to which we may wish to turn in this nation.

QUESTION: When fire is so intense that it burns down to the mineral soil, how does that effect revegetation and wildlife?

ROBERTS: There has always been a natural erosion process that occurs following a fire, prior to human interference with it. In our current day management ethics, erosion is considered to be "awful," but that is not necessarily true. That is only when it is out of context with the normal response of the ecosystem.

WILLARD: In the Pacific Northwest, Douglas-fir must have open mineral soil and sunlight in order to reproduce. This is not true in the Rocky Mountains. We do not know all the ins and outs on this, or on phytotoxins (mentioned above), because we have not had the needed ecosystem studies, about which we talked earlier. The reason for this is that as a nation, we tend to do *point*-type research instead of the big *integrated* type. We did have a five-year international biological program that brought us a great deal of understanding, but not all that we needed. Much more research is necessary, perhaps a program that lasts for 25 or 50 years.

QUESTION: Since education is important and should be emphasized, do you see this as an area of funding that is going to grow?

ROBERTS: I talked to the Fire Management Director in Washington, DC recently and expressed my concern that we have not set aside enough dollars in the budget to address the problem of fire education. We cannot continue to depend on the media for free advertising. We must do a better job ourselves in getting the message across that *we* want to portray. We are *not* doing it now. We are living in dreamland if we think we are going to get additional funding to do the job of public relations. What we have to realize is the ultimate cost of *not* doing it. That is a tremendous problem. We are going to have to set aside part of our funds to address that purpose. Education on local-level problems will have to come from local budgets, since there is not enough dollars at the Regional level.

WILLARD: What about diverting funds from "Smokey?"

ROBERTS: You would be surprised how underfunded the "Smokey" program is. We get $1000 per Region per year. The suit for "Smokey" costs $1700. We *do* get a lot of donated ads.

KILPATRICK: I would like to expand on the problem we have in Wyoming with fire suppression, not only in forested areas, but also in sage and mountain scrub stands along the foothills, and even as low as the Red Desert. We are looking at natural fire frequencies that, according to fire ecologists, are supposed to be between 30 and 50 years. Mule deer depend on these particularly. Some sage is 136 years old, with no leader growth, in various stages of decadency. We are trying to provide an uneven-age mosaic.

ROBERTS: All the agencies need to do a better job of monitoring and evaluating the work that we do. We frequently get the funds, go out and burn a small area of 1000 acres or less, then turn our backs and say "Great! It's finished, and we've done a good thing." But that is not necessarily true. We do not know. We have not made long-term plans. When will it need to be burned again? What has been the response? The composition of the plants may change but not the frequency. We need to know how the phenology of the plants reacted to fire. For example, grasses may grow more, but there are no new plants. Monitoring and evaluation will be really helpful to us in the future, and *sharing* that information is most important. (It does no good in the desk drawer!)

QUESTION: Do you see the need for defoliants?

KILPATRICK: We objected in the 1960's to the Bureau of Land Management (BLM) killing sagebrush in massive stands this way. But 20 years later, these are the only areas with young, vigorous plants, to the enhancement of deer winter range.

An interesting technique is to crisscross an area with an airplane spraying half-dosages, so that some areas get 50%, some get 100%, and some get none. This creates a mosaic. If the defoliants are safe, we should use them. For example, 2,4-D makes aspens "sucker" extensively.

ROBERTS: We are *not* currently using herbicides, especially with the cost difference; just prescribed burning, which ranges from $2.50 to $5 (average: $3.50) per acre . . . a low cost.

In prescribed burning, we must remember to keep the fire in context with the ecosystem. So often we burn too small an area.

For lodgepole pine, 3000–10,000 acres is effective and keeps down the cost.

DAVIS: To conclude this panel, what I hear is that we need to go back to our agencies and local wildlife societies and take some action, instead of just talking. We need to *monitor* these processes, and we need to *educate* the public!

SESSION V:

MITIGATION OF IMPACTS FROM NATURAL RESOURCE DEVELOPMENT

OFF-SITE HABITAT MITIGATION: A REGIONAL APPROACH FOR RESOLVING CONFLICTS BETWEEN LAND DEVELOPMENT AND HABITAT PROTECTION

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Abstract: In 1986, the Florida Game and Fresh Water Fish Commission initiated a pilot off-site mitigation program to determine the efficacy of mitigating impacts created by large scale development projects on protected wildlife populations. Referred to as the Wildlife Resource Acquisition and Management program (WRAM), it offers an alternative to past on-site protection efforts by allowing developers the option of paying for the acquisition of equivalent habitats elsewhere within a region. WRAM is jointly administered by the local regional planning council, The Trust For Public Lands (TPL), Florida Defenders of the Environment (FDE), and the Commission. Mitigation monies received from developers are deposited into an interest-bearing account that is administered by the TPL. TPL plays the principal role in the acquisition process and in turn, transfers ownership of acquired lands back to the State. Both the Commission and the regional planning council are involved with selecting lands for acquisition. Management responsibility is assumed by the Commission and funded by a separate interest-bearing account that is administered by FDE. WRAM has the biological advantage of consolidating many smaller habitat preserve parcels into a single unit, thus increasing both species richness and management potential of preserve areas. In two years of operation, WRAM has generated approximately $700,000 towards land acquisition within the State of Florida.

INTRODUCTION

Today more than 102 different species of wildlife appear on Florida's official list of endangered and potentially endangered fauna (Wood 1988). Despite the trend towards more additions to the list, there is an increased regulatory emphasis being directed at the mitigation of impacts of development on the state's wildlife resources. Florida's Development of Regional Impact (Chapter 380.06 F.S.) process is currently one of several state land use review programs that considers the impacts of new development on important wildlife resources. As part of the DRI application process, developers document the occurrence of protected wildlife populations within a proposed development site, and discuss the steps that will be taken to mitigate for the project's impact on these resources. State agencies including the Florida Game and Fresh Water Fish Commission typically review these applications and may submit habitat protection recommendations to the appropriate regional planning council coordinating the review. When listed species are observed utilizing a proposed project area, mitigation usually involves the protection of the core habitat "on-site" for the purpose of maintaining the target species and it's habitat in perpetuity within the development site.

ON-SITE MITIGATION

The process of "on-site" mitigation or protection has been the target of both economic and biological criticism. Historically, the only mitigation option available to a developer was to preserve the critical habitats of a protected species and restrict development to the remainder of the site. Obviously, this approach may pose a serious threat to the economic viability of a project, regardless of the property's intrinsic developmental potential. For this reason, habitat protection efforts have been perceived as a direct challenge to the entire economic success of a project, particularly when habitat protection is proposed for a species that requires a large area in relation to the total size of the development.

But even in instances were habitat protection can be accommodated by development, biological constraints may often result in less than desired levels of resource protection. Many protected species such as the red-cockaded woodpecker, southeastern kestrel, gopher tortoise, and Sherman's fox squirrel utilize fire-adapted plant communities, or those that are maintained only through the recurring incidence of fire. In the absence of fire, these communities gradually grow into completely different plant communities, thus altering habitat characteristics beyond a point that is acceptable for species utilization. While the practice of controlled burning can be used to maintain fire-adapted systems and mimic natural fire regimes, this activity does involve a high margin of risk and liability, especially when used in close proximity to commercial and residential development. As a result, most preserve areas in development sites tend to succeed to later stages of plant succession, and this leads to the eventual degradation of the habitat of the species that served as the basis for the original habitat protection effort.

Another criticism of "on-site" habitat protection has been that it normally results in the protection of a small, isolated population of a target species that is eventually surrounded by relatively high intensity development. In most cases, the amount of protected habitat within a development is less than 50 acres in size, and rarely does an opportunity exist to connect these areas to larger publicly owned lands. Also, consideration is seldom given to providing more than what might be considered the "minimum viable habitat requirement" for a species, or for the use of buffer strips around the core area to insulate

wildlife from adjoining development. Consequently, wildlife populations within these small preserves tend to experience severed migratory corridors and a higher incidence of genetic depression. Human-induced disturbance and mortality also tends to be higher as a result of the introduction of domesticated pets and increased levels of vehicular traffic.

WILDLIFE RESOURCE ACQUISITION AND MANAGEMENT PROGRAM

In response to some of the problems associated with "on-site" mitigation, Florida Game and Fresh Water Fish Commission officials have recently developed the Wildlife Resource Acquisition and Management program as an alternative wildlife mitigation strategy. The program allows for the mitigation of wildlife resources to occur "off-site" from the development through the contribution of funds into a regional habitat acquisition program. Monies collected on behalf of the program are used for the acquisition of a state owned and managed Regional Mitigation Park facility. The facility itself would be a minimum of 1,000 acres in size, and acquired in an incremental fashion over a given period of time depending on the rate of developer participation.

From a developers standpoint, there are clear advantages for participating in a regional off-site mitigation program. Foremost is the opportunity to mitigate impacts to significant wildlife resources without assuming any loss of the development potential of his property. Presumably, those developers mitigating for impacts on either small-sized or high-priced lands would stand to benefit the most from this program.

Biologically, there are both costs and benefits to the program. The most obvious drawback is that it will always result in a direct loss of/or impact to certain significant wildlife resources that inhabit a proposed development site. In essence, a developer who elects the off-site option would be exempt from any requirement to protect significant wildlife habitat within a proposed development.

On the other hand, the program offers several biological benefits. First, it provides an opportunity for wildlife habitat protection efforts to become proactive by acquiring significant habitats before they become subjected to new growth and development pressures. Additionally, the program offers a mechanism to consolidate many otherwise small and isolated preservation parcels into a larger unit. With a larger unit comes the ability to protect more individuals of a target wildlife population, thus maintaining genetic integrity and reducing the probability of random extinction (Boecklen 1986). Larger tracts also allow for the safe and efficient use of management activities such as controlled burning. More importantly, this program allows for wildlife resource problems and opportunities to be considered on a regional level, particularly for those species with large territory requirements (e.g. scrub jay, indigo snake, red-cockaded woodpecker, etc.).

IMPLEMENTATION

Responsibility for administration of WRAM is divided between the participating Regional Planning Council, The Trust For Public Lands (TPL), the Florida Defenders of the Environment (FDE), and the Commission. Both the Commission and the participating regional planning council share the role of selecting suitable sites for acquisition within the region. TPL's role as a non-profit intermediary is to administer the disbursement of all funds collected on behalf of the Wildlife Resource Mitigation Fund, an account whose funds are specifically earmarked for mitigation park acquisition. This organization is also active in both the negotiations and contractual phases of land acquisition for the wildlife resource mitigation park. FDE is charged with the establishment and administration of a separate land management fund which receives ten percent of all monies that are directed towards the mitigation park program. In order to provide a perpetual source of management monies, only the interest that accrues on behalf of this account is available on a yearly basis for land management activities.

The program has operated in the following manner. In certain cases, land developers have been given the opportunity to mitigate the fish and wildlife impacts of a proposed development project either by following the Commission's initial recommendations for on-site habitat protection within the development site, or by electing to participate in the mitigation park program. Developers who have elected to participate in the program have made a payment to the Wildlife Resource Mitigation Fund that is sufficient to acquire an amount of acreage equivalent to that which was recommended for protection on the original development site. These monies are then applied toward the acquisition of lands within the mitigation park. The formula used thus far for determining mitigation bank payments is based on the average cost per acre of undeveloped land within a particular region. However, once a mitigation park facility is selected, the per acre cost for the acquisition of that facility will be used. Approval to utilize the mitigation park option must be secured from both the participating regional planning council and the Commission. An example of an inappropriate use of the mitigation park option could include situations where a proposed development project would result in serious impacts to a state or federally listed endangered species. In this case, on-site protection of the resource is the only option available to a developer.

CONCLUSION

Though still in its infancy, WRAM is gaining rapid acceptance within the development community. Currently, mitigation park programs are operational in both the Northeast Florida and Withlacoochee Regional Planning Councils. Approximately $700,000 has been collected

between both programs, and these monies will be used to initiate mitigation park acquisitions within each respective region. In time, it is expected that all eleven of Florida's regional planning council jurisdictions will have a mitigation park program available to assist with the resolution of land use and wildlife resource conflicts.

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IMPACT FEES FOR WILDLIFE HABITAT

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Abstract: One way for local governments to compensate for the loss of wildlife habitat in rapidly growing Florida is to enact impact fees that generate revenue for the purchase of wildlife habitat. Although these habitat impact fees cannot compensate for the loss of all wildlife resources, such fees do allow local governments to compensate for habitat loss by protecting and preserving other habitats elsewhere within their jurisdiction. The habitat impact fees are charged to new development in order to compensate for the loss of habitat caused by that development. One method of assessing habitat impact fees is to determine what types of habitat will be lost to development and then compensate proportionally for each habitat lost. A simpler method of impact fee is to compensate for all habitat types equally. The ratio of habitat lost to habitat compensated for is determined by the local government. Two alternatives to local habitat impact fees are a statewide habitat impact fee or a local tax referendum to purchase wildlife habitat.

INTRODUCTION

Florida is one of the fastest growing states in the nation. The new development that results from this fast population increase is causing the rapid destruction of wildlife populations and habitats. The large number of vertebrate species listed as endangered and potentially endangered attests to the fact that wildlife species are diminishing throughout the state (Wood 1988). This rapid loss of wildlife populations and habitat has led state agencies concerned with wildlife to cooperate with local governments in a search for ways to preserve and protect wildlife and open space. The key to protecting wildlife is to protect, preserve and manage its habitat.

As new development destroys wildlife habitat, a cost is incurred to the environment of the local area and region that has largely gone unrepaid in the past. This cost may be divided into two areas, opportunity costs and ecological costs. Opportunity costs are the costs to the residents of the area and the region, such as the opportunity to hunt on the existing habitat area. These opportunity costs are related directly to the utilization of the wildlife and their habitat as well as the general use of the open space. The ecological cost is incurred with the loss of certain wildlife and plant species, the decrease in the biodiversity of the local area, the decrease in habitat size, the decrease in the local population of plants and animals and the fragmentation and loss of habitats from the regional landscape. Generally, in the past, if wildlife habitat was to be preserved, the cost of preservation and management was either borne by the general taxpayer or a wildlife-oriented special interest group. The developer has not generally been held responsible for mitigating for the habitat lost.

The exception is large developments, which are defined by Florida Statutes as Developments of Regional Impact (DRI) and which have regionally significant wildlife resources on the development site. These DRIs have set aside habitat preserves or have given land with similar habitat value to a managing agency or have contributed a set amount of money to a wildlife habitat mitigation bank to be used to purchase offsite lands. Requiring large developments to compensate for the loss of habitat while smaller non-DRI developments have no such requirements has raised the issue of fairness of government regulation.

If wildlife habitat is considered a valuable resource to the local community and government, it is logical that all persons diminishing this resource by development or other means should in some way compensate the local community for the loss. This compensation could be to purchase wildlife habitat so as to ensure that the habitat will not be lost to future development.

IMPACT FEES

One way for local governments to deal with the rapid loss of wildlife habitat is to enact impact fee ordinances that require new development to mitigate for the loss of habitat. In general, impact fees are calculated fees set by local governments that are paid by developers to cover a portion of the cost of providing the new facilities and infrastructure needed to serve the newly developed areas. Impact fees are generally used to finance capital improvements, such as new roads, sewage systems, schools and parks. The need for these facilities is a direct result of the new development. An impact fee for wildlife habitat would charge the developer a calculated fee in order to compensate for the loss of wildlife habitat resulting from the development. The funds collected from the wildlife habitat impact fee would be used to purchase wildlife habitat in the local area.

When considering impact fees for wildlife habitat, we need to remember that these fees compensate for the loss of habitat. Wildlife habitat impact fees cannot replace lost habitat, but only attempt to ensure that other habitat is preserved and protected. Habitat impact fees should only be used to compensate the loss of private lands, not for the loss of public lands. Lands already protected under public ownership should remain in that ownership and not be considered as areas for potential development. There are certain valuable habitats, such as those containing endangered wildlife, wading bird rookeries or other

irreplaceable wildlife resources, that cannot be compensated for, so these resources must be preserved on the site. These irreplaceable wildlife resources cannot be logically compensated for with land purchased from impact fees.

Legal decisions and precedents in the State of Florida have established that impact fees are legal so long as the new development only pays its proportionate share of the capital facilities and service costs to local governments. Impact fees cannot require new developments to pay past costs accruing from previous development. The rational nexus standard is used to determine if the impact fee fairly assesses the impacts of the development (McKay et al 1986). There are two key parts of the rational nexus standard: (1) the need for the new capital facilities or services results directly from a new development or from the resulting population growth (Bosselman and Stroud 1985); and (2) impact fees must benefit those who pay the fees (McKay et al 1986).

Any impact fee for wildlife habitat must pass the rational nexus standard. If the impact fee revenues are used to purchase wildlife habitat in the area of new development, either in the county or region, the habitat would directly benefit the residents of the new development by providing wildlife-oriented recreation. One mechanism for insuring that habitat impact fees benefit those who pay the fees would be to set up a habitat trust fund that would be managed to ensure that fees are not lost in the general revenue at the local government level (Downing and Frank 1987). Fees in this fund could only be used for habitat acquisition and management within the local jurisdiction. Since surveys conducted by the Florida Game and Fresh Water Fish Commission found that wildlife is important to the majority of Floridians (Duda 1987), the assumption could be made that preserving wildlife habitat near a new development would directly benefit the residents of that development.

METHODS FOR ASSESSING HABITAT IMPACT FEES

Local governments that draft wildlife impact fee ordinances will need to be assured the methods for assessing the fees pass the rational nexus standard. The following are examples of logical assessments of habitat impact fees that appear to meet the standard.

The first method for determining how a habitat impact fee should be assessed is based on the assumption that, if a particular type of wildlife habitat is destroyed by new development, a certain proportion of that type habitat needs to be acquired to compensate for the habitat lost. In order to use this method, the amount of each habitat type on the site being developed must be enumerated. An assessment of the habitat types on the site should be completed prior to commencing the development. The statewide habitat mapping, using the LANDSAT remote sensing data, currently being undertaken by the Florida Game and Fresh Water Fish Commission will provide generalized habitat maps throughout the state. These maps could be the basis for the habitat maps needed for this method. Another approach would be to separate the locality into several broad, generalized habitat types that could be determined by elevations and soil types. The elevations and soil types could be used to identify habitat types even if the site had previously been disturbed by development or other activities.

Using this approach, the following method was developed for assessing habitat impact fees. The first step involves determining the number of habitat types within a jurisdiction of the governmental entity. Each habitat type would be given a relative value, which is determined by the importance of the habitat to listed species (endangered and potentially endangered) of wildlife, scarcity of the particular habitat in the area, the general fish and wildlife value of the habitat and other ecologically significant aspects of a particular habitat.

The following equation illustrates one way habitat impact fees could be assessed on new development using this method:

$m_{(n)}$ = impact fee for the habitat on the development
$h_{(n)}$ = value of a particular habitat (the values would range from 0.1 for least valuable to 1.0 for most valuable)
$a_{(n)}$ = number of acres of a particular habitat type on a site
$c_{(n)}$ = cost of purchasing an acre of the particular habitat type in the area

The general equation for a development with two habitat types would be:

$$m_{(1+2)} = h_{(1)} (a_{(1)}) c_{(1)} + h_{(2)} (a_{(2)}) c_{(2)}$$

The following practical example illustrates how this methodology might be used.

Knox County has two basic types of wildlife habitat: 1) high, dry sandhills covered with xeric vegetation; and 2) xeric oak scrubs. The wildlife habitat values of these types are determined to be .4 for the sandhills and .7 for xeric oak scrubs. The 750-acre Short Oaks residential development has 300 acres of sandhill and 350 acres of xeric oak scrub in Knox County. Short Oaks will have 2,600 single family homes on 1/4-acre lots at build out. The cost of acquiring an acre of sandhill habitat is $3,300 and the cost of acquiring xeric oak scrub is $3,000 per acre . What will the habitat impact fee be for the entire development?

M_{1+2} =
0.4 (300 acres) $3,300/acre + .7 (350 acres) $3,000/acre =
$1,131,000

Based on this method, the impact fee for the entire

development would be $1,131,000.00. If this were to be assessed on a per residential unit basis, the total impact fee ($1,131,000.00) would be divided by the number of residential units (2,600) arriving at an impact fee of $435.00 per residential unit.

Possibly the simplest method for determining impact fees for wildlife habitat is based on the assumption that all land has similar potential value as wildlife habitat. One habitat, such as sandpine scrub, would be given the same value as another habitat, pine flatwoods for instance. When using this method all habitats including those that had been altered by humans, such as improved pasture or croplands, would be given equal habitat value. If the impact fee is to reflect the full cost of obtaining the replacement habitat at a ratio of 1:1, then we can use a modified version of the first equation to determine the impact fee:

m = impact fee for the development
a = number of acres on site
c = cost of purchasing an acre of habitat
$m = c(a)$

An example of this impact fee assessment methodology follows:

The Bare Meadows Subdivision is a single-family residential housing development on a 120-acre tract in Koger County. There will be 340 houses built in this development. The cost of acquiring an acre of wildlife habitat in the Koger County Wildlife Mitigation park is $1,500 per acre. What will be the impact fee for the entire development? What would be the impact fee per house?

$$m = 120 \text{ acres } (\$1,500/\text{acre}) = \$180,000$$

$$\text{assessment per house} = \frac{\text{total impact fee}}{\text{number of houses}}$$

$$= \frac{\$180,000}{340} = \$529.41$$

Using this method, the entire development would be charged an impact fee of $180,000 or each house would be assessed an impact fee of $529.41.

One-for-one compensation of habitat may not be politically or economically feasible for some local governments adopting habitat impact fees. A local government may choose to set the impact fee so that one acre of habitat may be purchased for every two acres lost to development or so that one acre of habitat may be purchased for every four acres destroyed. The following modification of the basic impact fee equation allows for whatever ratio of compensation is desired by a local government:

R = number of acres destroyed for each acre compensated;

$$m = \frac{c(a)}{R}$$

The following is an example of how a local government can compensate for habitat loss at a ratio of their choosing.

The county commissioners of LaSalle County have adopted an impact fee ordinance that would generate revenues sufficient to purchase one acre of habitat for every three acres of habitat developed. The Moonland Development Corporation is developing a trailer park on 220 acres of pine flatwoods in the northeastern part of the county. The full cost of purchasing wildlife habitat in LaSalle County is $3,000 per acre. What should the impact fee be for this development?

$$m = \frac{c(a)}{R} = \frac{\$3,000/\text{acre } (220 \text{ acres})}{3} = \$220,000$$

The wildlife habitat impact fee for this trailer park would be $220,000.

One advantage of wildlife habitat impact fees is that the fees could be used to encourage on-site preservation of habitat by crediting developers for preserving habitat on the developed site. For example, a developer proposes to build a subdivision adjacent to a state forest with quality wildlife habitat. The developer agrees to preserve 80 acres of upland habitat adjacent to the state forest to serve as a habitat buffer to the development. The local government could give the developer credit toward impact fees equal to the fair market value of the preserved land.

With habitat impact fees, local government will need to determine what areas should be preserved as wildlife habitat. Once these habitat areas are designated, the local government could then determine the period of time over which these habitats would be acquired. If the areas were in need of immediate preservation to avoid being developed, a bond issue might be needed as a source of initial capital to purchase the designated preservation areas. New development could then be assessed impact fees over a projected time period to pay for the purchase of the designated wildlife habitat. This method would be similar to the fees being paid by developers and builders in Coachella Valley, California, to assist in the purchase of a 14,000-acre preserve for the endangered fringe-toed lizard (Holing 1987).

A potential problem with a local wildlife habitat impact fee could be the difficulty of adopting ordinances county-by-county in Florida. There could be resistance from the parties who might be directly affected by the new impact fees, possibly developers, builders and contractors. The fact that impact fees will fairly charge all development, large and small, instead of just the large developments, as has been the case through the DRI process, may persuade some of those interests to support such impact fees. The popular support by Floridians for wildlife and increased spending on the environment and wildlife conservation should also aid in the adoption of habitat impact fee ordinances (Duda 1987).

ALTERNATIVES TO THE LOCAL IMPACT FEES

One alternative to the local habitat impact fee might be some type of statewide habitat fee or tax. Such a fee could be based on the amount of habitat lost to development, similar to the assessments described for the local habitat impact fee. One advantage of a statewide impact fee is that development in all counties could be assessed equally, rather than each having different impact fees and some counties not having an impact fee at all. The funds generated from a statewide habitat impact fee could either be targeted towards habitat of statewide significance or distributed to the regions to acquire habitats of significance to each region. Funds might also be used to link isolated habitats within the state.

A local alternative to habitat impact fees is a tax referendum to increase property taxes over a fixed period of time in order to acquire wildlife habitat. Three counties in Florida Hernando, Volusia and Marion have passed tax referendums to purchase environmentally sensitive lands. There appears to be good public support for the idea of using the taxpayer's money to purchase these lands, which are generally good wildlife habitat. One disadvantage to a tax referendum is that new development does not pay any fee for the destruction of wildlife habitat. Instead this cost is borne by all residents, new and old.

An advantage of a county habitat impact fee is that it allows counties experiencing the highest rates of population growth to enact impact fees appropriate to their areas. The funds generated from the impact fees are sure to be used to acquire habitats (land) that will directly benefit the new residents and other residents of the county. In contrast, if a property tax or sale tax is used to raise revenue for purchasing land for wildlife habitat, all residents (both existing and new) will be taxed. Impact fees also allow local governments to have greater control over their own affairs. Local governments could target and acquire significant wildlife habitats before the areas are platted for development, thereby avoiding future conflicts with developers wanting to develop these. Furthermore, the counties and municipalities have clear direction from the Florida Legislature (Florida Statute 380.06(15) and (16)) to enact impact fees.

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IMPACTS AND MITIGATION FOR CANADA GEESE AT TWO HYDROELECTRIC PROJECTS IN NORTHWEST MONTANA

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Abstract: Beginning April, 1984, the Bonneville Power Administration funded a study of the effects of the operation of Hungry Horse and Kerr Dams on the western Canada goose (*Branta canadensis moffitti*) population of the Flathead Valley, northwest Montana.

Annual nest losses to flooding and predation occurred as a result of dam operations. Ten percent of river island ground nests failed due to flooding during peak annual runoff. Nests on stumps in the remnant Flathead River delta were strongly influenced by the operation of Kerr Dam. Nest success ranged from 58 to 81%. Of the annual nesting effort, 54% took place on elevated sites that were secure from the flooding and dewatering effects of fluctuating water levels.

The annual average production was more than 400 goslings. Eight of nine important brood-rearing areas were off-river sites with minimal water level fluctuations. At Flathead Lake, extensive mudflats separated the lake from upland vegetation, forcing broods to travel and feed more to meet their energy requirements. No resultant effect on gosling survival could be verified. An exotic emergent plant, *Butommus umbellatus*, was heavily used by broods.

Large-scale losses (2000 acres) of important waterfowl habitats occurred since the construction of Kerr Dam. A remnant delta used traditionally for nesting was lost completely in 1987. Stumps used for nesting were lost at a 33-89% annual rate. A minimum of 22 secure nest sites, representing 16% of the study area population, will have been lost by the mid 1990's.

Operation of Hungry Horse Dam for flood control may actually prevent nest failure in some years. Recommended interagency mitigation alternatives for losses due to Kerr Dam included the construction of a subimpoundment with islands, nest structures, brood habitat manipulation, and habitat acquisition. Results of the study have applicability to water developments elsewhere in the West.

INTRODUCTION

The Columbia River Basin Fish and Wildlife Program was developed by the Northwest Power Planning Council in 1982, in response to the Pacific Northwest Electric Power Planning and Conservation Act of 1980. The Program specifically calls for evaluation of effects on wildlife and wildlife habitat attributable to both Hungry Horse and Kerr dams in nothwest Montana and development of mitigation plans to offset these effects. This study (BPA Project 83-498) was designed to address the effects of these projects on the western Canada goose (*Branta canadensis moffitti*) population inhabiting the northern portion of the Flathead Valley in northwest Montana. A similar study was conducted by the Confederated Salish and Kootenai Tribes (CSKT) to evaluate the impact of water level fluctuations due to Kerr Dam on Canada goose populations inhabiting the southern half of Flathead Lake and the lower Flathead River below Kerr Dam. Both projects were also coordinated with the objectives of the Flathead Valley Canada Goose Committee (a multiagency working group), established in 1975 to promote effective Canada goose management in the Flathead Valley.

Hungry Horse Dam is owned and operated by the U.S. Bureau of Reclamation. The dam, located on the South Fork of the Flathead River, was completed in 1953, and is operated primarily for hydroelectric energy production and flood control. Construction and operation of the dam as a power peaking facility has had a pronounced effect on water levels in the main stem downstream, except during those times of the year when runoff from the unregulated North and Middle forks overrides these effects (Fraley and McMullin 1983). Since 1982, a year-round minimum flow restriction of 3,500 cubic feet per second (cfs) has been in effect to protect and enhance salmon spawning in the main stem. Since that time, abnormally low flows probably no longer occur during the goose breeding season. Peaking operations at Hungry Horse can cause abnormally high flows early in the nesting period, when river levels can fluctuate 1 m or more daily at Columbia Falls.

Kerr Dam, located 7 km downstream of the natural outlet of Flathead Lake, was completed in 1938. The dam is operated by the Montana Power Company (MPC) under a lease with the CSKT primarily for hydroelectric energy production and flood control, and controls water levels of Flathead Lake between elevations 2,883 ft and 2,893 ft. Maximum lake elevation is reached in July and maintained into September, and minimum lake levels occur in March and April. MPC is currently preparing a management (mitigation) plan for Kerr Dam, under the terms of a 1985 relicensing agreement (FERC Lic. No.5-004/2776-000). The dam altered the annual pattern of fluctuations in the level of Flathead Lake, by maintaining the lake at peak spring runoff levels throughout most of the year (Fig. 1). Subsequent habitat losses have been most severe in the delta area at the mouth of the river (Fig. 2), where continued erosion due to wave action had reduced the delta to two small remnant islands prior to our study (Moore et al. 1982). Wave action (Moore et al. 1982), freezing and desiccation as water levels recede and advance have precluded establishment of emergent aquatic vegetation along much of the north shore, although

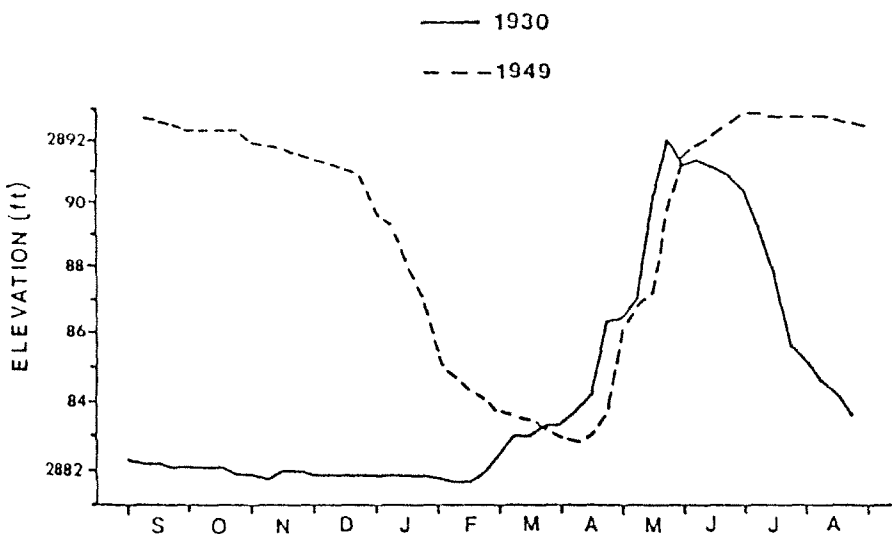


Figure 1. Annual water level fluctuations of Flathead Lake before and after the construction and operation of Kerr Dam.

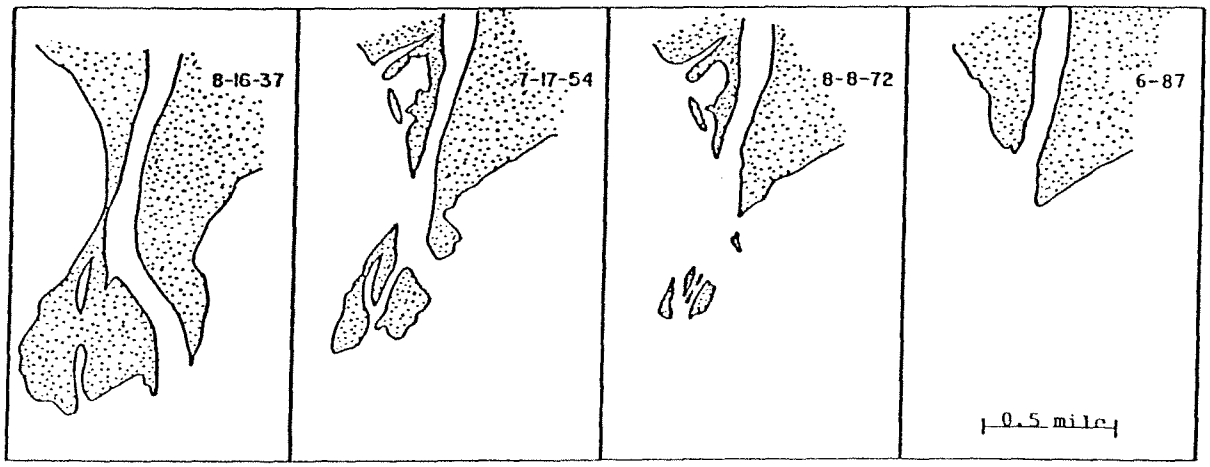


Figure 2. Changes in the Flathead River delta, 1937–1987, north shore Flathead Lake (after Moore et al. 1982).

the acreage of cattails (*Typha latifolia*) and the exotic *Butomus umbellatus* have increased in some areas over the past few decades (Hauer et al. 1988). Expansive mudflats separate upland vegetated areas from open water when the lake is low.

As early as 1954, there was a concern that the broad expanses of mudflats present during the brood-rearing period might expose goslings to an increased risk of predation (Barraclough 1954). Craighead and Stockstad (1964) documented decreases in the Flathead Valley goose population during the 1950's, but attributed them to excessive hunting pressure rather than to habitat characteristics or hydroelectric operations. Ball (1981, 1983) documented Canada goose nesting populations and success in the Flathead Valley during 1980, 1981, and 1982. Recent nesting populations for the entire Flathead system compared favorably to those of the 1950's, (Geis 1956, Craighead and Stockstad 1961, 1964), although decreases in nest numbers occurred on the lower Flathead River and the northern shore of Flathead Lake (Ball 1983). Ball suggested that goose productivity was limited by the lack of suitable brood habitat along most of the lake shoreline and by a shortage of secure nesting sites along the lower Flathead River. Particular concerns related to the effects of water level fluctuations included habitat losses due to erosion, flooding of nest sites, and dewatering of river channels, which exposes island nest sites to predation (Ball 1983).

Extensive erosion of the islands at the mouth of the Flathead River was documented by Moore et al. (1982). Habitat types lost to erosion in the delta islands and elsewhere along the north shore had not been previously documented. The effects of island flooding and channel dewatering were documented along the Flathead River below Kerr Dam (Gregory et al. 1984), but had not been assessed for nesting areas along the main stem above Flathead Lake.

Objectives

The objectives of this study were to document the size, distribution and productivity of the Canada goose population in the northern Flathead Valley, and how they are influenced by water fluctuations due to hydroelectric operations at Hungry Horse and Kerr dams. Specifically, we wished to: (1) identify effects of water level fluctuations on goose nesting success and nesting habitat, particularly at the Flathead Lake WPA and on main stem river islands; (2) identify effects of water level fluctuation on gosling survival and brood-rearing habitat; (3) document characteristics of currently utilized nesting and brood-rearing habitats; (4) develop estimates of past and ongoing habitat losses along the north shore of Flathead Lake, and along the river above the lake; (5) identify seasonal trends in distribution and numbers, and habitat use; formulate recommendations to protect and enhance Canada goose nesting habitat and nest success; and (6) formulate recommendations to protect and enhance Canada goose brood-rearing habitat, consistent with management goals for the species and other wildlife resources of the Flathead Valley.

Study Area

The study area included 74 km of the main stem Flathead River from its confluence with the South Fork, approximately 6.5 km east of Columbia Falls, downstream to the mouth of the river, on the north shore of Flathead Lake 1.4 km west of Bigfork (Fig. 3). Islands and riparian benches along the upper river reach are primarily dominated by deciduous (*Populus trichocarpa*) or mixed (*Populus/Picea* spp.) forests, while the dominant land-uses in the adjacent valley are agriculture and suburban development. From Kalispell 36 km downstream to Flathead Lake, the habitat characteristics of the river are accentuated by seasonal water level fluctuations due to the operation of Kerr Dam. Extensive stands of riparian forest occur along some portions of this reach, but in many places they are absent or limited to a very narrow strip immediately adjacent to the river. Land use in the surrounding floodplain is heavily dominated by agriculture, primarily wheat and hay fields.

The study area also included the northern portion of Flathead Lake (Fig. 3). This southern boundary of the study area was selected to approximate the northern boundary of the area studied by Matthews et al. (1986). Most of the north shore of the lake is designated as the Flathead Lake WPA, administered by the USFWS. The north shore is primarily floodplain, characterized primarily by dense herbaceous vegetation, varying from emergent stands of cattail, *Butomus* and *Scirpus* spp. (bulrush) to mixed grass/forb cover types (USFWS 1981). The east and west shores are generally steep rocky topography dominated by coniferous forest, with profuse residential and recreational development characterizing the immediate shoreline areas.

METHODS

Aerial surveys were conducted on a year-round basis throughout the study. A total of 100 aerial surveys was conducted between April 21, 1984 and May 26, 1987. Additional boat and ground surveys of the number and distribution of geese were conducted during summer (post-breeding season), autumn and early winter. The number, location, and activity of all geese observed during these surveys was recorded and mapped; when possible, the number of adults and goslings in each flock was recorded. These surveys documented the seasonal trends in goose numbers prior to and during the hunting season, seasonal importance of habitats within the study area, and the dispersal of local breeders. Twenty-six geese equipped with radio-collars during 1985 and 1986 trapping efforts plus two geese radio-collared by CSKT biologists also provided data descriptive of habitat use and movements within the study area. During the four years, 560 locations were documented for the 28 radio-collared geese.

Nesting Studies

Pair Surveys

Surveys of territorial pairs were conducted throughout the study area on a weekly basis from early March through early May, using a combination of aerial, boat, and ground surveys. During each survey, the time, location, number of geese, and behavior were recorded. Singles, pairs, nests and flocks were recorded using methods similar to Hanson and Eberhardt (1971) and Allen et al. (1978). Pairs of geese were counted as indicated territorial pairs if they were at least 10 m from any other geese when observed. Lone geese were assumed to be males of nesting pairs, and therefore also were counted as an indicated territorial pair. The location of each indicated pair was mapped. Selection of areas to be searched for nests was based on these locations. The location and status of occupied nests were recorded for each nest observed during the pair surveys, and females on nests were counted as territorial pairs if no lone (presumed male) goose was seen within 200 m.

Nest Searches

Nest search efforts were initiated during late February of each year, with an inventory of all elevated nest sites within the study area. These included vacant nests built by ospreys (*Pandion haliaetus*), bald eagles (*Haliaeetus leucocephalus*), red-tailed hawks (*Buteo jamaicensis*), great blue herons (*Ardea herodias*) and artificial nest structures. Each nest was mapped and given a unique code number. This inventory was continually updated throughout the course of the study. The status of each nest (species in occupancy, number and behavior of birds on or near the nest, nest condition) was also updated throughout each breeding season. These data were useful for identifying potential interspecific conflicts

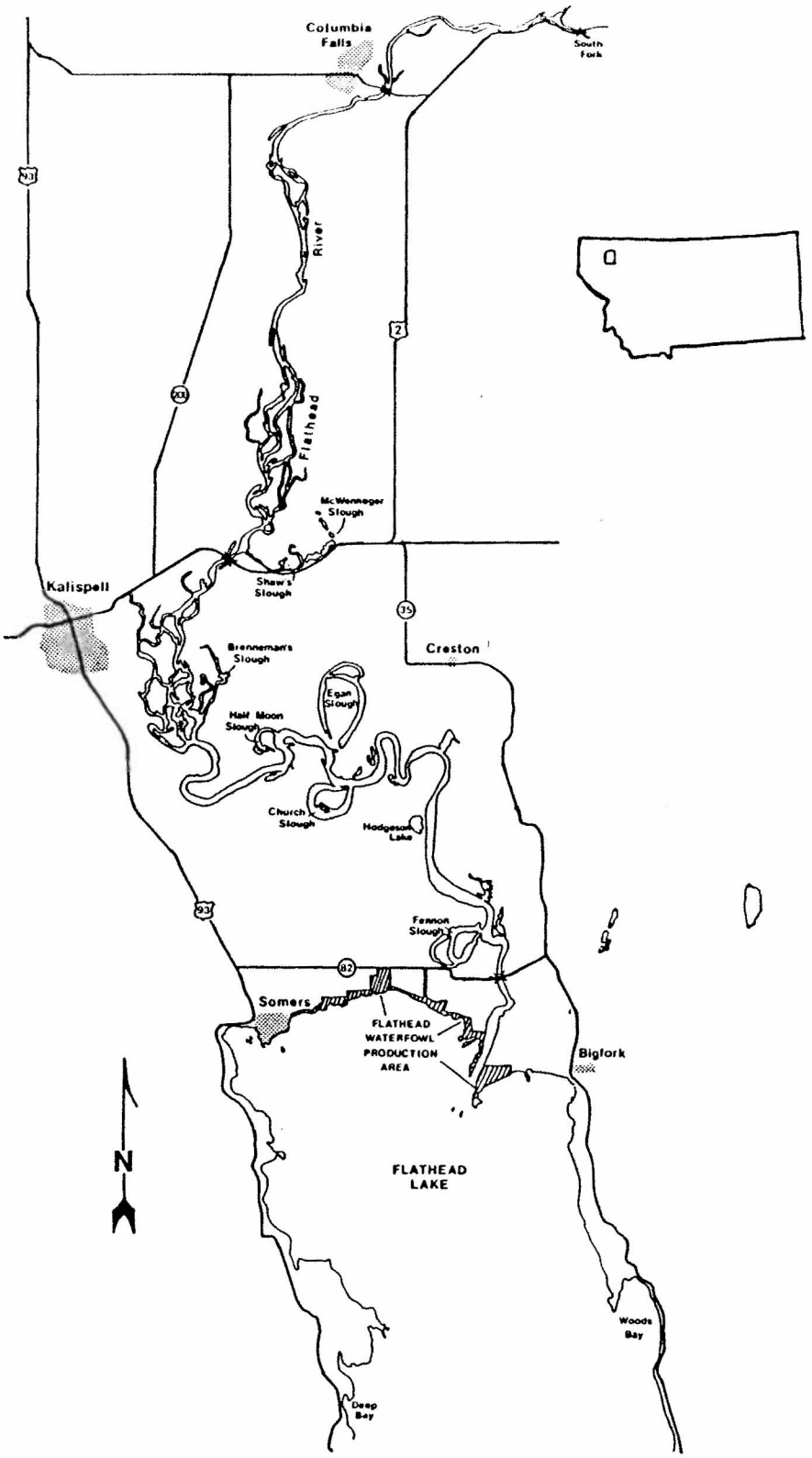


Figure 3. Study area for Canada goose project (BPA Contract 83-498), northern Flathead Valley, Montana.

that influenced goose productivity and allowed close coordination with the fieldwork being conducted under an ongoing MPC-funded study of bald eagles and osprey ecology (Mace et al. 1987). Annual helicopter flights to document occupancy and clutch size of elevated nests were initiated in 1985. These flights were most useful for locating goose nests in the broken, hollow tops of natural snags that were easily missed during airplane and ground surveys.

Most ground nesting in the Flathead Valley occurs on islands (Geis 1956, Ball 1983, Gregory et al. 1984, Casey et al. 1985). Annual ground searches for nests were conducted throughout the study area from mid April through early June. Islands to be searched were selected based on: (1) the presence of potential breeding pairs; (2) previous use; and (3) the presence of particular representative habitats and island sizes. Criterion (3) was used in order to gather data representative of a variety of island types within the study area, because a complete census of all river islands each year was not feasible.

Approximately 50–70 river islands and five lake islands were searched each year. Teams of three to seven people spaced approximately 10 m apart completely searched each island, except on the largest islands, where only the outermost 50 m was searched. Research has shown that the majority of island nests (59 to 84%) are within 10 m of the shoreline (Mackey et al. 1985, Casey et al. 1985).

The remnant delta area in the Flathead WPA was searched completely for nests during late April 1985, 1986, and 1987. These mudflats had not been searched for stump nests by previous investigators (J. Ball, Montana Cooperative Wildl. Research Unit, pers. commun.). Remnant vegetated island(s) on the delta were searched each year. Searches were also conducted annually for marsh nests in selected portions of the WPA, off-river wetlands, and sloughs.

The location, number of eggs, stage of egg development (or nest fate), nest materials, general cover type and adjacent habitats, and distance to water were recorded for each nest. We attempted to visit all nests at least twice, before and after hatching. Egg stage was determined by floating, using methods similar to Westerskov (1950) and modified based on an experiment we conducted to verify this technique for Canada geese (Casey and Sorensen, in prep.) Nest fate was determined from eggshell fragments (Rearden 1951). Nest success was calculated as the percent of total nests of known fate in which at least one egg hatched (Geis 1956).

Data from the nest searches were used to develop a minimum known total of active nests for each year. An assessment of the accuracy of this total was based on a comparison of nest count data and with the indicated pairs data, using pair/nest ratios calculated by other local and regional studies (Hanson and Eberhardt 1971, Ball 1981, Gregory et al. 1984), mapped pair locations, and by comparing brood count data to hatching success data.

Nest Chronology

The timing of nest initiation and hatching, particularly for ground nests on river islands, had to be described in order to assess the potential effects of water level fluctuations. Nest chronology was investigated at most ground and stump nests, and a few elevated nests. Dates of initiation of egg-laying, initiation of incubation and hatching were estimated using egg stage data or known hatching dates. These calculations were based on the assumptions of a 28-day incubation period, preceded by a seven-day egg-laying period (Hanson and Eberhardt 1971, Bellrose 1976). We assumed one day pipping, one day hatching, and one day brooding in the nest. Because of the assumptions inherent in the back-dating method, and imprecision of the egg-floating technique (Westerskov 1950) for determining egg stage, we typically determined a two- to ten-day period during which a nest was initiated or hatched.

Brood Studies

Production, distribution, and survival of broods were documented through a combination of aerial, boat, and ground surveys. Surveys of the entire study area were conducted weekly (when possible) during the brood-rearing period (early May through late July). For each brood observation, the time, location, number of adults, number of young, age class of the young (Yocom and Harris 1965), and habitat were recorded. Yearly maximum counts from aerial surveys were used as an index to annual production.

We attempted to document survivorship of broods in several ways during the course of the study. During 1985, we analyzed 316 observations of individual broods, by age class (Yocum and Harris 1965), and by date, to see if mean brood size decreased through time. In 1986 we attempted to document the survival of individual broods through marking, through the injection of dye (Geis 1956) into advanced-stage eggs in three nests, and direct application of permanent ink to newly hatched goslings in six nests. We also developed an estimate of gosling survivorship by comparing our maximum gosling count to the production estimated by multiplying the number of nests by the nest success rate, by the average clutch size. We assumed that hatching success was nearly 100%.

The locations of important brood-rearing areas were determined through a combination of radiotracking of collared adults with broods, the periodic brood surveys (mapped brood observations), and use of three 6-m observation towers that were constructed within the WPA.

Brood Activity Budget Surveys

In order to document behavior, habitat use and habitat selection by broods of various age classes, we utilized activity budget surveys (Altmann 1974) as modified by Matthews et al. (1986). These surveys (N=353) were conducted from late April through mid July, in both 1985

and 1986. They were conducted primarily from the three observation towers at the WPA (N=151, 1985; N=123, 1986), although broods were surveyed at other upriver brood-rearing areas when possible (N=26 in 1985; N=53 in 1986). During each survey, one observation was made each minute within a 30-minute sampling period. For each observation, the activity, habitat (cover) type, and landform of one systematically selected gosling and one adult within the brood was recorded on coded data sheets. Gosling age classes were recorded using the plumage characteristics described by Yocom and Harris (1965).

Most of the analysis of activity budget survey data was performed by transforming each survey (N=312) into one set of values that represented the percentage of a particular survey that was spent in a particular activity or habitat (cover) type. These percentage values were then used to compare the cover type use and activity of goslings and adults at various lake levels and between sites. Cover type and landform were combined into one set of cover type codes for the final analysis.

Water Level Chronology

Analysis of water levels was conducted using unpublished data from the U.S. Geologic Survey (USGS) and MPC. An emphasis was placed on the timing of releases for Hungry Horse Dam and their potential effects on downstream nests, and the annual fill schedule for Flathead Lake, particularly as it related to the success of nests on the river delta. Lake elevations were also considered in the analysis of brood-rearing activities on the north shore of the lake.

Habitat Measurements

Nests

Physical habitat and vegetation measurements were collected at 155 nest sites during the four field seasons. Fifty-six (39%) of 144 ground nest sites were analyzed. Type of nest (ground, tree, marsh), lateral and vertical distance to existing water level and to the seasonal high water mark (HWM, recorded to nearest 0.1 m), and evidence of disturbance or interspecific interactions were recorded at each nest site. Cover type and landform were identified at all sites. Canopy cover, overhead cover, and woody stem density were measured at each ground nest site.

Nest distribution by cover types and habitat availability on potential nesting islands were compared in the upper river portion where most of the island ground nests were found. The observed and expected frequency of nests were calculated and tested with the Chi-square test. Only those islands 30 acres or less in size were included in the analysis because the largest island used for nesting was 29 acres. Selection of nesting islands based on size was also tested, using proportions of use and availability in eight island size classes. Differences were tested for significance with a t-test.

Fifteen stumps used for nesting on the Flathead River delta were measured in 1985. Six newly-used nest stumps, ten of those measured the previous year, and 172 other flat or concave-topped stumps 35 cm in diameter were measured in 1986. The height of the stump, and height of nest above existing water level were recorded. The elevations of the nests were calculated using gauge height data and nest height data from each day these nests were measured. This allowed us to calculate the height of the nests relative to full pool, and the date of nest inundation for those stump nests below the full pool elevation.

Brood-rearing Area Habitat Measurements

Physical parameters including landform and vertical/lateral distance to the high water mark and the existing water level (Gregory et al. 1984) were described at key brood-rearing areas. In order to describe brood and nesting habitat available to Canada geese occupying the upper river portion in the study area, a cover type map was drafted. Riparian habitats were mapped on infrared aerial photographs (1978 series; scale 1:2,400) and black and white aerial photographs (1979 series; scale approximately 1:16,000). Cover types followed habitat and wetland type classifications of Pfister et al. (1977), Pfister and Batchelor (1984), Cowardin et al. (1979), and Mueggler and Stewart (1980). Acreages were calculated to the nearest 0.1 acre using an electronic digitizer. All habitat mapping was field-checked.

Determination of Habitat Losses

Habitat losses were determined by comparing pre-dam photos (1937) to current aerial photos similar to methods we have used in other loss estimate documents (Casey et al. 1984; Wood and Olsen 1984; Yde and Olsen 1984). Habitats lost to inundation and erosion along the north shore of the lake were determined by comparing black and white aerial photos (1937) with aerial photos taken June 1, 1985, when the lake was nearly at full pool (2,891.3 ft).

Habitat losses in the remnant river delta in the Flathead WPA were quantified in several ways. Use of reference photo points provided a pictorial record of island erosion. Measurements of the dimensions of the two small vegetated island remnants were taken in 1985 and 1986, respectively, in the years shortly before they were lost completely to erosion. All remaining stumps were counted during January 1987 for comparison with our minimum count recorded during May of the previous year, to quantify losses of this particularly important nesting habitat component.

Habitat losses occurring on the river below Kalispell and influenced by Kerr Dam were developed from data supplied by the Biological Station (Hauer et al. 1988) and from current research on water level impacts to aquatic furbearers (Bissell 1987).

RESULTS

Nesting Studies

The majority of indicated pairs in all years were seen on the north shore of the lake and the river below Kalispell. The mean pair count data for the years 1985–1987 were calculated for three major areas within the study area in order to calculate pair/nest ratios. On the north shore of the lake (primarily the WPA), annual pair/nest ratios ranged from 0.94 to 1.42 ($\bar{x}$ = 1.14); ratios along the river were very similar (range 0.89–1.43, ($\bar{x}$ = 1.19). Studies elsewhere in the Flathead Valley (Mackey et al. 1985) and region (Hanson and Eberhardt 1971, Ball et al. 1981) have noted ratios of 1.2 to 1.4 pairs/nest. Mapped pair locations approximated nest locations with a high degree of accuracy in the years when nest searches were most intensive (1985, 1986). In many cases, "excess" pairs were in reality using difficult-to-find nest sites.

An average total of 106 nesting attempts (range= 44-136) were recorded annually in the study area. Most nests (annual mean = 89.9%) in all years were found from Kalispell downstream to (and including) the north shore of the lake. An average of 37 nesting attempts (35.2% of the annual nesting effort), occurred on the north shore (Table 1). In contrast, an average of seven nests (6.0% of the annual nesting effort) were found along the river reach above Kalispell. Nest totals for the river portion of the study area were heavily skewed toward the downstream portion, primarily due to the high number of snag nests in that river stretch. Elevated nest sites are a very important component of the habitat available to geese in the northern Flathead Valley (Fig. 4), averaging 54.3% of all nests for the four years of the study (range = 52.7–55.5%).

Table 1. Number of known Canada goose nesting attempts, by area, northern Flathead Valley, Montana, 1984 to 1987.

Area	1984[a]	1985	1986	1987
Flathead WPA	15	30	42	41
Somers Bay	1	5	6	8
Flathead River				
Kalispell—Lake[b]	26	62	69	68
C. Falls—Kalispell	1	9	8	10
McWenneger Slough	1	0	7	4
Weaver Slough/Ashley Creek	–	2	4	3
TOTALS	44	108	136	134

[a]Nest search efforts in 1984 were limited as compared to other years.
[b]Includes Fennon, Egan, Church and Half Moon sloughs, Brosten's Pond (Hodgeson Lake).

Nest Success

Our overall average estimate of nesting success was 68%. Estimated nesting success varied widely between years, from a high of 82% in 1984 to a low of 50% in 1987. Predation was the most common cause of nest failure ($\bar{x}$ = 23%) each of the four years (Fig. 5), but may have been somewhat overestimated. Abandoned nests are frequently destroyed by scavenging predators, and are easily classified incorrectly (Hanson and Eberhardt 1971). The fact that we classified an increasing number of nests as abandoned over the four years reflects our increased precision in timing revisits to nest sites.

Nesting success along the north shore of the lake varied from 31% to 78% over the four years, with an average of 60%. The predominance of tree nests on the lower river reach also led to higher nest success in that reach (mean = 67%, range 59 to 78%) as compared to the reach above Kalispell (mean = 48%; range = 25 to 86%). Tree nests had the highest success rate (mean = 88%, 1985, 1986) of all nest types throughout the study area.

Nesting success was lowest (mean = 39%, range = 14 to 75%) for ground nests in marsh habitats (Table 2), primarily due to predation. Of the 89 known-fate island ground nesting attempts in our study area, 38% failed. Four of these flooded and 25 failed due to predation. Craighead and Stockstad (1961) determined the major causes of nesting failure for geese in the Flathead Valley were predation and desertion; Geis (1956) attributed most predation losses (90%) to ravens (*Corvus corax*) or crows (*Corvus brachyrhynchos*). Black-billed magpies (*Pica pica*) are also a common avian predator in the Flathead Valley. We documented seven failures due to bird predation and eight due to mammal predation, but were unable to determine the predator type at 61 nesting attempts that failed due to predation. We observed sign of coyote (*Canis latrans*), dog, raccoon (*Procyon lotor*), and skunk (*Mephitis mephitis*) on nesting islands, and both crows and ravens were common throughout the study area.

Nest Chronology

Ground nest initiation in the study area during the four years spanned from March 12 through May 2, with the annual peaks occurring from March 21 through April 15 (Fig. 6). These data are similar to the usual peak reported by previous regional studies (Geis 1956, Craighead and Stockstad 1964, Mackey et al. 1985). Data from 1985 indicated that elevated nests were the earliest nests started, with the WPA stump nests apparently being initiated later than the other elevated sites.

Nest Site Habitat Measurements

Data from 52 ground nests were combined to describe nest sites in relation to the seasonal HWM. Nine nests (17%) were located at or below the HWM. Of the ground nests, 71% were found less than 1 m above the HWM.

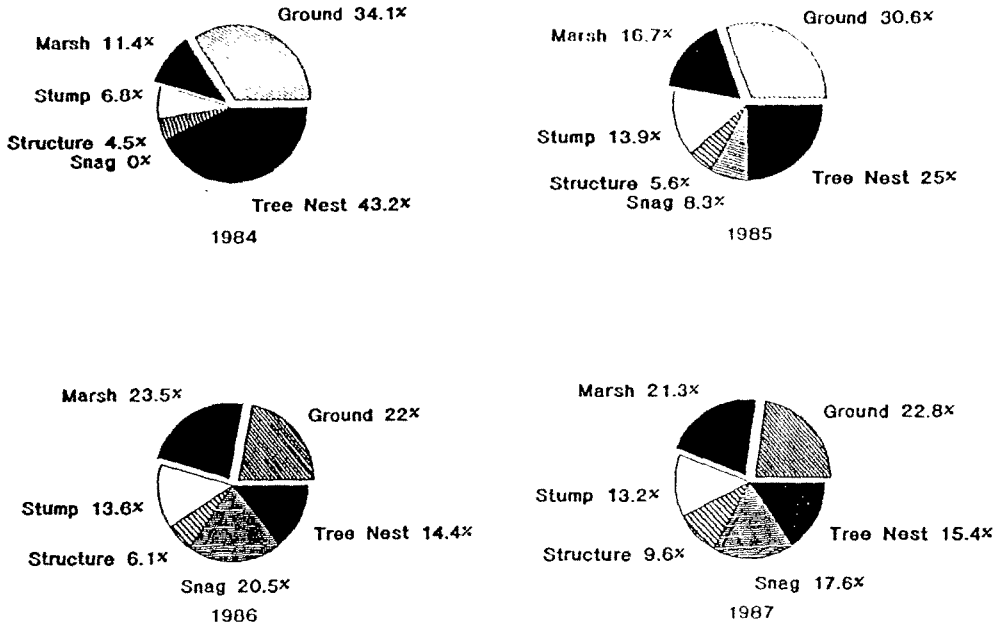


Figure 4. Annual percentage of Canada goose nests by type, northern Flathead Valley, 1984–1987.

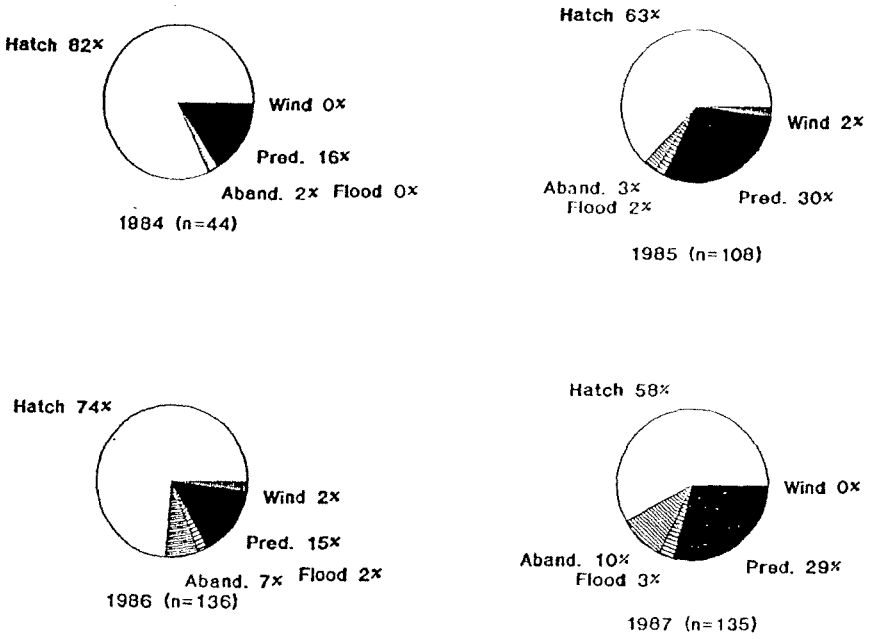


Figure 5. Annual percentage of Canada goose nests by fate, northern Flathead Valley, 1984–1987.

Most (63%) of the ground nests were less than 2 m horizontal distance from the HWM. The large percentage (71%) of nests found less than 1 m above the HWM indicates the potential for loss of nest sites due to flooding and erosion. Two nest sites on the upper river were lost to erosion, and all but one of the ground nests found on the two delta islands were lost due to erosion.

Most nests were found in deciduous forest (43%) or the dense shrub (29%) habitat types. Island ground nests in upper river area were found in eight cover types (Table 3). The largest proportion of nests (29%) were found in the deciduous forest-immature cover type.

Islands used by nesting geese were significantly different from islands not used for nesting ($\chi^2 = 23.21$; $p < .002$).

Table 2. Observed fate of Canada goose nests, by type and year, northern Flathead Valley, 1984–1987.

Nest Type	Observed Nest Success by Year (%)				
	1984	1985	1986	1987	$\bar{x}$
Ground—Island	72	50	68	65	63.8
Ground—Marsh	75	14	43	24	39.0
Stump	–	82	86	13	60.3
Structure	50	50	88	67	63.8
Tree	–	87	88	66	80.3

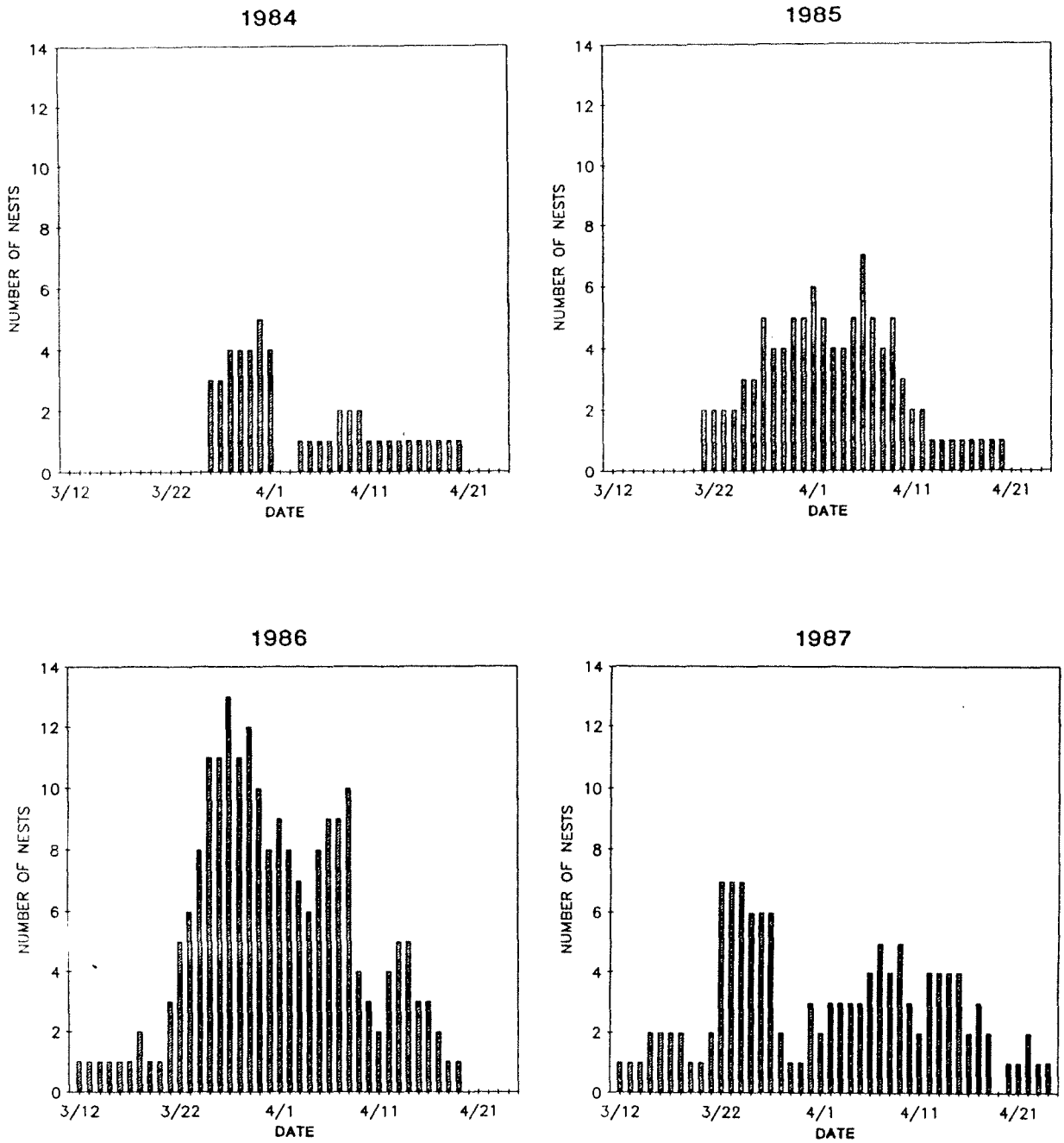


Figure 6. Canada goose ground nest initiation curves, northern Flathead Valley, 1984–1987.

Table 3. Cover type distribution by nest (number) and island (acres) for island ground nests found on the upper Flathead River.

Cover Type	Number of Nests (%)	Nest Islands N=25 (%)	Non-Nest Islands N=102 (%)	All Islands N=127 (%)
Deciduous Forest—mature	2 (5)	19.75 (13.4)	82.26 (24.0)	102.21 (20.8)
Deciduous Forest—immature	11 (29)	22.88 (15.5)	54.64 (15.9)	77.52 (15.8)
Mix forest	2 (5)	5.92 (4.0)	20.83 (6.1)	26.75 (5.4)
Dense shrub—cottonwood/willow	9 (24)	38.37 (26.1)	64.05 (18.6)	102.42 (20.8)
Dense shrub—mixed	5 (13)	11.02 (7.5)	24.11 (7.0)	35.13 (7.1)
Sparse shrub	5 (13)	34.05 (23.1)	85.02 (24.7)	119.07 (24.2)
Herbaceous	3 (8)	11.25 (7.6)	9.08 (2.6)	20.33 (4.1)
Unvegetated	1 (3)	3.99 (2.7)	4.08 (1.2)	8.07 (1.6)
Total	38	147.23	344.27	491.50

Eight cover types were tested. Less acres of deciduous forest-mature stands ($\chi^2 = 12.13$; $p < .001$) and more acres of herbaceous cover type ($\chi^2 = 4.98$; $p < .05$) were found on nest islands.

No significant difference was found in the distribution of nests by cover types and the distribution of cover types on the nest islands ($\chi^2 = 11.12$; $p < .13$). However, significant differences were approached for two cover types. Fewer nests were found in deciduous forest-mature stands and sparse-shrub stands suggesting a slight selection against these types. Distribution of nests by cover types was significantly different from the distribution of cover types found on all islands less than 30 acres ($\chi^2 = 25.22$; $p < .001$). More nests were found in deciduous forest-immature than expected based on the percent available.

There was no significant difference ($p = 0.58$) between the mean size of nesting islands (5.97 acres, ±6.96), and those not used (mean = 8.37, ±23.68). Analysis of distribution of nesting islands by size class revealed that geese use islands in relation to their availability, except for those islands in the smallest size category (<.51 acres). Geese apparently select against the smallest islands ($p < .05$), perhaps due to the tendency for such sites to be very sparsely vegetated, and their susceptibility to flooding.

The average elevation of stump nests was 2,891.2 ft. Only two of the nests were above the elevation of full pool (2,893 ft). A majority (91.5%) of the 188 stumps measured in 1986 had top elevations below full pool. The percent of stumps above full pool elevation was similar for those used as nest sites (10%) and those not used (8.4%).

Brood Studies

The importance of the WPA as a brood-rearing area for geese nesting elsewhere was verified by radio-collared geese. Three broods moved 37 km downriver, 24 km downriver, and 17 km north on the lake , respectively, to reach the WPA. The north shore of Flathead Lake west of the river delta received the most consistent use as well as the highest count of broods during the entire study period. The annual high brood counts (96–155 goslings) at the WPA were similar to the 160 reported by Barraclough (1954), and to the average annual trend count of 95 young (range 31 to 173) at the WPA during the years 1975 through 1985 (USFWS, MDFWP; unpubl. data). Maximum gosling counts were consistently lower than predicted production, averaging 67.5%.

Barraclough (1954) estimated 23% mortality at the lake as a whole, and 8% mortality of goslings using the north shore, for the years 1953 and 1954. This is the highest gosling mortality reported for any western Canada goose population (Krohn and Bizeau 1980). Our analysis of census data and estimated production at hatching indicated that at least 65% of the goslings produced in the northern Flathead Valley survive the first month or more of the brood-rearing period.

Nine important brood-rearing areas received consistent use during the four field seasons. Areas selected for brood-rearing provided secure feeding sites, loafing sites and escape cover. All but the north shore were terrestrial habitat mosaics, with the highest use areas consisting primarily of pasture, natural herbaceous stands, and cultivated fields in that order. On the main stem Flathead River above the lake, most brood use occurred off-river oxbow sloughs.

Activity budget surveys at the WPA indicated extensive use of bays outside the zone of emergent cattail vegetation. All sites were nearly identical in species composition and density. The nearly monotypic communities were dominated by *Butomus*. Early in the brood-rearing period these preferred

feeding areas were separated from open water by 200–600 m of barren mudflats.

Brood Activity Budgets

Gosling activities were analyzed for surveys conducted at Flathead WPA, to assess behavioral changes in response to rising lake levels during the brood-rearing period. Goslings spent more time traveling at lower lake levels (<2,889.5 ft) than at higher lake levels. Most of this time is spent walking on exposed mudflats. As the brood-rearing season progressed, the geese became more sedentary, probably due to the increase in forage and cover available as the lake inundates emergent vegetation stands. Geese were also more easily disturbed during the period when mudflats are more extensive, and traveled more in response. Percent of time spent feeding increased from 48.0% at lake levels between 2,884.5 and 2,887.0 ft, to 69.2% at 2,889.6 to 2,891.6 ft, and dropped again to 45.8% at highest lake levels. This trend resulted from decreasing disturbance as lake levels rose, and the drop late in the season may represent a decrease in the caloric intake needed by broods as they approached adult size. This is supported by the increase in time spent resting by goslings as the season progressed.

Goslings spent much (47.3%) of their time in unvegetated or short herbaceous cover types. At lower lake levels, broods spent 77.8–85.2% of their time in these types. It is still unclear if this trend of using the exposed mudflats affects survival of goslings. We witnessed several instances where predators came close enough to broods to influence their behavior, but witnessed no actual predation during our brood surveys. We witnessed geese using stumps, logs, depressions in the mud flats, and emergent stands as escape or resting cover at the WPA. Broods in the mudflats fled either to upland/mudflat ecotones or onto the open water of the lake, depending on the location of the perceived threat.

Habitat Loss Estimates

The habitat destruction occurring on the north shore is a result of increased erosion when the lake elevation remains high during the storm seasons. Woessner et al. (1985) provided a clear description of wave dynamics and erosional processes occurring along the north shore of Flathead Lake. Moore et al. (1982) reported that more than 8 sq km (approximately 2,000 acres) of sediment was removed from the delta plain between 1937 and 1981. The area near the Somers side has apparently approached equilibrium (Hauer et al. 1988). The area immediately west of the river mouth continues to erode at a rate of approximately 13 m per year, and the Bigfork side is also rapidly retreating.

We documented a dramatic change in the delta islands through direct measurements and photo-documentation starting in 1985. Prior to the lake reaching full pool, the remnant cattail island was 47.4 m long and about 411 m^2 in area. The wooded island was approximately 20 m long and 90 m^2 (±10 m^2) in area. By November, the cattail island had been completely eroded away and the wooded island had eroded down to an estimated 30–40 m^2 (T. O'Neil, pers. commun.). As of May 1987, less than 2 m^2 of island remained, and this was lost completely by mid July 1987.

Analysis of aerial photographs revealed the loss of 1,859 acres of habitat along the north shore of Flathead Lake (Table 4). This loss represents the amount of terrestrial vegetated habitat that is now the mudflat region between the lake and the cattail/bulrush marsh when the lake is below full pool. Most (63%) of the lost habitats were herbaceous types. Of the habitat lost, 31% was forested, primarily deciduous (cottonwood) riparian stands.

Only ten of the 15 delta stumps used for nesting in 1985 were still available for use in 1986. Three of the ten were lost during the following year (full pool 1986), as were six of seven newly-used stumps that year. These losses amount to an annual loss rate of 33 to 89% of stumps used for nesting. A minimum of 816 stumps were present on the delta during May 1986. A total of 712 stumps remained standing as of January 1987, meaning that a minimum of 104 (12.7%) stumps were lost to erosion during full pool 1986.

We determined that a minimum of 335 acres of terrestrial habitat was lost on the Flathead River above Flathead Lake, based on maps developed by Hauer et al. (in prep). Excluding unvegetated and revegetated areas yielded a minimum net loss estimate of 235 acres of terrestrial habitat for this reach. Bissell (1987) reported a net loss of 273 acres for this same reach, including 135 acres of deciduous forest and 162 of herbaceous habitats, some of which have revegetated with cattails.

Water Level Fluctuations

During each year of the study, minimum water levels at Flathead Lake coincided at least in part with the Canada Goose nesting season (Fig. 7). The duration of time that the lake was within 0.5 ft of minimum pool ranged from 31 days in 1985 (March 5–April 14), to an extreme of 61 days in 1987 (February 15–April 16).

The seasonal hydrograph for the Flathead River at Columbia Falls varied dramatically on an annual basis during the four years of this study (Fig. 8). During two of the four years (1984 and 1986), the period March–June was characterized as having several peak flow periods corresponding to releases from Hungry Horse Dam. Releases from the dam contributed over 70% of the flows for five peaks late March–mid April, and 30–60% of eight peaks in late April and May. A similar pattern was evident for 1986, when ten peaks of 15,000–35,000 cfs occurred from mid March through late May (Figure 4). South Fork flows comprised more than 50% of the flow for five of those periods, and 30–50% for the other five peak flow periods.

Flathead River hydrographs for 1985 and 1987 were

Table 4. **Habitat losses on the north shore of Flathead Lake, Montana, 1937–1985, as determined from aerial photographs.**

Habitat Type	No. Acres Inundated/Eroded
Forest[a]	571
Dense shrub	76
Herbaceous	
Grass/forb, sparse shrub	671
Wet meadow	114
Shoreline herbaceous	190
Pasture	118
Hayfield	86
Wetlands (ponds/marsh) (n=12)	33
Total	1,859

[a]Includes coniferous, deciduous, and mixed conferous, and mixed coniferous-deciduous stands.

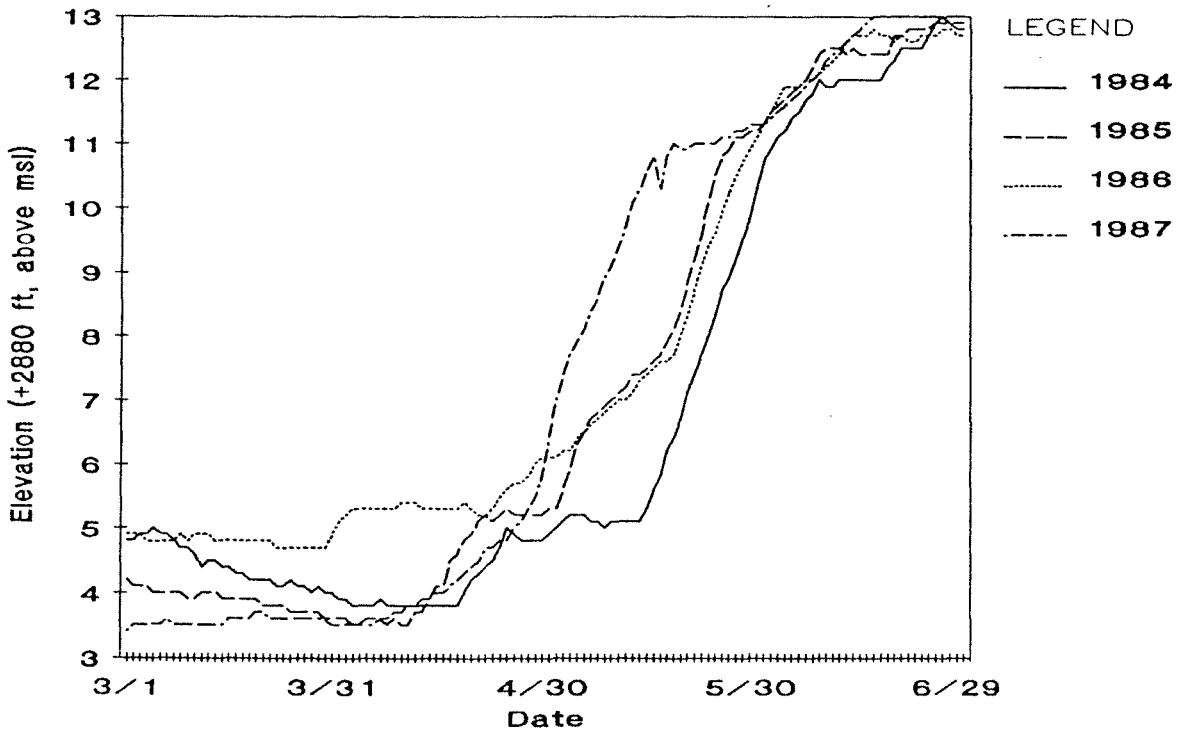


Figure 7. **Flathead Lake Elevation as influenced by Kerr Dam, March 1–June 30, 1984–1987.**

both characterized by early peak flows stimulated by runoff, with releases for the dam contributing very little of the flow at Columbia Falls (Fig. 8). Peak flows of over 30,000 cfs were experienced before May 1 during each of these years. Releases from the dam comprised more than 50% of the flow at Columbia Falls for only one peak of less than 10,000 cfs each year. During these two spring periods, operation of Hungry Horse Dam as a flood control tool lessened the effects of early peak flows due to runoff.

We analyzed historic flow data to determine the past role that Hungry Horse Dam has played in determining flows during the breeding season for geese. We selected 25,000 cfs as an appropriate (conservative) mean flow indicative of a potential threat to ground-nesting geese. The percentage of high flow days during the three-month nesting period dropped from 45% for the years 1950–1953, to just 24% for

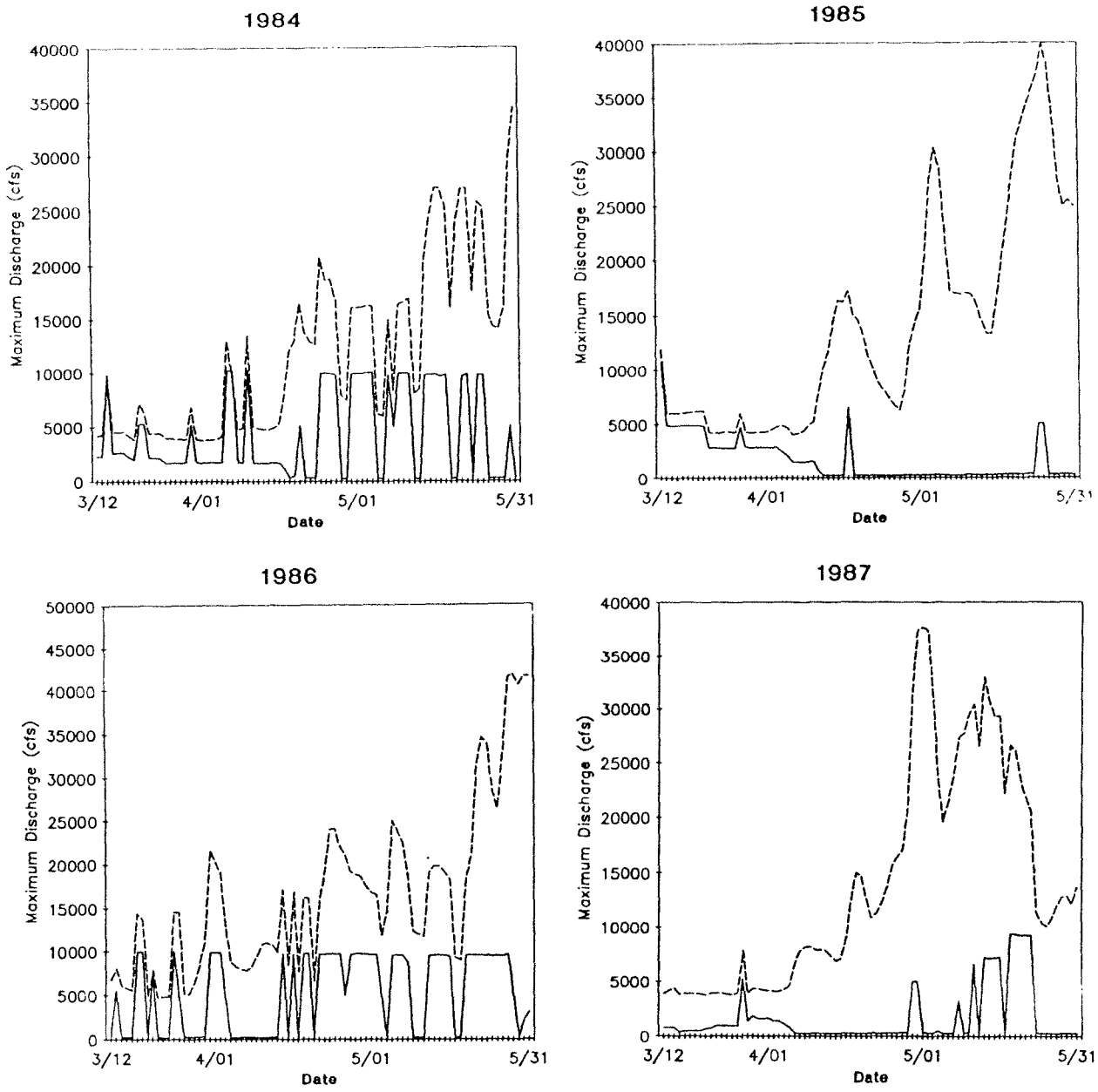


Figure 8. Daily maximum discharge, South Fork and main stem Flathead River at Columbia Falls, March 12–May 31, 1984–1987.

all subsequent years. This indicates that the dam is serving a flood control function, particularly in late May and early June when runoff usually peaks. Less than 20% of the 748 days with flows above 25,000 cfs fell during the period March 15 – May 15, when most nests would be at risk. On half of those days, running the dam at base load (approximately 165 cfs) would have prevented the flow at Columbia Falls from reaching 25,000 cfs. The mean flow for the South Fork on those days was 8,865 cfs. These data indicate that in certain years, releases from the dam may very well have put downstream nests at risk of flooding, and could have been adjusted downward to lessen that risk.

DISCUSSION

Water Level Effects

The primary effects of both Hungry Horse and Kerr Dam operation occur during the nesting and brood-rearing period. Large-scale losses of goose nesting habitat occurred and continue to occur on the north shore of the lake, due to the operation of Kerr Dam. The entire delta island area, at least 400 acres in size when the dam was built, was likely used for ground nesting. An average of 13 ground nests were found there between 1953 and 1960 (Geis 1956, Craighead and Stockstad 1961). As recently as 1982, 11 ground nests were found on the delta (Ball 1983). Over the last four years

(1984–1987), the last of the vegetation has disappeared to erosion, and ground nests in the area have dropped from eight to two. It is evident from our data that as the remnant islands diminished, ground nesting pairs moved onto the mudflats of the delta, where predators and flooding destroyed most of their nests.

Given the predominance of tree-nesting in this population, it is highly likely that the 500 or more acres of forest habitat that were lost on the north shore also supported goose nests. Remnant stumps, currently an important component of north shore nesting habitat, are not as secure as tree sites for nests. Flooding destroys some such nests, but the greatest risk to these sites is the continued erosion during full pool periods. Not only are stumps being lost at a rate of nearly 13% a year, but those used for nesting are apparently even more susceptible (33–89% per year). Using a constant loss rate of 13% per year, Mace et al. (1987) predicted that all free-standing stumps on the delta will be gone by the year 1994. While annual erosion rates obviously can be expected to vary, it is clear that all nesting potential in the delta will be lost within the next decade. This represents a loss of 22 nesting pairs (1985, 1986), assuming that these birds are unable to relocate successfully. Such a loss would represent approximately 16% of the breeding population in the northern Flathead Valley.

Erosion losses due to Kerr Dam have also affected brood-rearing habitat on the north shore. Most (63%) of the habitat lost included herbaceous cover types which were likely used by geese during the brood-rearing period. The pastures and herbaceous shoreline areas along the north shore provided known brood-rearing habitat (Barraclough 1954). It is likely that even after construction of Kerr Dam, broods continued to utilize these areas. However, once erosional processes on the Somers side stabilized, stands of cattails began to replace the herbaceous areas used by broods. Today extensive cattail stands separate the open water from the upland herbaceous areas. During our brood activity budget surveys, we rarely documented broods utilizing the cattails except for brief periods of time when they were disturbed. We never observed broods in upland areas beyond the cattails.

The direct loss of habitats important to brood-rearing geese and the development of extensive cattail areas would have had a more serious negative impact on the goose population without the establishment of *Butomus*. The importance of this species as a primary food source for broods on the north shore was well documented by our research. The fact that *Butomus* exploits a habitat apparently unfavorable to any other species implies that without this species brood habitat would be very limited on the north shore. Although we have no clear evidence of how or when *Butomus* was first introduced into the lake, we suspect that the number and size of stands were very limited until recent years. Notable expansion has occurred between 1985 and 1986 (J. Jourdonnais, pers. commun.).

Time budget data provided insight into the quality of remaining brood-rearing habitat on the north shore of Flathead Lake. Deviations from optimum use of time and resources affect energy balance and should only occur when an individual or population encounters altered or changing environments (Burton and Hudson 1978). Water level fluctuations can affect brood time (hence energy) budgets through direct changes in food availability (e.g., unvegetated mudflats), or through the increased energy demand resulting from the use of open water as escape cover (i.e., travel between feeding areas and cover). Matthews and Mackey (in prep.) implied that brood habitat is limiting on the lake, based on the fact that goslings there spend more time feeding (50.6%) than do birds on river brood-rearing areas below the lake (39.6% of time spent feeding). Since time spent obtaining energy relates directly to energy needs (Schoener 1971), birds in energy stress need to feed more. Birds on the north shore of the lake spent 48% of their time feeding. The broods on the north end also spend less time resting (10.6%) than either of the population segments discussed by Matthews and Mackey (16.5 and 28.9%). These data indicate that brood habitat on the north shore is suboptimal, and that changes which have occurred since Kerr Dam was built have likely put an energy stress on broods reared on the lake.

Matthews and Mackey (in prep.) noted that as water levels rise, broods on the lower half of Flathead Lake spent more time grazing in upland areas as access to those areas improved, with a corresponding dramatic (31x) shift away from the use of marsh areas. Cover type use differed dramatically at the north end of the lake, where use of marsh was highest (75.8%) at full pool. This difference is important in two ways. Given the choice, geese apparently prefer short herbaceous to marsh cover types when open water is available nearby. At the north end of the lake, short herbaceous (upland) habitats have been lost, and access to such habitat is limited by cattail growth. The extent and preference for *Butomus* at the north end are extremely important in off-setting these changes by providing a succulent, apparently nutritious food source for broods.

Losses of nesting and brood-rearing habitat have also occurred over time along the river reach below Kalispell. These losses included 135 acres of deciduous forest that have been replaced by seasonally flooded mudflats. Deciduous forest habitat supports 95% of the annual nesting effort on that river reach, so it is very likely that these forest stands were used by tree-nesting geese. Approximately 162 acres of natural herbaceous habitats lost in this area were probably used by broods, particularly those locations along the margins of oxbow sloughs and at the mouth of creeks.

Nesting Success

Displacement of geese into less secure nest sites, predation due to land-bridging and flooding due to water level

fluctuation were recorded as causing nest failures. An important component of this study was to determine if the operation of Hungry Horse Dam put river island nests at risk, either through abnormal dewatering of high water channels that otherwise afforded nests with protection from mammalian predators, or through abnormally high flows which resulted in flooding. River island nests generally had a higher annual success rate than marsh nests (Table 2), but had a lower success rate than tree nests. On the average, 36% of island nesting attempts in the study area fail each year. Of all ground nest failures, 72% were due to predation, 10% were due to abandonment, and 15% were due to flooding.

The percentage of nests lost to flooding on an annual basis was consistently low ($\bar{x}$ = 2%, range 0–3%), for the study area as a whole. However, four of 40 nesting attempts, or 10% of the river island nesting effort for 1984–1987 on the reach most influenced by Hungry Horse Dam during the same period, failed due to flooding. All four failed as the result of natural high flows due to early runoff. The average annual peak flow at Columbia Falls for the years 1966–1987 was 44,146 cfs (range 19,700–77,600). Annual peak flow occurred in April (once) or May a total of 16 of these 22 years. Peak flows occurred before May 15 (when nests would be at risk) in only four years. Three of the four documented ground nest failures due to flooding occurred at annual peak flows. Only one of these was a late renesting attempt.

As erosional losses in the delta area forced ground-nesting pairs to attempt nesting on the unvegetated delta, their susceptibility to flooding increased dramatically. Two such nest failures were recorded in 1986. Both nests were at elevations of 2,886 ft, on the outer edges of the delta, but even those on the center portion, where average elevations were 2,888 ft, would be at risk in many years. During the four years of our study, the lake reached this 2,888 ft as early as May 6 and no later than May 24. Lake levels reached 2,891, the average elevation of delta stump nests, as early as May 19 and no later than June 3. Nest success on stumps is likely to be affected by wave action when the lake is still well below the nest elevation. Three stump nest failures due to flooding were recorded during the study; all three were likely to be renesting attempts based on egg stage data.

The potential for ground nest failures due to predation is greatest on those "islands" that become peninsulas at low flows, or which are connected to islands large enough to support predators. These HWC's are dewatered at low flows and provide access for predators. Thirty-eight of 150 islands in the study area fit this description. A total of 11 nesting attempts were recorded over the four years on such sites, and seven of these attempts failed due to predation. None of these seven sites was used again the following year.

Flows from the South Fork have contributed an average of 44% of the daily mean flow at Columbia Falls during the period March 15 through April 30 in the years since the dam was shut. It is, therefore, unlikely that abnormally low flows are caused by the operation of the dam, during that period when ground nests are most at risk of predation. Water level data were reviewed for 25 river sites at which opportunistic observations of flooding and dewatering were recorded. Seven of these areas included nest sites used during at least one year during the course of our study. Ten of the areas were gravelly peninsulas or small islands characterized by sparse cottonwood-willow regeneration stands. Nine of the ten were entirely inundated by flows ranging from 16,300 to 24,400 cfs. The remaining site was 75% inundated at 30,360 cfs. It was the only site of these ten which was used for nesting.

The other 15 areas for which we collected dewatering/flooding data were primarily young deciduous forest stands interspersed with shrub and herbaceous types. Only one of these was completely inundated at 34,200 cfs; flows of 39,690 cfs were adequate to flood eight of the sites, with the others ranging from 30 to 75% flooded at this flow. Five of the areas supported at least one nesting attempt during the study period.

These data support the premise that avoidance of small island and sparse shrub types by nesting geese is related to flooding and dewatering effects. It is apparent that whether a goose pair will use a given island for nesting during a given year depends on its history of flooding and/or dewatering (and subsequent predation). Failures of either type, over time, will cause a shift in nesting to more secure sites. This is accomplished either through active avoidance of such sites by pairs in subsequent years, or through the failure of pairs that consistently use such sites to successfully raise young that would return to natal areas to nest. In the latter case, as pairs die, the areas they occupied would no longer support nesting pairs unless young recruited elsewhere pioneered into such sites. Based on our data, it is likely that some mechanisms such as these account for the very low nesting effort on the river above Kalispell.

Dewatering effects were also noted at the Flathead River delta, where the extended period of minimum pool (61 days) in 1987 caused land bridging to delta nesting areas. As a result, ten stump nests and one ground nest on the delta failed due to predation.

SUMMARY AND CONCLUSIONS

Population/Habitat Status

The number of known Canada goose nesting attempts recorded in the northern Flathead Valley ranged from 44 in 1984 to 108 in 1985, to 135 in both 1986 and 1987. An average of 15 nesting attempts took place annually on the delta stumps, an area influenced strongly by water level changes caused by the construction and operation of Kerr Dam. This stump-nesting effort had not been recorded by previous researchers.

An average of 54% of all annual nesting attempts were at elevated sites, including nests built by other species (primarily osprey), natural snags, stumps, and nesting structures. Nesting success varied from 58 to 81%, and averaged 68% for the four years. The primary cause of nest failure was predation, but flooding caused the failure of 10% of all ground nests in the river reach influenced by Hungry Horse Dam.

Estimated annual production for the northern Flathead Valley averages more than 400 goslings. Nine important brood-rearing areas were located primarily at pasture or natural herbaceous sites adjacent to off-river aquatic habitats, with the exception of the Flathead Waterfowl Production Area. This was the most heavily-used brood-rearing area, and represents an important security area for geese during the molting period and through the winter.

We documented extensive loss of terrestrial habitat on the north shore and the lower river below Kalispell. Losses were attributed to inundation and continuing erosion due to operation of Kerr Dam. Impacts on the north shore included the loss of 1,859 acres of habitat, the conversion of approximately 205 acres of herbaceous cover to cattails, and the establishment of 121 acres of *Butomus*. Most of the habitat lost included herbaceous cover types (1,179 acres) and deciduous forest (571 acres). A net loss of 235–273 acres of habitat occurred on the river reach above the lake.

Patterns in selection of river islands for use as nest sites indicate that geese select against the smallest available islands, and against sparse shrub sites. This reflects the likelihood of such sites to flood; most are gravelly islands that are inundated regularly by high flows. Yet most (73%) ground nests in the area were less than 1 m above the seasonal high water mark, and most (63%) ground nests were less than 2 m from the HWM. Most tree nests were in very large cottonwoods (mean dbh = 0.98 m). Most (62%) of the trees were less than 10 m from the HWM, which indicates that such sites may be at risk of erosion during full pool periods.

Ease of access to marsh nest sites made them particularly susceptible to predators. More than half of the marsh nest sites (55%) were less than 10 m from open water and most nests (64%) were at least 20 m from upland areas. Water depth at the nest site averaged 0.63 m.

Pasture brood-rearing sites were primarily in areas not influenced by water level fluctuations. Natural herbaceous sites used by broods included wet meadows, stream banks, and sandbars. These sites were usually less than 0.5 m above the high water, however, only the sandbar sites were flooded by high flows. Marsh sites were found in the off-river sloughs and were used for security, loafing, and some feeding. A unique marsh site was found on the WPA where *Butomus* dominated (85%) the mudflat area beyond the cattails.

Water Level Effects

The primary and most significant effect of Kerr Dam on geese has been the loss of a minimum of 1,850 acres of nesting and brood-rearing habitat on the north shore of the lake, and an additional 235 acres or more of terrestrial habitats along the Flathead river below Kalispell. On the east side of the river mouth, tree nesting sites will be lost in the near future. During the course of our study, we have seen the loss of at least eight secure nest sites in the delta, as the last remnant of vegetation has washed away. Within ten years, all 22 nest sites we documented in 1985 in that area are likely to be lost to erosion. Twenty-two pairs represent 16% of the nesting population of the northern Flathead Valley. Over 1,200 acres of short herbaceous and small wetland habitats were lost along the north shore, and is likely that these habitats were important brood-rearing areas. Current brood habitat on the north shore is less than ideal (due to the extensive mudflats), but due to the appearance of *Butomus umbellatus* the geese apparently are capable of having productive years by brooding there (e.g., 1986).

The upriver effects of Kerr appear to be somewhat limited, although long-term habitat changes have probably changed the availability of preferred habitats. Few, if any, positive changes have occurred. "Created" marshes are not high quality for nesting or brood-rearing. Tree-nesting is most prevalent in this area, and the continued success of geese is closely tied to the expanding osprey population. Some loss of nesting habitat (cottonwood stands) apparently occurred in areas such as Fennon Slough, as indicated by the current distribution of stumps below the full pool elevation. Where ground nesting does occur (off-river sloughs/potholes), predation is a major problem. Although this predation is unrelated to dam operation, it has important ramifications for developing mitigation options.

On the upper river reach (above Kalispell), there is essentially no tree nesting, and the number of island ground nests is limited in comparison to available habitat. This indicates that flooding during the nesting season has limited goose production in this segment of the population.

As it is currently operated, Hungry Horse Dam is not having a significant effect on downstream island nests. Some protection is afforded to island nest sites by flows in the early nesting period, which are supplemented above natural levels with releases from the dam. Over time, high flows during the nesting period have limited the nesting effort through the periodic flooding of islands; currently, the only sites that are being used for nesting are those that only flood at exceptionally high water levels (30,000 cfs). Drastic daily fluctuations in river water level occur frequently in most years, and have the potential for flooding nests of pairs "pioneering" lower elevation sites on islands. How often this occurred in the past is difficult to say, but in two of the four years of this study, Hungry Horse Dam served a flood

control function by being run at or near base load during periods of early runoff.

MANAGEMENT/MITIGATION IMPLICATIONS

The identification of limiting factors for the goose population, the role that water level effects play in those factors, and potential mitigation techniques to offset such effects were the primary goal of the study. Results of this study have important additional implications to both the methods used to monitor goose populations and the approaches used to mitigate water level effects in the Flathead Valley and elsewhere. No mitigation for impacts identified during this study has been undertaken to date. FWP biologists are currently involved in consultation regarding Kerr Dam mitigation.

The availability of secure nest sites is limited in much of northern Flathead Valley. The lack and continued loss of delta vegetation and stumps will influence the potential for reaching the population goal for the north shore, which was identified as 120 nesting pairs (Flathead Valley Goose Committee, 1986, unpubl. data). These losses could be mitigated through an extensive nesting structure program, if structures were placed in areas secure from erosion. One or more subimpoundments, if constructed on the north shore, could replace lost nesting and brood-rearing habitat. Inclusion of islands could provide some nest security.

The availability of secure nest sites is also limited on the Flathead River above Kalispell. This river reach supports few nesting geese and thus has much room for enhancement, either to meet management goals or mitigation objectives. An intensive structure program on this river reach might increase numbers over time, as young are recruited from the four elevated nest structures already in place on this reach. There was no indication that any surplus adults are present along this reach, as was the case where structures were extremely successful elsewhere in the Flathead system (Mackey et al. in prep.). Only extreme water level manipulations could improve the security of these river islands.

Though very few islands are available for nesting on the Flathead River below its confluence with the Stillwater River below Kalispell, an abundance of natural elevated nest sites are available. The rapid increase in osprey populations over the last 15 years (Mace et al. 1987) has provided tree-nesting geese with an abundance of potential nest sites in addition to natural broken-topped snags. Protection of the areas where old-growth cottonwood stands are available would guarantee nest site availability into the future. Populations could be supplemented in certain areas along this river reach through the use of tree-nesting platforms such as those described by (Mackey et al. 1988), in those areas where old-growth stands are not available.

Nest Success

The average nest success rate we observed for this population was 69%, slightly lower than the 73% figure reported by Krohn and Bizeau (1980) from studies throughout much of the western U.S. Still, this rate of nest success seems adequate, under existing mortality regimes, to allow the population to remain stable or to increase. Given that ground-nesters and tree-nesters are apparently distinct segments of the population, it is likely that the ratio between the two will change naturally, based on the differential in their success rates, and that overall nesting success for this population should gradually increase. This will occur only to the extent that suitable nest sites are available for the new birds produced.

Changing overall nest success through the manipulation of water levels is another option. Operating Hungry Horse as a flood-control facility during years of early runoff could achieve this for the upper river, but would only affect less than 10% of the annual nesting effort. Because flooding potentially affects approximately 10% of the river island nests, and runoff is only early in certain years, the effect of such an approach on overall nesting success would be minor. A reduction of land-bridging to river islands, through supplemented flows early in the nesting season, could also reduce nest losses to predation.

Brood-rearing

Brood habitat in the WPA is currently able to support large numbers of broods only due to the fortuitous appearance of *Butomus*. Because of its local importance to brood-rearing geese, we reviewed information on this species. The plant was introduced from Eurasia and was first observed in the Great Lakes region of North America in 1897 (Stuckey 1968). The species invades marsh and lake shoreline areas and apparently has a wide tolerance for water levels (A. Schuyler, pers. comm.).

Wildlife refuge managers in the Great Lakes region were contacted to discuss the impacts of *Butomus* in their areas. Although fairly common in occurrence, they did not recall ever seeing geese specifically using this plant for forage (K. Bednarik, pers. comm.). In addition, as far as they could tell *Butomus* had not replaced any other species. Early articles on *Butomus* expressed concern that indigenous riparian vegetation such as *Scirpus* and *Sparganium* may be displaced (Dansereau 1957).

Butomus may have great potential as an enhancement tool for brood-rearing areas in the Flathead Valley and elsewhere. Due to its tolerance of fluctuating water levels, it seems particularly suited for reservoir situations where management for goose brood habitat is desirable. Experiments should be conducted to determine the best methods to propagate or transplant this species, including soil preferences and timing in relation to water level changes.

The WPA could be enhanced for brood-rearing through

habitat manipulation. Access to secure upland herbaceous areas could be opened up by removal of shoreline debris and cattail stands. More security for broods would be provided by raising lake levels earlier in May, but would reduce the capability of Kerr Dam to contain spring runoff.

Brood areas along the lower river would also benefit from earlier spring increases in lake elevation. The higher water levels would provide quicker access for broods from the herbaceous feeding sites thereby reducing the possibility of predation.

Habitat Protection

Protection of those habitats that are currently used by geese, but threatened by erosion due to water level fluctuations, is a desirable management strategy, but not one easily achieved. Protection of north shore habitats through water level manipulations would require drastic changes in the operation of Kerr Dam, which would conflict with power generation and recreational use of Flathead Lake. Diking to form one or more subimpoundments could protect some of the most important threatened areas if designed properly, but is also a high-cost approach.

Currently-utilized areas, or areas that have potential for enhancement, could be protected from future detrimental habitat changes, other than erosion, through the use of easement or acquisition with subsequent habitat management. We have identified important brood-rearing areas, nesting areas, and the habitat characteristics of such sites that make them suitable. These data are being used in the development of criteria to rank potential easement/acquisition properties in the northern Flathead Valley. Such properties might be selected as mitigation sites, for losses identified in this document, or for habitat losses elsewhere, or they might be selected (or offered) as lands to come under agency management (i.e., fishing accesses, waterfowl production areas) exclusive of any mitigation processes.

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MITIGATION FOR ELK WINTER RANGE LOSSES AT A HYDROELECTRIC FACILITY IN NORTHWEST MONTANA

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Abstract: When Hungry Horse Dam was closed in 1954, over 13 square miles of important elk and mule deer winter range were inundated. Under the authority of the Pacific Northwest Electric Power Planning and Consevation (NW Power) Act, the Bonneville Power Administration (BPA) has funded a habitat enhancement project designed to offset these losses. Habitat enhancement work is being performed by the U.S. Forest Service, with monitoring of vegetation and population response being conducted by the Montana Department of Fish, Wildlife & Parks.

The project was initiated during September 1987. Baseline data regarding elk and mule deer population levels and distribution was collected using marked animals and periodic aerial surveys. Transects were used to describe habitat conditions and ungulate use within two winter range areas. A short-term enhancement plan prepared in 1988 identified 18 sites to be treated in 1989 and 1990. These include 12 natural openings that will be burned to stimulate forage, and 6 forested sites in which openings will be created through timber harvest or slashing and burning.

Preparation of a long-term (10-year) enhancement plan has been accomplished using an interdisciplinary team. A Geographic Information System (GIS) was used to delineate old growth, thermal cover, hiding cover and foraging areas. Planning has paralleled the current Integrated Resource Analysis process being used to implement the Flathead Forest Plan. All enhancement work has been designed to complement ongoing programs of the involved agencies.

INTRODUCTION

Portions of two important elk (*Cervus elaphus*) winter ranges, totalling 8,749 acres, were lost due to the construction of the Hungry Horse Dam hydroelectric facility (Casey et al. 1984). This habitat loss decreased the carrying capacity of these winter ranges by an estimated 175 elk, and the loss of 3,844 acres of upland shrub habitat on these winter ranges was also responsible for lowering the carrying capacity for mule deer (*Odocoileus hemionus*) (Casey et al. 1984). In 1985, using funds from the Bonneville Power Administration (BPA) as authorized under the Northwest Power Act, the Montana Department of Fish, Wildlife and Parks (FWP) completed a mitigation plan for Hungry Horse Reservoir (Bissell and Yde 1985). This plan identified habitat enhancement on currently-occupied winter range as the most cost-efficient, easily implemented mitigation alternative available to address these large-scale losses of winter range. The Columbia Basin Fish and Wildlife Program, as amended in 1987, specified that BPA shall fund winter range enhancement to meet an adjusted goal of 133 additional elk.

A 28-month advance design phase of the BPA-funded project was initiated by FWP during September 1987. Primary goals of this preliminary phase of the project include detailed literature review, identification of enhancement areas, baseline (habitat and population) data collection and the preparation of 3-year and 10-year implementation plans. The short-term enhancement plan outlined the design and implementation of habitat treatments and associated monitoring to be conducted jointly by FWP and the USDA Forest Service (USFS) during the period 1989–1990 on lands immediately adjacent to Hungry Horse Reservoir. The short-term enhancement activities serve as pilot projects during the period in which the 10-year plan is being finalized. The project includes implementation of a site-specific habitat and population monitoring plan that will allow assessment of the results of enhancement efforts against mitigation goals.

It is typically the quantity and quality of winter range and the interspersion of cover and forage that is assumed to control the size, dynamics, distribution and productivity of big game populations. Transitional habitats (those used during late fall and late winter) are also considered to be extremely important, for it is the condition in which an animal enters winter and its condition immediately before parturition that effect winter mortality and natality, respectively (Cheatum and Severinghaus 1950, Taber et al. 1982). The assumption upon which this enhancement project is based is that poor interspersion of cover and forage, and a deteriorating forage base (due to fire suppression and subsequent stagnation and conifer encroachment) continue to limit the elk and deer populations adjacent to the reservoir.

The scope and objectives of the project directly address the management concerns for elk and mule deer in FWP administrative Region 1 (Mussehl et al. 1986), and for big game winter range management on the Hungry Horse and Spotted Bear Ranger Districts of the Flathead Forest. Population goals for both species call for increases by 1990. Public ownership of key habitats, consideration of habitats as land uses intensify and provision of a diversity of hunting opportunities are all designated as important regional FWP concerns. Areas selected for enhancement are located on lands administered by the Forest Service and project goals are consistent with USFS stated goals (USDA Forest Service 1985) of maintaining suitable ratios of forage and cover in these areas.

The primary responsibilities of the FWP project personnel are to develop and implement the population and habitat monitoring studies. Enhancement activities are being

conducted by personnel employed by or under contract with the Flathead National Forest, under separate contract(s) with BPA. Coordination and planning of long-term enhancement activities are being facilitated through regular meetings of the Hungry Horse Interdisciplinary Team. This team consists of wildlife, timber, and planning specialists from both FWP and USFS, and is also responsible for the preparation of Integrated Resource Analyses for the areas containing the two winter ranges selected for enhancement. These Resource Study Areas are contiguous geographic units with similar management goals, concerns, and management direction (first decade through 50 years). This process forms the framework for implementation of the Forest Plan at the Ranger District level.

The elk/deer project is part of a larger package of mitigation projects currently being funded by BPA for Libby and Hungry Horse dams. Other projects include habitat improvement for the Ural-Tweed bighorn sheep (*Ovis canadensis*) herd and mule deer near Libby Dam (Yde et al. 1986), and a habitat easement/acquisition project designed to offset losses of waterfowl, bears, furbearers, and Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*).

STUDY AREA

Two big game winter ranges adjacent to Hungry Horse Reservoir were selected for initial enhancement activities. The Firefighter Mountain winter range (Firefighter) is located on the east side of the reservoir near its north end (Fig. 1). As defined for this project, this winter range comprises approximately 44 square miles. The Dry Parks/Spotted Bear winter range (Dry Parks) lies at the southeast end of Hungry Horse Reservoir, and encompasses a portion of the South Fork Flathead River drainage above the reservoir, as well as the lower portion of the Spotted Bear River drainage (Fig. 2). As defined for this study, the winter range is bounded on the west by the reservoir and the South Fork; on the east and south by wilderness boundaries, comprising approximately 70 square miles.

The two winter ranges differ substantially in distribution and interspersion of dominant habitat types. Though dominated by fire-caused shrubfields when the dam was built, the Firefighter area is now primarily forested, as conifers have gradually encroached into the openings. Natural open areas on Firefighter are typically less than 30 acres in size. The Dry Parks area, on the other hand, is dominated by fairly steep western exposures with very large shrubland areas interspersed with smaller patches of timbered habitat.

Historical data on the South Fork elk herd, summarized by Casey et al. (1984), indicated that elk populations have fluctuated around 1000–1500 in the South Fork outside the wilderness, with the majority wintering on Dry Parks (Biggins 1975). Recent estimates (J. Cross, S. Riley, pers. commun.) based on annual surveys indicate a current population of 500–1000 at Spotted Bear, and 50–100 at Firefighter. Based on the habitat condition and status of the population, Firefighter was selected for the primary emphasis of the short-term enhancement activities.

A limited population of mule deer winters in the South Fork; one of the only pre-dam estimates listed the population at 375 (Rognrud 1949). Few are currently recorded during aerial surveys of the two winter ranges in the study area (Cross, pers. commun.). The deer tend to use the higher portions of the winter range, along exposed ridges, moving into lower areas as spring greenup progresses.

The Flathead Forest Plan (USDA Forest Service 1985) has designated approximately half of Firefighter (Fig. 1) as Management Area (MA) 13 (and 13A), or elk and mule deer winter range. The other half consists mostly of areas designated as MA 15 (cost-efficient timber production emphasis) and MA 16 (timber production without roads). The remainder of the area is designated as MA 7 (visual quality emphasis). Each MA (except 13A) has a designated timber harvest yield and therefore contains some level of timber management, depending on resource emphasis. The emphasis in MA 13 is to provide size, age, diversity and distribution of cover and forage areas suitable for elk and mule deer winter habitat. Dry Parks contains proportions of MA's similar to Firefighter. The majority of land designated MA 13 at Dry Parks is nonforested.

Project Goals and Objectives

The general goal of the project is to increase elk carrying capacity in currently occupied winter range areas through habitat enhancement. Specific goals include the creation of foraging habitat (openings of ≤ 20 acres) in areas where natural succession has skewed cover/forage ratios; and rejuvenation of existing openings through prescribed burning. We hope to increase habitat quality/availability for mule deer by incorporating their habitat needs into the design of habitat treatments planned primarily for elk, and by providing additional spring range areas through the creation, treatment or expansion of natural openings.

The general goal of our population monitoring program is to design and implement an intensive population monitoring program that will allow assessment of population responses to habitat treatment. Specifically, we wish to determine bounded estimates of baseline elk and mule deer populations using the two winter ranges; design and implement surveys to monitor populations through continued estimation of population size and dynamics; to determine baseline patterns of distribution within winter ranges; design and implement surveys to document changes in distribution over time; to determine baseline and post-treatment patterns in habitat use and food habits; design and implement systematic surveys to monitor changes in habitat use over time.

The general goal of our habitat monitoring program is

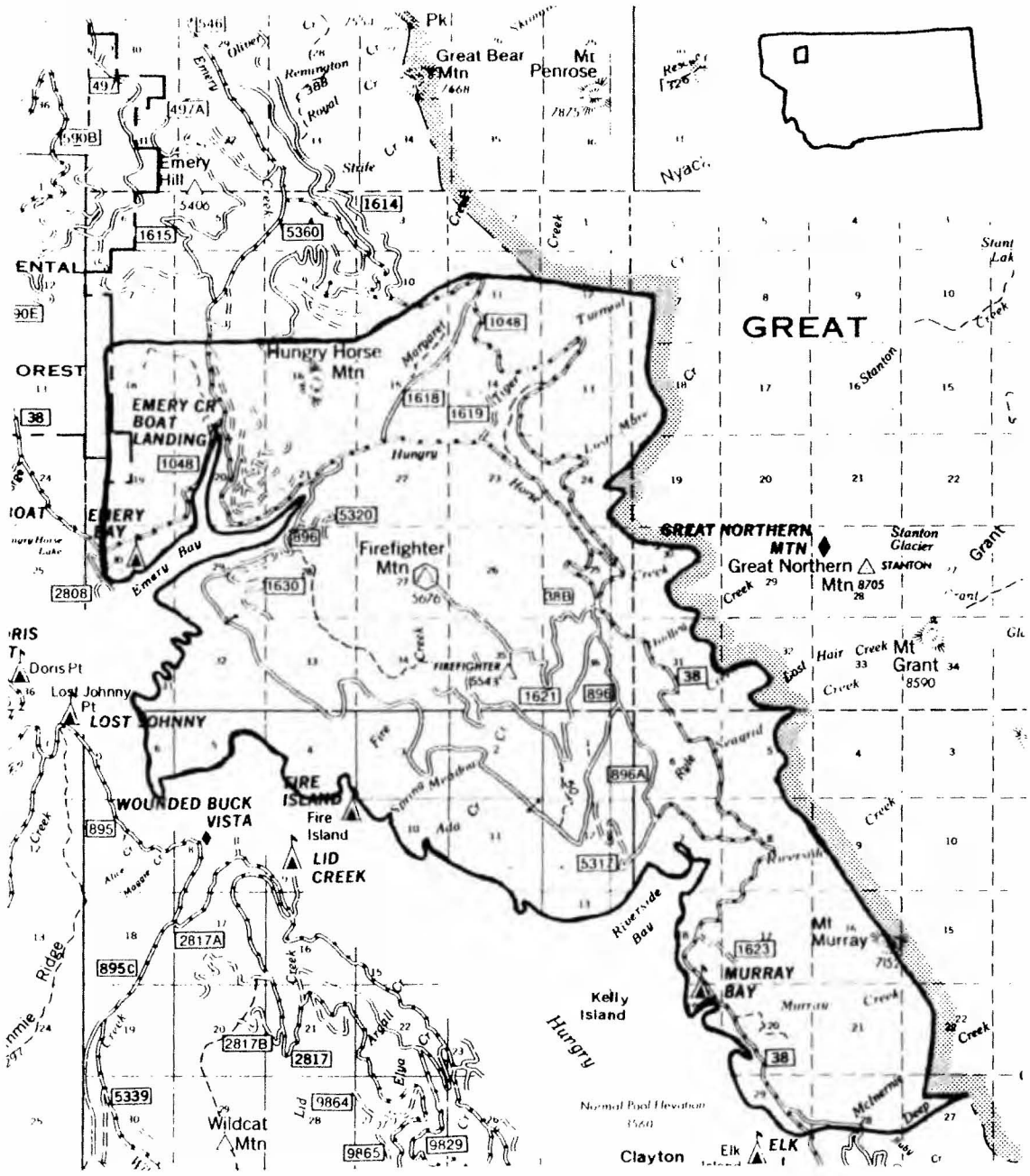


Figure 1. Map of the Firefighter Mountain big game winter rage, northwest Montana.

to describe baseline habitat condition, and design and implement a habitat monitoring system that allows determination of habitat responses to treatment. Specifically, we will calculate baseline and post-treatment habitat effectiveness, based on road density, cover/forage ratio, and habitat distribution within each winter range. Site-specific response monitoring goals are to determine species composition, density, cover values of dominant and subdominant plant species, and forage production in treatment areas, before and after treatment.

METHODS

Habitat loss estimates were developed from review of historic aerial photos, annual game survey data, interviews with local biologists, trappers and foresters, and other sources as described by Yde and Olsen (1986). Frequent interagency review was incorporated throughout the development of loss estimates and mitigation plans.

The primary activity during the preparation of the short-term implementation plan was to select treatment sites and techniques. Two primary enhancement techniques have been

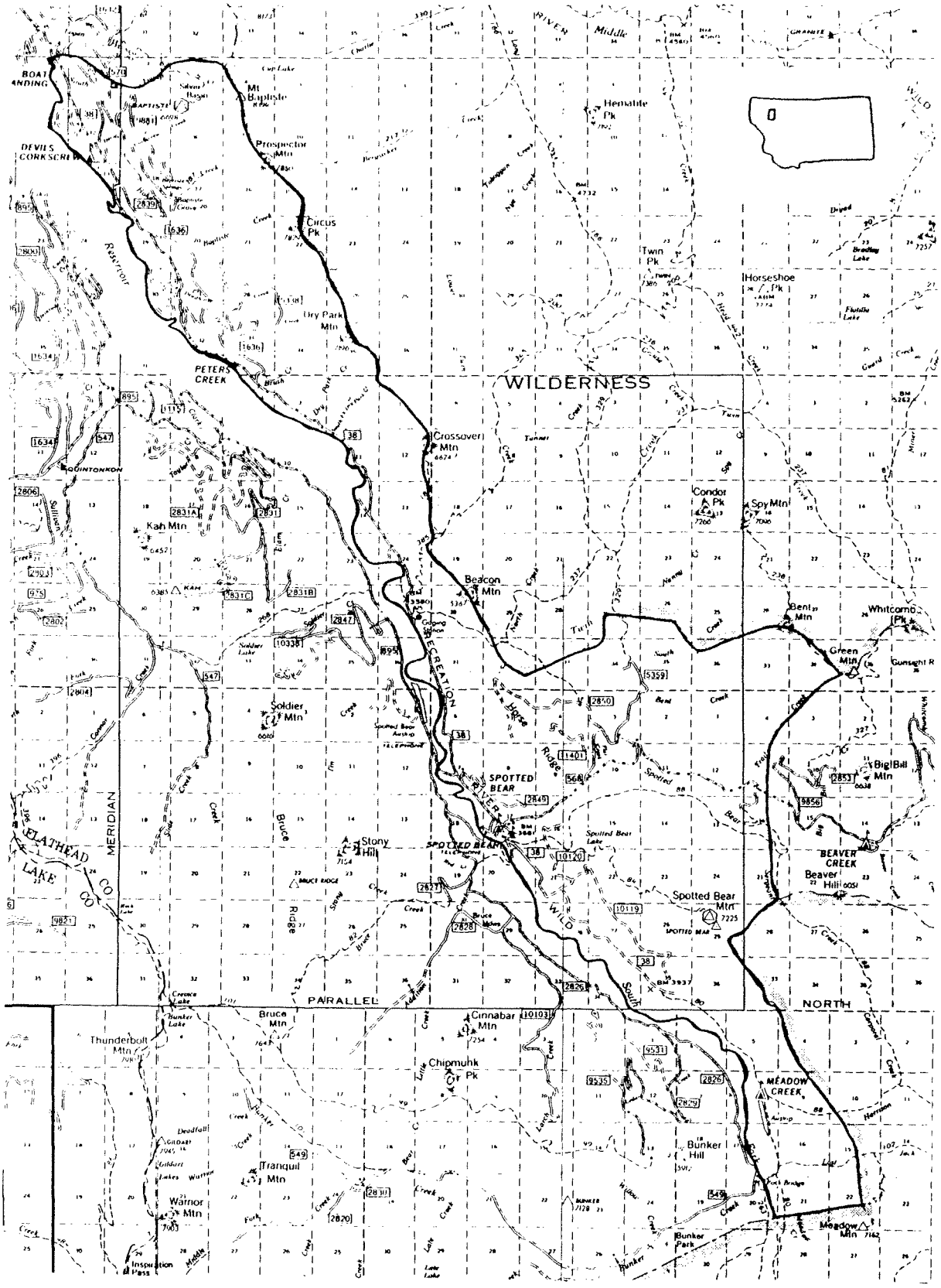


Figure 2. Map of the Dry Parks/Spotted Bear big game winter range, northwest Montana.

selected as tools to manipulate habitat during the short-term implementation phase:

1. Prescribed Burns, Natural Openings. Aerial application of Lumigell/gasoline mixture will be used to burn a minimum of 323 acres of existing shrubfields during the 3-yr period. Ground crews will be used to control the burns, which will be conducted as early in the spring (late April–early June) or in the fall (Sept.) as conditions allow. Natural openings were selected based on apparent browse condition, aspect (S-SW-W), and known elk use.

2. Slash and Burn. Portions of the Firefighter Mountain winter range were selected for treatment through timber harvest or slashing and burning in dense, even-aged lodgepole pine stands. Trees will be felled (with or without concurrent harvest of commmercial materials), allowed to dry for a full year (or more), and then burned using the techniques listed for natural openings. Treatment plots will be paired for experimental purposes, with one of each pair being fertilized and seeded with a standard grass/forb mixture. The salvage of commercial materials from treatment sites will be scheduled wherever timber characteristics, access and time allow.

Forest stands to be treated were selected based on aspect and elk use (or proximity to high use areas), as well as tree density (lack of understory). Proximity to existing roads was also considered, because easy access and lack of road construction shorten the lead time necessary to implement treatment. Additional consideration was given to visual concerns as expressed by the Forest Landscape Architect. Slashing will be conducted through a timber sale and/or slashing contract, with the contractor salvaging commercial stock when feasible. Three treatment sites will be fertilized and seeded with a standard grass/legume mixture. Game-proof exclosures at least 20x50 m in size will be built on certain paired sites, for analysis of vegetative response.

Population Monitoring

Baseline population and habitat data collection was begun during late fall, 1987. Radio-marked elk were used to determine current distribution and seasonal use patterns. Animals were captured using folding Clover traps (Thompson et al., in prep.), and fitted with individually marked radiocollars and eartags. Population monitoring has concentrated on establishing baseline information, and on testing methods for assessing response to pilot habitat treatments. Ultimately, we plan to determine and mark a sample size adequate for determining a 95% confidence interval around our population estimates (Rice and Harder 1977). The original estimate of 25% observability for fixed-wing surveys of this herd, developed by Biggins (1975), are being tested using a double sampling scheme similar to that developed in Idaho by Samuel et al. (1987). This method assesses observability as a function of group size, canopy coverage, and other factors (Samuel et al. 1987). Standard mark-recapture estimates will also be developed for elk and for mule deer.

Aerial surveys of both winter range areas are being conducted at least twice monthly during the months of September–May, and occasionally during the summer months (since some elk are year-round residents of the study area). At least two surveys each year will be conducted by helicopter. Surveys will be coordinated with ongoing regional surveys in order to maximize data-sharing and efficiency in data collection. Population trend indices will likely be calculated almost entirely from aerial survey data, though additional harvest and sign survey data will also indicate trends.

Changes in sex and age ratios, age structure, and physiological condition can all serve as indicators of the condition and trend of a big game herd. To calculate sex and age ratios, all animals seen during aerial and ground surveys are classified by age class and sex. Age distribution is also determined through examination of trapped animals and the collection of teeth at hunter check stations. During long-term monitoring, pregnancy rates will also be calculated from blood samples taken during trapping, and/or from urine samples collected in the field (Del Guidice et al. 1988)). Aerial survey and harvest data will be used in available computer population models to estimate composition, size and status (stable, decreasing, increasing) of the population.

Long-term trends in distribution and habitat use by elk and deer will be monitored within and around the treatment areas, particularly to determine if increased use indicates actual population gains or merely shifts in distribution. The locations of all elk and mule deer seen within the project area are mapped in order to describe current seasonal distribution and habitat use patterns within each winter range. Locations are then mapped on mylar overlays to a habitat map of the area in order to identify heavy use areas and habitat preference (comparison with random points). Seasonal home ranges of radioed elk are being mapped from relocation data. Calving areas and other important use areas will be identified for incorporation into enhancement plans.

Habitat Monitoring

The habitat monitoring effort will consist of two phases: documentation of baseline and changing habitat distribution, and documentation of specific vegetative response to treatment.

Early in the advance design phase of the project, a baseline elk habitat map of each winter range was drafted, based on the USFS Geographic Information System (GIS), forest types (Pfister et al. 1977), review of orthophotos and ground-truthing. Habitat effectiveness ratings (Lyon (1979) will be calculated for specific areas containing enhancement sites. This rating can then be re-calculated post-treatment to assess the effective acreage enhanced.

Site-specific treatment response will be described in several ways. The initial effectiveness of treatment (e.g. extent of burn) will be recorded photographically and in narrative. Vegetation plots/transects (ECODATA, USDA Forest Service handbook) will be sampled in each treatment stand prior to treatment, and again on an annual basis for at least two years thereafter. Permanent photo plots will be established at each site, and will include the exclosures where applicable. Vegetation responses will be compared between those sites seeded and fertilized and control sites, and between treatment types, in order that the concept of adaptive management can be implemented early in the project. Stands treated prior to the initiation of the project (i.e. wildlife burns, clearcuts, thinned stands) will also be analyzed. This should shorten the time necessary to assess long-term enhancement effects.

Habitat conditions and elk use patterns during the winter of 1987–1988 were assessed in part through the use of browse condition/pellet group transects. Transect locations were selected through a stratified random selection process. Elevation, aspect and canopy coverage classes were equally represented in each of an equal set of transects located in each winter range. A total of 36 transects were sampled during 1988. At each site, the starting point was marked and a compass reading was taken parallel to the slope to define the transect. Transects were 250 m long. All pellet groups within 2 m of the center line were recorded, and classified as either new, moderately old, or old. The closest shrub perpendicular to the line was recorded at 5 m intervals, so that measurements were taken for 50 shrubs on each transect. Measurements taken at each shrub included distance from the line, height and width (to the nearest (0.05 m) and number of browsed/unbrowsed twigs within a random cluster picked within the estimated reach of elk (>0.5 m and <2 m above the ground). This effort will serve as a pilot study to determine the number of transects necessary to adequately describe habitat use. In addition to the random points, transects have been established in each of the treatment areas.

Preparation of the Long-term Enhancement Plan

As a requirement of the 28-month advance design phase of the project, a long-term (10-year) enhancement plan is being prepared for submittal to BPA in December 1989. This plan identifies specific treatment alternatives and schedules, based on the integrated review process undertaken by the Hungry Horse ID Team. The planned enhancement activities must balance other resource objectives, such as control of insects and disease, timber harvest opportunities, preservation of old growth and riparian values, and visual integrity of the landscape.

Primary tools used in the planning of the long-term plan have been baseline data on elk distribution and habitat condition collected during the first project field season, public input, and GIS data. GIS queries were developed to produce maps of generalized elk cover types (hiding cover, thermal cover, forage, and forested forage; Table 1). Additional queries were developed for old growth habitat values and beetle risk. Series of overlays are being used to juxtapose roads, riparian zones, elk use areas and GIS maps for treatment site selection. Alternatives that represent a broad range of economic, timber, elk and habitat quality goals are being evaluated.

RESULTS

Initial radio-tracking data, habitat reconnaissance and interagency planning resulted in the selection of 18 sites to be treated during the short-term implementation phase.

A set of seven natural openings (or groups of openings) have been selected for prescribed fire treatment at Firefighter (Table 2). The sites range in size from 7.2 to 27.4 acres, though two sites are composites of openings as small as 0.3 acres. These sites are characterized by sparse to moderately dense shrub cover, with mountain maple (*Acer glabrum*), serviceberry (*Amelanchier alnifolia*), *Ceanothus spp.*, and chokecherry (*Prunus virginianus*) as the dominant species, with lesser amounts of rose (*Rosa spp.*), snowberry (*Symphoricarpus spp.*), and mixed forbs and grasses in the understory.

Six sites on the middle slopes of the western aspect of Firefighter Mountain were selected for treatment through timber harvest or slashing and burning (Table 3). Stands selected for initial treatment typify the dense seral stands of lodgepole pine that have replaced the shrub stands prevalent at the time the dam was built (Casey et al. 1984). Specific stands were selected from the largest contiguous section of "doghair" lodgepole, to represent various combinations of aspect, slope and elevation.

Five sites at Dry Parks (Table 4) were selected for treatment by prescribed fire. The sites selected at Dry Parks are segments of the very large open hillsides that constitute the core of the winter range. The area is heavily used by elk, and is characterized by extremely decadent stands of maple and serviceberry. The sites represent a range of the lower and middle elevations used by elk. They range in size from 28 to 69 acres. The USFS has successfully burned areas of up to 250 acres in the Dry Parks area in recent years.

Long-term Planning

Review of GIS data for Firefighter indicates that current cover/forage ratios are high, with hiding cover being the predominant elk cover type available (Table 5). Thermal cover stands are limited, and correspond closely with those stands meeting our criteria for potential old growth. Such stands have the potential of becoming true old growth within 50-100 years, but no existing stands in the analysis area qualified as old growth given current habitat characteristics.

Planning for creation of forage openings during the next

Table 1. Data queries used to define elk cover types for long-range enhancement planning, Firefighter Mountain Resource Study Area, northwest Montana.

	Habitat Characteristics[a]		
Cover Type	Forest Size Class	Canopy Coverage (%)	Other
Forage	seedling	0 – 100	Nonforested openings
	sapling	0 – 70	
Forested Forage	pole	0 – 40	
	mature	0 – 40	
	old	0 – 40	
Thermal Cover	mature	40 – 100	Dominated by species other than larch, >40 ft. canopy, > 50 trees/acre with dbh >7 in.
	old	40 – 100	
Hiding Cover	sapling	70 – 100	Stands which do not meet thermal cover criteria
	pole	40 – 100	
	mature	40 – 100	
	old	40 – 100	

[a]Based on landsat imagery, timberstand inventory data stored in Geographic Information System (GIS)

Table 2. Locations and characteristics of natural openings with potential for rejuvenation through controlled burns, Firefighter Mountain winter range, northwest Montana, 1988–1990.

Site	Location	Approx. Size (acres)	Elevation[a]	Aspect	Year	Comment(s)
I	NE-1/4 Sec 28, T30N R18W	24.3	4600	SW	1989	
II	NW-1/4 Sec 27, T30N R18W	7.2	5300	WSW	1989	Could be tied in with I
III	NW-1/4 Sec 33, T30N R18W	14.3	4350	SW	1989	Six small openings
IV	NE-1/4 Sec 32, T30N R18W	10.0	4000	SW	1989	
V	SW-1/4 Sec 22, T30N R18W	19.3	4450	S	1990	
VI	SW-1/4 Sec 12, T29N R18W	20.7	4050	SSE	1989	
VII	Sec 34, T30N R18W	27.4	4200–5000	S/SE	1990	Ten small openings

[a]In feet above sea level; approximate mean elevation of opening.

decade has focused on those areas classified as hiding cover on SE to W aspects. These areas should be easiest to maintain through re-treatment, and existing thermal cover stands are thereby protected.

DISCUSSION

The selected treatments are based on the assumptions that carrying capacity can be increased through two means: increased productivity, or decreased mortality (or both). Since both productivity and natural mortality of elk are closely tied to their physiological condition (Taber et al. 1982), the provision of more, higher quality forage should allow increased carrying capacity through improved animal condition. Burning has repeatedly been shown to be one of the best tools for improving forage quality. Dead stems are removed, encroachment by trees is forestalled, and nutrients are recycled, allowing robust new growth.

Other habitat treatment techniques, such as underburning, select cuts, strip cuts, thinning, or directed reforestation are not scheduled for the short-term implementation period, but may be used later in the project. Over the long term, habitat treatment areas will be designed and maintained so as to provide a combination of forage and cover verified to be most effective on a site specific basis. Re-treatment (e.g., burning at designated intervals) may be necessary to maintain forage quality.

As the primary target species of the project, elk will receive the greatest benefit from the short-term

Table 3. Locations and characteristics of elk foraging areas to be created through slashing and burning, Firefighter Mountain winter range, northwest Montana, 1988–1990.

Site	Location[a]	Size (acres)	Elevation[b]	Aspect[c]	Year Slash	Year Burn	Associated Treatment(s)
A	W-1/2 Sec 2, E-1/2 Sec 3	≤20	4300	L/SE	1989	1990	Post and Pole Sale[d] Exclosure
B	SW-1/4 Sec 2	≤20	4300	L/SW	1989	1990	Post and Pole Sale[d] Exclosure Seeded/Fertilized
C	NW-1/4 Sec 11	≤20	3860	S	1989	1990	None
D	SW-1/4 Sec 12	≤20	4300	L/SE	1989	1990	Post and Pole Sale[d] Seeded/Fertilized
E	SE-1/4 Sec 12, SE-1/4 Sec 13	≤20	3700	SE	1989	1990	Post and Pole Sale[d] Seeded/Fertilized
F	SE-1/4 Sec 11	≤20	3800	SW	1989	1990	None

[a]All sites in T29N, R18W
[b]Feet above mean sea level; approximate mean elevation of stand to be treated.
[c]L=Mostly level.
[d]Post and pole sale to precede slashing, if feasible.

Table 4. Locations and characteristics of natrual openings with potential for rejuvenation through coltrolled burns, Dry Parks/Spotted Bear winter range, northwest Montana, 1988–1990.

Site	Location	Approx. Size (acres)	Elevation[a]	Aspect	Year	Comment(s)
1	SW-1/4 Sec 3, T26N, R16W	50.7	3700	SSW	1989	At Dry Parks trap site
2	Sec 3, T26N, R16W	27.2	4180	SSW	1990	Adjacent to (1)
3	SW-1/4 Sec 13, T26N, R16W NW-1/4 Sec 24, T26N, R16W	60.8	4050	WSW	1989	Crossover area
4	SE-1/4 Sec 8, T26N, R15W NE-1/4 Sec 17, T25N, R15W	57.6	4530	S	1989	Horse Ridge
5	SE-1/4 Sec 2, T26N, R16W	68.8	4600	SSE	1990	South Dry Parks

[a]In feet above sea level; approximate mean elevation of opening.

implementation activities. Within one year following initial treatment, the quantity and quality of forage available to elk should have increased. It is likely, however, that population responses will not express themselves until several years of enhancement activities have taken place, along with the physiological changes leading to increased natality and/or decreased mortality. Ideally, the long term changes will result in a habitat mosaic capable of carrying the extra 133 elk identified as a mitigation goal.

Mule deer will gain the same benefits from the planned enhancement activities as elk. The creation of more winter and spring range should result in improved production and/or decreased mortality. Competition between elk and deer for forage should also be reduced as more and varied foraging areas are provided.

An important product of the two-year advance design of this project is the development of a statistically-sound, site-specific (population and habitat) monitoring plan. That plan will have specific schedules, sample sizes, and methods based not only on current "state of the art", but on preliminary habitat and population studies within the project area. The monitoring effort will serve as our tool for

Table 5. Acreage of elk cover types, Firefighter Mountain Resources study Area, northwest Montana.

Cover Type[a]	Acres	% of Area
Forage	1,080	8.9
Forested Forage	1,927	15.9
Thermal Cover	5,980	49.3
Hiding Cover	3,133	25.8
TOTAL	12,120	100.0

evaluating whether mitigation is being achieved. The population monitoring portion of the plan will be structured to determine current population size and distribution, herd structure, population dynamics, and the changes in these attributes as enhancement activities are implemented. The habitat monitoring effort will document changes in the density, species composition, canopy coverage, and vigor in treatment areas.

The data collected during the monitoring phase will serve to direct future management (enhancement) actions. This project allows for adaptive management, with an accounting against mitigation goals as a driving influence, i.e.:

A. Assess new population status against baseline, and against mitigation goals.
B. Evaluate whether habitat goals have been met.
C. Recommend management actions:
    1. Revise treatment schedules.
    2. Revise enhancement techniques.
    3. Revise acreage goals.
    4. Revise population goals.
    5. Revise monitoring methods.

The mitigation plan developed for Hungry Horse assumed overlapping benefits from separate mitigation projects (Bissell and Yde 1985). How these overlapping species benefits will be accounted for has not yet been resolved.

Much of that effort should come about as part of the function of an Advisory Committee, set up to administer a mitigation trust fund agreement signed by the State of Montana and BPA in early 1989. Under this agreement, BPA will make annual deposits to a trust fund over the next six years, until such time as they have provided FWP with $12.5 million. The funds are to be used to mitigate the effects of Hungry Horse and Libby dams only, with perpetual principal of $4 million to be maintained in the account to fund long-term O&M of projects or facilities acquired as part of the mitigation program.

SUMMARY

During September 1987, BPA funded several wildlife enhancement projects in northwest Montana, including elk/mule deer winter range enhancement adjacent to Hungry Horse Reservoir. The initial phase of this enhancement project is designated as an advance design phase, with initial implementation of population monitoring (baseline), habitat mapping, and and detailed literature review. The contract also called for the preparation of a long-term implementation plan by December 1989, and a short-term plan to govern enhancement activities during the period 1988–1990.

The short-term plan was completed March 1988, by an interdisciplinary team of FWP and USFS specialists. Habitat treatment sites were selected in both the Firefighter and Dry Parks winter ranges, and were scheduled to begin during the spring of 1989. More than 400 hundred acres were selected for treatment either through prescribed fire alone, or prescribed fire following slashing and/or timber harvest. Sites were selected for ease of access, obvious decadence of the forage base, and known use by elk. Planned activities were based on the assumption that some enhancement should occur as early in the project as possible, in order that the concept of adaptive management may be used to guide future enhancement activities.

Preparation of the long-term enhancement plan is ongoing. Use of GIS databases allowed for the mapping of important elk cover types, old growth and other forest characteristics in the design and selection of treatment sites. Future enhancement activities will be funded through a trust fund agreement between FWP and BPA, with use of funds overseen by an Advisory Committee made up of representatives of the involved agencies and other regional interests.

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MITIGATING WETLANDS IMPACTS UNDER SECTION 404 OF THE CLEAN WATER ACT

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Abstract: What were once known as swamps, bogs, marshes or bottomlands we now call wetlands. These water-dominated areas, we have learned, perform many important ecological functions. Wetlands provide habitat for a variety of wildlife species: prairie potholes are breeding areas for waterfowl, marshes and bottomlands provide food and shelter for mammals, and coastal marshes are critical habitat for shellfish and marine fish. Wetlands also serve as flood barriers and sediment traps, prevent erosion and stabilize shorelines. Finally, wetlands can improve ground water and surface water quality by trapping metals, nutrients and other pollutants. As our awareness of wetland values has increased, regulatory control over wetlands impacts has received more emphasis. The primary federal provision used to regulate wetlands is Section 404 of the Clean Water Act.[1]

Section 404 of the Clean Water Act requires a permit from the Corps of Engineers before any dredge or fill activity affecting the waters of the United States can occur. The permitting program run by the Corps of Engineers and overseen by the Environmental Protection Agency has become the primary regulatory protection of the nation's wetlands. This paper discusses the nature of that regulatory program, focusing on mitigation requirements under Section 404 of the Clean Water Act, as well as some legal issues surrounding wetlands protection under this Section.

WHEN 404 APPLIES: THE DEFINITION AND DETERMINATION OF WETLANDS

Both the Corps of Engineers and the EPA promulgated regulations under The Clean Water Act creating broad jurisdiction over the nation's waters.[2] Included within the scope of that jurisdiction are this country's wetlands. The Corps and the EPA define "wetlands" as "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal conditions do support, a prevalence of vegetation typically adapted for life in saturated soil conditions."[3] The Supreme Court recently upheld Corps jurisdiction over wetlands so defined.[4] The trend in the case law, with a few exceptions, supports a broad reading of this definition and great deference to the Corps' determination of whether an area is a wetland.

The definition of "wetlands" creates a three factor test for designating an area as wetland. The central aspect of this definition is the presence of vegetation suited for wetlands. The Corps also looks to the nature of soils in the area under scrutiny, and to the saturation or inundation of the tract. The Corps and the EPA act as factfinders in wetlands determination, and agency determination will be upheld on judicial review unless arbitrary and capricious.[5]

Definition

The Clean Water Act requires a permit from the Corps of Engineers for any discharge of dredge and fill material into "navigable waters."[6] The Act further defines "navigable waters" as "the waters of the United States."[7] In promulgating regulations under this statute, the Corps of Engineers and the EPA offer an enumeration of the waters of the United States.[8] This definition extends Corps jurisdiction to those waters that are navigable in fact, their tributaries, wetlands adjacent to these waters, and any waters that may affect interstate commerce.[9]

The Corps' jurisdiction over these waters extends to the mean high water mark, or to the edge of any wetland adjacent to a navigable stream or its tributaries.[10] The Corps jurisdiction over wetlands rests on the dual inclusion of wetlands in the enumeration of the waters of the United States. Any wetlands that could affect interstate or foreign commerce fall under Corps jurisdiction under the regulations, as will any wetland adjacent to any other waters under Corps regulation. The phrase "adjacent to" defined as "bordering, contiguous, or neighboring."[11] Further, a wetland separated from a waterway by a man-made dike or a natural barrier will still be considered adjacent.[12]

The Corps and the EPA define "wetlands" as "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal conditions do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.[13] Both definitions further list as example of wetlands "swamps, marshes, bogs, and similar areas."[14] These examples do not limit the breadth of the definition, as a wetland that is not properly a swamp, marsh, or bog may still come within the definition of a wetland.

The definition of "wetland" is broad, and captures areas that fall outside the traditional definition of navigability. In the earliest reading of the Clean Water Act, the courts refused to limit the phrase "navigable waters" to traditional tests of navigability, finding that the phrase "asserted federal jurisdiction over the nation's waters to the maximum extent permissible under the Commerce Clause of the Constitution."[15] The question remaining is just what is permissible under the Commerce Clause.

The Supreme Court recently resolved that question to some extent in the context of wetland regulation.[16] A developer owned 80 acres of marsh land near Lake St. Clair in Michigan, and, in 1976, began to fill it. The Corps of Engineers sought and was granted an injunction against further filling. The Sixth Circuit reversed, holding that Corps jurisdiction extended only to those wetlands flooded

by adjacent navigable waters at a frequency sufficient to support aquatic vegetation.[17] The issue presented to the Supreme Court was whether Corps jurisdiction is limited to those wetlands frequently flooded by waters navigable in the traditional sense.

The Supreme Court unanimously held that the definition of wetlands in the Corps and EPA regulations is a permissible interpretation of the Clean Water Act. The Court took the broader meaning of "waters of the United States" to be consistent with the purposes of Congress in enacting the Clean Water Act.[18] Given that the goal of the legislation is to improve the quality of United States waters, the Supreme Court found that Congress recognized the need for broad federal authority to control pollution.[19] Further, in 1977 the Congress reconsidered the scope of authority granted the Corps of Engineers, but not to enact legislation limiting that authority.[20] Thus the Court upheld the Corps definition of "waters of the United States" as including wetlands in the broad sense outlined in the regulatory definition. That definition takes as its differentia the capacity to support aquatic vegetation, and in no way refers to navigability. It may be that Corps' assertion of jurisdiction over some waters will be found to fall outside the scope of the Commerce Clause, but its jurisdiction over wetlands seems settled.

Determination

The Supreme Court's decision affirming the Corps' definition of "wetland" does not resolve all difficulties in the application process for Section 404 permits. That definition must still be applied to the particular situations arising under Section 404, and the Corps must determine whether a given area is indeed a wetland.

The Corps regulations create a three factor test for determining if an area is wetland. First, the tract must be frequently inundated or saturated by surface or ground water. Second, the area must be one that under normal conditions will support vegetation adopted for life in saturated soil conditions. Finally, one can look at the nature of the area to see if it is indeed typically saturated.[21] The critical element in this definition is the presence of wetlands vegetation, or the ability to support such vegetation. The existence of obligate wetland vegetation is nearly conclusive proof that an area is indeed a wetland. While the typical swamp, marsh, or bog may easily fit these criteria, the Corps has in the past asserted jurisdiction over areas falling within the penumbra of these criteria.

In Minnesota, for example, a developer began to fill 18 acres of wetland for commercial development. This particular tract was once dry land, but highway construction and a storm sewer system changed it into an artificial wetland.[22] The Corps notified the developer that a permit was required for placing fill in this tract. When the developer applied for a retroactive permit, the Corps denied his application. The developer then sought relief, arguing that the Corps lacked jurisdiction because the tract was not a natural wetland.[23] The court held that the Corps did have jurisdiction over this artificial wetland, as the question is not how a wetland comes to be, but whether or not the area is indeed a wetland.[24] This court's holding implies that if an area is frequently inundated or saturated so as to support aquatic vegetation, it will be a "wetland" within the scope of Section 404, whether artificial or natural.

Another case in the Eighth Circuit places an apparent limitation on the scope of jurisdiction over artificial wetlands. The City of Fort Pierre, South Dakota wished to fill in a slough for health and safety reasons and to construct two streets through the area.[25] The slough was once a side channel of the Missouri River, but had long been dry. In 1968 the Corps of Engineers dredged the bottom of the Missouri River and in the process blocked the end of the Fort Pierre slough, trapping water inside. The trapped water became stagnant, killing the trees in the area. Yet when the city sought a permit to fill the slough, the Corps denied their request under Section 404 of the Clean Water Act.

The Eighth Circuit held that the Corps did not have jurisdiction over the slough. The court reasoned that the Corps should not be allowed to exercise jurisdiction over private land that would not have fallen within Corps jurisdiction absent an affirmative, albeit unintentional, action by the Corps.[26] The court limited its holding to those instances where the Corps itself creates a wetland where none previously existed. Yet the court further notes that Congress may have the power to assert jurisdiction over the slough legislatively.[27] This holding seems to view the scope of the definition of wetlands as more narrow than the limits of power under the Commerce Clause.

The rationales in *Track 12* and *Fort Pierre* conflict, and the court in *Track 12* distinguished *Fort Pierre* by limiting it to its facts. That approach seems appropriate, as the jurisdiction of the Corps over a wetlands is seldom questioned. The rule announced in *Track 12*, that the Corps has jurisdiction over a wetland no matter what its origin, is that of the majority.[28]

For example, the Fourth Circuit held that Corps jurisdiction over a man-made canal was within the ambit of the Commerce Clause as the filling of that canal might effect waters that are traditionally navigable.[29] In another case a rancher wished to fill a swamp area in the middle of his farm. Even though this swamp was artificially created through irrigation and flood control projects, the court held that the Corps properly asserted jurisdiction over the area.[30] The rancher ingeniously argued that the area did not support wetland obligate vegetation "under normal conditions." The area was upland until surrounding projects flooded it, and so the area would not "normally" support aquatic plant life. The court rejected this argument, construing the phrase "under normal conditions" in the definition of wetlands to preclude

only those upland areas that may by aberration support obligate wetland vegetation.[31]

THE REGULATION OF WETLANDS

Corps of Engineer Regulations

The Corps evaluates permits under a process it calls "public interest review."[32] Public interest review is a general balancing test weighing the reasonably expected benefits of a project against its reasonably foreseeable detriments.[33] The goal of public interest review is to "reflect the national concern for both the protection and utilization of important resources."[34] The regulations offer an enumeration of the factors to be considered in this balancing: conservation, economics, aesthetics, general environmental concerns, wetlands values, historic properties, fish and wildlife values, flood hazards, floodplain values, land use, navigation, shore erosion and accretion, recreation, water supply and conservation, water quality, energy needs, safety, food and fiber production, mineral needs, consideration of property ownership, and the general needs and welfare of the people.[35]

While these factors form the broad outlines of balancing, the regulations also provide for three specific criteria that are a part of every permit evaluation. The Corps must consider (1) the relative extent of the public and private need for the proposed project, (2) the practicability of using reasonable alternative locations and methods for the project and (3) the extent and permanence of the beneficial or detrimental effects on the public and private users for which the area is suited.[36] Further, the regulations specify that, given the importance of wetlands, development of wetlands is to be discouraged.[37] No permit involving the alteration of wetlands shall be issued unless the District Engineer concludes after engaging in the balancing outlined above that the benefits of the proposed alternative outweigh the damage to the wetlands resource.[38]

The balancing test proposed in the Corps regulations straightforwardly balances the benefits of development against its detriments. The factors to be considered are broad and include not only environmental concerns but also socio-economic factors. This balancing test forms the background of the EPA regulations requirement that a permit not be issued when it might lead to unacceptable adverse impact. Given the importance of most wetlands to the ecosystem, the majority of dredge and fill operations will have adverse impact. That impact will be acceptable when, in the balance, the benefits to society outweigh the harm to the environment.

Developments that affect wetlands are subject to a higher level of scrutiny than other projects. One court has fashioned a presumption against the development of wetlands that must be overcome before a Section 404 permit will be issued.[39] Yet given the range of factors to be considered in the balance the benefits may well outweigh even this presumption. Environmental factors, as determined by the District Engineer, do not trump other factors.[40] Also, the applicant's goals in development are a factor to be considered in the balance.[41] The District Engineer is to consider both public and private need for development while performing the public interest review.[42]

The Clean Water Act provides that any applicant for a federal permit for a project that may adversely affect the navigable waters of the United States must provide the permitting agency a certification from the state in which the discharge will occur.[43] Permits issued under Section 404 of the Clean Water Act are subject to this certification procedure. Certification verifies that the activity will comply with state and federal water quality standards. State certification is generally limited to water quality issues.[44]

EPA Regulations

The EPA has veto power over Corps Section 404 permits pursuant to 33 U.S.C. §1344(c). The Administrator for the EPA may prohibit or restrict a proposed Section 404 activity if that project will adversely affect fish, wildlife, or recreation.[45] He first notifies the Corps and the applicant that he intends to issue a proposed determination under Section 404(c). The Corps has 15 days to persuade the Regional Administrator that there are no adverse impacts, or to identify corrective measures. Failing that, the Regional Administrator publishes notice of the proposed determination to veto the permit in the Federal Register and invites comment and provides an opportunity for a public hearing. After hearing and comment, the Regional Administrator may withdraw his proposal or prepare a recommended determination. The recommended determination and administrative record are forwarded to the Assistant Administrator for Water at the EPA headquarters for a final decision. That decision may affirm, modify or rescind the recommended determination. The Corps and the applicant are consulted before this final determination is made.[46]

EPA standards for reviewing a permit fall under three guidelines. First, no dredging shall be permitted so long as some practicable alternative to the proposed activity exists.[47] The practicability of an alternative rests in part on the water dependency of the proposed use. Second, no permit will be issued unless it can be demonstrated that there will be no unacceptable adverse impact on wetland values either individually or in combination with known and probable impacts of other activities.[48] Finally, any permit must rest on a showing that "appropriate and practicable steps have been taken to minimize potential adverse impacts."[49]

Regulations promulgated by the EPA under Section 404 create a test for Section 404 permits based on the notion of "practicable alternatives." The EPA will allow a Section 404 permit to be issued only if there is no practicable alternative to the proposed action. If the proposed action is not "water

dependent," then the existence of a practicable alternative is presumed.

The EPA regulations create a stricter test than those of the Corps for determining the practicability of alternatives. The EPA regulations state that "no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge that would have less adverse impact on the aquatic system, so long as the alternative does not have other significant adverse environmental consequences."[50] The EPA defines "practicable" as "available and capable of being done after taking into consideration cost, existing technology and logistics in light of overall project purposes."[51] The regulations also note that an area not owned by the proponent of the action may be a practicable alternative if it could "reasonably be obtained, utilized, expanded or managed in order to fulfill the basic purpose of the proposed activity."[52] This test is stricter because the existence of a practicable alternative to the proposed action *entails* that the permit for that proposed action be denied by the EPA. Under the Corps of Engineers regulations the existence of a practicable alternative merely weighs against issuing a permit. As a practical matter the Corps of Engineers applies the EPA standard and generally will not issue a permit if the EPA is likely to veto that permit.

A pair of cases involving a proposed shopping mall in Attleboro, Massachusetts, illuminate the notion of a practicable alternative. The Pyramid Corporation wished to build a shopping mall on 80 acres of land near Attleboro. Fifty of these acres were a red maple wetlands known as Sweedens Swamp. The developers sought a Corps of Engineers permit to dredge and fill this area. The Corps ultimately issued a permit to the Pyramid Corporation. However, the EPA suspended the permit pending public hearings.

The developer challenged the EPA's right to suspend the permit and conduct public hearings in *Newport Galleria Group* v. *Deland*, 618 F. Supp. 1179 (D.D.C. 1985). Pyramid argued that because the Corps of Engineers had already determined that no practicable alternative existed, the EPA could not, as a matter of law, conduct public hearings on that issue.[53] Pyramid also argued that an alternative site for the mall considered by the EPA was owned by another developer, and therefore could not be considered available for the purpose of determining practicable alternatives.[54]

The court rejected both arguments. The court noted that the EPA veto under Section 404(c) allowed the EPA to consider a no action alternative, and thus the EPA could conduct hearings to determine if the project should be barred altogether.[55] The court refused to determine if the site owned by another developer was a practicable alternative. The court noted that such a determination must rest on an administrative record, and thus the practicability of the alternative could not be reviewed until the agency reached a final determination.[56] The EPA did veto the permit issued to the Pyramid Corporation. Pyramid challenged the EPA veto by arguing that the alternative site was not in fact practicable.[57] The EPA veto rested in large part on the existence of another potential site for the mall in North Attleboro. Pyramid offered information on that site to the EPA and argued it was impracticable because it lacked traffic volume and received less than enthusiastic support from potential tenants and the surrounding community.[58] The EPA vetoed Pyramid's permit nonetheless. A shopping mall is not a water dependent use, and the EPA found that Pyramid failed to overcome the presumption that a less environmentally damaging alternative existed.[59]

Pyramid challenged the EPA veto on several grounds. Pyramid argued that the avoidability of impacts is irrelevant to the acceptability of those impacts.[60] In other words, Pyramid claimed that the EPA should consider the impacts of the action proposed and determine if those impacts are acceptable, whether avoidable or not. Pyramid pressed this argument because the Corps found that the wetlands in Sweedens Swamp were of relatively low value.[61] The court rejected Pyramid's position as too restrictive a reading of the regulations. The court held that "the avoidability of a loss may be considered in conjunction with its magnitude in determining whether it is 'unacceptable' within the meaning of Section 404(c) and 'significant' within the meaning of the implementing regulation.[62]

Pyramid also argued that the EPA review of the Corps permitting process should be limited to a review of environmental factors. Thus EPA review of Corps findings on the feasibility or availability of alternative sites would be precluded.[63] Pyramid argued that because the language of Section 404(c) enumerates environmental basis for EPA action under that statute, the EPA could therefore review only environmental factors of the Corps determination.[64] The court, however, found that the EPA may conduct a de novo review of practicable alternatives.[65] The court surveyed the legislative history of the Clean Water Act and found that there was no evidence that Congress intended to limit EPA review in that manner.

Pyramid also argued that the EPA could not look to sites available at the time the developer entered the market, but could only consider alternative sites available at the time the agency makes its decision on the permit.[66] The court, however, found that EPA consideration of sites available from the time the developer entered the market was reasonable under the statute and regulations. Thus the North Attleboro site was a practicable alternative to the Sweedens Swamp site because it was available when Pyramid initially selected its site for the mall.

Finally, Pyramid challenged the substantive basis of the EPA's determination that a practicable alternative existed. Pyramid argued that the North Attleboro site was not feasible, and therefore was not a practicable alternative.

Pyramid argued that the EPA substituted its own judgment for that of the marketplace and so acted impermissibly.[67] The court reviewed the data supporting EPA's determination that the North Attleboro site was a feasible, and therefore practicable, alternative and found that the EPA's decision was not arbitrary.[68] Thus EPA determinations may address areas outside environmental matters, including the economic viability of alternatives to the proposed action.

This case finds that when looking at practicability, the EPA must consider practicability for a particular purpose. If the proponent wished to construct a shopping mall, an EPA veto cannot rest on the existence of a better site for the development of a bowling alley. The idea underlying the test is that the public is best served through development that meets its needs and demands. If a genuine need exists, but a less environmentally detrimental (and practicable) site exists for development to meet those needs, then the EPA veto, or Corps denial of the Section 404 permit, is appropriate. If, on the other hand, a genuine need exists and the wetlands are the best site for a project to fulfill those needs, then a Section 404 permit should be granted. However, the EPA and the Corps have the power to deny a permit for any project that has adverse environmental impacts that outweigh its other benefits. For example, both courts in Bersani[57] held that even if the EPA finding of a practicable alternative site were arbitrary, the fact that the EPA found that the impact on Sweedens Swamp would create significant loss to wildlife habitat was sufficient to sustain their veto of the Section 404 permit.[69]

The EPA seems more willing to employ its veto power after judicial decisions supporting its exercise. Indeed, sources in the EPA have said that the decision in *Bersani* may encourage the EPA to invoke its Section 404 veto power more often.[70]

Executive Orders

On May 24, 1977, President Jimmy Carter issued two Executive Orders that may affect the permitting process under Section 404 of the Clean Water Act. Executive Order 11988 is entitled "Floodplain Management." Executive Order 11990 is entitled "Protection of Wetlands." Each order provides some guidance to the Corps of Engineers in issuing permits under Section 404.

Executive Order 11988 directs federal agencies to take steps to "avoid to the greatest extent possible the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative." The Order directs agencies to reduce or avoid impact on floodplains in a variety of federal programs affecting land use.[71] Substantively, the Order directs agencies to evaluate the effects of any action it may take affecting a floodplain, by identifying actions affecting floodplains, analyzing alternatives to development in a floodplain, and by minimizing impacts when development in a floodplain is required.[72] In discussing alternatives, the Order authorized development in a floodplain only if there exists no "practicable alternative consistent with the law and the policy set forth in this Order."[73] The Order also requires public review of proposed actions affecting floodplains.[74] Executive Order 11990 directs agencies to "avoid to the extent possible the long- and short-term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative."

The directives in Executive Order 11990 are in many ways identical to those in Order 11988. However, Executive Order 11990 expressly states that this Order will not apply "to the issuance by Federal agencies of permits, licenses, or allocations to private parties for activities involving wetlands on non-Federal property."[75] The Order also directs the agency to avoid undertaking or assisting construction in wetlands unless the head of the agency finds there to be no practicable alternative to development and further takes all practicable measures to minimize adverse impacts.[76] This Order also allows the agency head to balance economic, environmental, and other pertinent factors in issuing its finding.[77]

The Corps of Engineers once published regulations to implement Executive Order 11988. However, those regulations were cancelled in 1984.[78] The Corps on that date issued an updated version of the earlier regulation previously published at 33 C.F.R. § 240. The Corps noted that the new version was designed to provide internal guidance, and as such would not be published in the Federal Register. The Corps also stated that this new internal regulation did not differ substantively from the earlier regulation at 33 C.F.R. § 240.

The sparse case law under these Orders supports the view that the Orders are limited to federal actions. In *Cape May Greene, Inc.* v. *Warren*, the court states that Executive Order 11988 was designed to apply to federal facilities and those constructed through federal funds.[79] The court in *County of Bergen* v. *Dole* found that Executive Order 11990 bound the United States Department of Transportation in the construction of a highway because that agency adopted Order 11990 in its regulations.[80]

MITIGATING WETLAND IMPACTS

A proponent for a project that involves impacts to wetlands will typically proffer a mitigation program to minimize those impacts. A project is more likely to pass the Corps of Engineers public interest review if wetland impacts are properly mitigated. Each impacted wetland area will differ, of course, but wetlands typically serve several functions, providing habitat and breeding areas for wildlife, creating areas to trap floodwaters and recharge ground water aquifers, and creating traps for sediments and pollutants. A

mitigation plan should be designed and evaluated in light of the wetland functions impacted. Less extensive mitigation should be required where the wetland impacted is of relative low quality. The functions performed by the mitigation wetlands should parallel those of the impacted wetlands as much as possible.

One method of mitigating the fill of an existing wetland is through the creation of artificial wetlands. The flooding of areas formerly upland can create new wetland areas.[81] Whether a new wetland area fulfills wildlife and water quality functions depends on the wetland being replaced. If the new wetland is created primarily to mitigate for the loss of breeding ground for migratory birds, then the new wetland may be able to be created a considerable distance from the wetland being filled. If the wetland is to be created to function as a flood barrier or sediment trap, then the range of geographical locations will be far more limited. The Colorado Division of Wildlife has suggested that the ratio of replacement wetlands to impacted wetlands should vary proportionately to the distance between the wetlands. If the replacement wetlands are built within 50 miles of the impacted area, then a 1:1 ratio is appropriate. If the replacement wetlands are within 150 miles of the impacted area, then the ratio should be 2:1, and the ratio should be 3:1 for a distance of more than 150 miles.

Another method of mitigating wetland impacts is through the enhancement of existing wetlands.[82] If a project proponent wishes to fill 50 acres of relatively low functioning wetlands, a program to improve another 50 acres of similar wetlands could create improved wildlife or water quality functions in that area,which allows the improved 50 acres to function as well as or better than did the 100 acres before development. Wetlands can be enhanced by increasing their area, or by increasing the mixture and diversity of wetland habitat.

Finally, a project proponent can mitigate wetlands impacts by contributing to a mitigation bank or wetlands bank.[83] Funds contributed to a mitigation bank are pooled and spent on the enhancement or creation of wetland areas or to purchase wetland areas for conservation. Donations to a mitigation bank are especially useful for mitigating impacts of small projects. The mitigation that might be undertaken by the proponent of a smaller project would have correspondingly small benefits, but by pooling and managing donations from smaller projects, a wildlife agency can produce a broader scale of wetland functions.

UNRESOLVED LEGAL ISSUES

The National Environmental Policy Act (NEPA) creates procedural guidelines for agency action.[84] Among those procedures, NEPA requires that an environmental impact statement (hereinafter, EIS) be prepared for any proposed "major Federal actions significantly affecting the quality of the human environment."[85] While an Environmental Assessment is usually sufficient, an EIS may be required before the Corps Engineers may issue a Section 404 permit.[86] The Corps determines when an EIS is necessary for a proposed 404 project. That determination may be reviewed by the court. At present, a split exists as to the standard of review, with some circuits holding the Corps to a standard of reasonableness,[87] while others will overturn a Corps determination only if it is arbitrary and capricious.[88]

Practicable Alternatives

The critical aspect of an EIS is its discussion of alternatives. The Council on Environmental Quality (CEQ) finds this discussion to be the heart of the environmental impact statement.[89] Generally, the CEQ requires that an agency preparing an EIS explore alternatives thoroughly.[90] The Corps of Engineers must consider alternative actions in every evaluation of dredge and fill proposals. In cases where an EIS is not required, alternatives are considered in the Corps' public interest review process.[91] When NEPA requires an EIS for a proposed dredge and fill activity, that EIS must of course contain a discussion of alternatives. The regulations of the EPA require that an EIS prepared in the context of a Section 404 permit include a discussion of "practicable alternatives," that is, those alternatives "available and capable of being done after taking into consideration cost, existing technology, logistics in light of overall project purposes."[92] In most instances, the EPA requirement of analysis of "practicable alternatives" will be coextensive with the NEPA and CEQ requirement of discussion of "reasonable alternatives."[93]

Both the Corps and the EPA regulations state that no Section 404 permit shall be issued where a practicable alternative to wetland development exists.[94] EPA regulations guide the application of these provisions. The word "practicable" is defined in the EPA regulations as "available and capable of being done after taking into consideration cost, existing technology and logistics in light of overall project purposes."[95] The goals of the developer are considered in figuring practicability. If the developer wishes to build a shopping mall in a swamp, then only those sites offering practicable alternatives for a shopping mall can trump his project. If an alternative site exists that the developer does not own but could reasonably obtain, the permit will not be granted.[96] The economic feasibility of alternatives is a factor in determining practicability, but the mere fact that the developer might make more money at another site is not by itself sufficient basis to deny a permit.[97] Courts typically defer to Corps of Engineers and the EPA determinations of practicability.[98]

In *Friends of the Earth* v. *Hintz*, the Ninth Circuit heard a challenge to a Corps Section 404 permit issue to a logging company for a log export sorting yard.[99] The Corps evaluation stated that no practicable alternative existed that would satisfy the proponent's needs and was not

prohibitively expensive.[100] Opponents of this facility argued that Corps consideration of practicable alternatives was inadequate. They argued that the Corps considered only sites previously rejected by the logging company, and further claimed that the Corps was not authorized to take the developer's costs into account.[101] The Court rejected the former argument by noting that the Corps evaluation also considered the alternative promoted by the opponents of the facility.[102] The court also held that the Corps did not err in taking the developer's costs into account.[103] Finally, the court noted that while two of the analyzed sites may in fact be feasible, it is appropriate to defer the Corps determination on these matters.[104] This case demonstrates the deference the courts offer agency determinations. As a rule the courts will not substitute their judgment for that of either the Corps or the EPA.

In *Louisiana Wildlife Federation* v. *York*, the Corps issued a permit to allow six landowners to convert bottomland hardwood wetlands to agricultural use.[105] Opponents of the permit argued that the Corps considered only as practicable the alternative that maximized the developer's profits. They also claimed that the Corps investigated alternatives with the landowner's objectives in mind.[106]

The court rejected both arguments. The court first noted that the Corps had placed restriction on the use of land, which limited the developer's profits.[107] The court also held that not only is it permissible for the Corps to consider the developer's objectives, but an affirmative duty to consider those objectives exists.[108]

Secondary, Indirect, and Cumulative Impacts

The regulations promulgated by the CEQ advise that the direct and indirect environmental impacts of the alternatives under study be analyzed.[109] Environmental Protection Agency regulations direct the Corps of Engineers to study the secondary and cumulative impacts of wetlands alteration on the aquatic systems before issuing a dredge and fill permit under Section 404.[110] Also, a federal district court required a discussion of secondary impacts in a Federal Highway Administration EIS for a major four season resort area.[111]

Some courts adopt a very narrow view of the effects to be considered in the Section 404 permitting process. In *Winnebago Tribe of Nebraska* v. *Ray*, an Indian Tribe objected when the Corps of Engineers determined that an EIS was not necessary in support of a Section 404 permit for a power line.[112] The court held that a discussion of the secondary impacts arising from building the part of the power line that did not cross the river (and therefore required no Section 404 approval) need not be considered: "Completion of the non-federal aspects of this single project does not constitute a secondary or indirect effect of the federal action."[113] Similarly, when the Corps of Engineers chose to consider the effects of an outfall pipe from a manufacturing plant while ignoring the effects of the plant itself, the Fifth Circuit held that the Corps need not look to the secondary effect of the plant in determining if an EIS was required.[114] However, the Court stated that it expressed no opinion as to the necessary scope of an EIS if one were required.[115] These cases are not universally followed.[116]

The concept of cumulative impact raises interesting issues for scoping an EIS. Theoretically any impact, no matter how remote, has some cumulative effect on the human environment. However, the discussion of cumulative impacts is guided by a rule of reason.[117] One instance where a discussion of cumulative impacts will be required is where the aspect under direct evaluation is an element of some larger project.[118] If the project under consideration has an effect that acts synergistically with other projects, an EIS must address those cumulative impacts.[119] If projects merely share common geography or timing, a programmatic EIS is optional.[120] The courts typically defer to agency determination of the scope of cumulative impacts in the EIS.[121]

Mitigation

A discussion of mitigation must be included in an EIS prepared for a Section 404 permit. The Corps states in its comments on regulations promulgated under Section 404 that "mitigation considerations are required as part of the Section 404(b)(1) guidelines.[122] The Fifth Circuit held that NEPA does not require that a mitigation plan redress every adverse impact.[123] However, it is in the interest of the developer to offer as thorough a mitigation plan as possible. A court in Puerto Rico upheld a Corps determination not to do an EIS for a waterfront development in part because the mitigation plan demonstrated that the net impact of development plus mitigation would be environmentally beneficial.[124]

The regulations of the CEQ state that the discussion of mitigation in an EIS "must cover the range of impacts of the proposal."[125] Mitigation measures must include "such things as design alternatives that would decrease pollution emissions, construction impacts, aesthetic intrusions, as well as relocation assistance, possible bad use controls that could be enacted, and other possible efforts. Mitigation measures must be considered even for impacts that by themselves would not be considered 'significant.'"[126] Mitigation measures must be discussed and analyzed. Some courts have suggested that the mere listing of mitigation measures is not sufficient.[127] A thorough discussion will protect the EIS from being held insufficient.[128]

Worst Case Analysis

The Council on Environmental Quality interprets NEPA as requiring a worst case analysis when the information necessary for thorough projection is incomplete or unavailable.[129] If the missing information can be obtained without excessive expense, the agency has a duty to get that

information.[130] If the information cannot be obtained at all, or can be obtained only at exorbitant cost, the agency must state in the EIS that the information is unavailable, and explain the relevance of the information, and analyze "the reasonably foreseeable significant adverse impacts on the human environment" of the project, accounting for this area of the unknown.[131] This "worst case analysis" should be within the rule of reason, and should not be pure conjecture.[132] The exorbitance of the costs are determined relative to the size of the project and the potential harm to the environment.[133] An agency may not omit a worst case analysis simply because it feels that the worst case is unlikely.[134]

Worst case analysis is often necessary in projects involving oil or chemicals, where the possibility of an environmentally detrimental accident exists. But a worst case analysis was required in a Forest Service EIS for a timber operation. Because the Forest Service proposed new erosion mitigation techniques, the Court required a worst case scenario as a necessary element of that EIS.[135] A court also required a worst case analysis of noise levels for a proposed highway because the noise tests conducted were incomplete.[136]

The Council on Environmental Quality no longer requires a discussion of worst cases. Rather, the CEQ requires that an EIS include a detailed analysis of the reasonably foreseeable significant adverse impacts (of an action) that are subject to incomplete or unavailable information.[137] The Ninth Circuit recently held that the requirement of a worst case analysis is still required when incomplete information colors an EIS, even though the CEQ has amended its worst case regulation.[138] In *Methow Valley*, the Ninth Circuit found a Forest Service EIS for a proposed ski area inadequate in part because data on the existing mule deer herd was incomplete, and the EIS did not contain a worst case analysis of the ski area's impacts on the herd.[139] In *Oregon Natural Resources Council*, the Ninth Circuit required a worst case analysis in a Corps of Engineers EIS for a dam because data on the effects of the dam on temperature and turbidity in a river for which the dam's waters would become a tributary was incomplete.[140] The Ninth Circuit has held, therefore, that the amendment of the CEQ NEPA regulations did not affect the requirement of a worst case analysis, as that requirement is part of NEPA common law.[141]

CONCLUSION

The discussion above reveals how layers of regulation have developed under Section 404 of the Clean Water Act. A proponent seeking a 404 permit to develop in a wetlands area must meet requirements imposed by the state, by the Corps of Engineers, and by the EPA. Further, a variety of state and federal agencies will be asked to comment on the Corps and EPA determinations. A mitigation plan under Section 404 will be subject to scrutiny at every step of this process. While the various reviewing agencies may have slightly different interests, all share a common concern: that the impacts of wetlands development be mitigated in a manner that reflects functions affected.

NOTES

1. 33 U.S.C. § 1344 (1987 and Supp. 1988).

2. 33 C.F.R. § 320 *et seq.*; 40 C.F.R. § 230, *et seq.* (1986)

3. 33 C.F.R. § 328.3(b); 40 C.F.R. § 230.3(t) (1986).

4. *See United States* v. *Riverside Bayview Homes, Inc.*, 474 U.S. 121, 5106 S. Ct. 455 (1985).

5. *See* Administrative Procedure Act, 5 U.S.C. § 706(2)(A).

6. 33 U.S.C. § 1344(a) (1985).

7. 33 U.S.C. § 1362(7) (1985).

8. The Corps' enumeration is made at 33 C.F.R. § 328.3 and 40 C.F.R. § 230.3 (1986). The EPA's slightly more expansive enumeration is found at 40 C.F.R. § 328.3(a)(3) (1986).

9. The Corps of Engineers may not have jurisdiction over potholes, reflecting pools, upland irrigation ditches, or artificial lakes. *See* 51 Fed. Reg. 41217 (Nov. 13, 1986). *See also* 33 C.F.R. § 328.3(a) (1986).

10. 33 C.F.R. § 328.4(c) (1986).

11. 33 C.F.R. § 328.3(c); 40 C.F.R. § 230.3(b) (1986).

12. *Id.*

13. 33 C.F.R. § 328.3(b); 40 C.F.R. § 230.3(t) (1986).

14. *Id.*

15. *NRDC* v. *Callaway* , 392 F. Supp. 685, 686 (D.D.C. 1975).

16. *See United States* v. *Riverside Bayview Homes*, Inc., 474 U.S. 121, 106 S. Ct. 455 (1985).

17. *United States* v. *Riverside Bayview Homes, Inc.*, 729 F.2d 391 (6th Cir. 1984).

18. *See id.*, 106 S. Ct. at 462.

19. *Id.*

20. Id. at 464.

21. *Cf.* 33 C.F.R. § 328.3(b); 40 C.F.R. § 230.3(t) (1986). *See also Avoyelles Sportsmen's League* v. *Marsh*, 715 F.2d 897, 931 (5th Cir. 1983) (upholding EPA wetland determination).

22. *See Track 12, Inc.* v. *District Engineer, United States Army Corps of Engineers*, 618 F. Supp. 448 (D. Minn. 1985).

23. *Id.* at 449-50.

24. *Id.* at 450.

25. *United States* v. *City of Fort Pierre*, 747 F.2d 464 (8th Cir. 1984).

26. *Id.* at 467.

27. *Id.*

28. An occasional aberration does occur. *Fort Pierre* is one such anomaly. Another occurred when a court held that the Corps did not have jurisdiction over a wetland area created by road and railway construction. *See 1902 Atlantic Ltd.* v. *Hudson*, 574 F. Supp. 1381 (E.D. Va. 1983). In that case the court denied Corps jurisdiction over a marsh area that was

connected to a navigable water and that ebbed and flowed with the tide. The court's holding rested on the assertion that federal influence was insufficient to establish navigability. In light of the Supreme Court's support for a broad reading of Corps jurisdiction in *Riverside Bayview Homes*, this rationale is clearly misguided.

Both *Fort Pierre* and *1902 Atlantic* involved stagnant pools of water that posed threats to health and safety. In *1902 Atlantic*, the puddle in question had claimed the life of a child. The holdings of the courts in these cases are instances of the courts reaching the right result while having no legal basis for that result. In each instance the Corps probably should have allowed the waters to be filled, but the court was unwilling to baldly substitute its judgment for that of the Corps.

29. *See United States* v. *Tull*, 769 F.2d 182, 185 (4th Cir. 1985), *rev'd on other grounds*, 481 U.S. 412 (1987).

30. *See United States* v. *Akers*, 651 F. Supp. 320, 322 (E.D. Cal. 1987).

31. *Id. See also Bailey* v. *United States Army Corps of Engineers*, 647 F. Supp. 44, 47-48 (D. Idaho 1986) (peat bog on farm a wetland, even though saturation occurs because of nearby dam); *United States* v. *Ciampitti*, 583 F. Supp. 483, 489 (D.N.J. 1984), *aff'd* 772 F.2d 893 (3rd Cir. 1985), *cert. denied*, 475 U.S. 1014 (1986) (presence of salt marsh grass and salt grass support determination of area as wetland).

32. 33 C.F.R. § 320 (1986).

33. *Id.* at § 320.01(a), 320.4(a).

34. *Id.* at § 320.1(a).

35. 33 C.F.R. § 320.4 (1986).

36. 33 C.F.R. § 320.4(a)(2) (1986).

37. *Id.* at § 320.4(b)(1).

38. *Id.* at § 320.4(b)(4).

39. *Buttrey* v. *United States*, 690 F.2d 1170 (5th Cir. 1982), *cert. denied*, 461 U.S. 927 (1983).

40. 51 Fed. Reg. 41207 (1986).

41. *Louisiana Wildlife Federation* v. *York*, 761 F.2d 1044, 1048 (5th Cir. 1985).

42. 33 C.F.R. § 320.4(a)(2) (1986).

43. 33 U.S.C. § 1341(a) (1986). A state may waive its right to certification. Environmental Defense Fund v. Alexander, 501 F. Supp. 742, 771 (N.D. Miss. 1980).

44. Arnold Irr. Dist. v. Dept. of Environmental Quality, 79 Or. App. 131, 717 P.2d 1274, 1278 (1986), rev. denied, 301 Or. 765, 726 P.2d 377 (1986).

45. *Id.*

46. *See* 40 C.F.R. § 231.2 (1986).

47. 40 C.F.R. § 230.10(a) (1986).

48. *Id.* at § 230.1(c).

49. *Id.* at § 230.10(d). *See Buttrey* v. *United States*, 690 F.2d 1170 (5th Cir. 1982), *cert. denied*, 461 U.S. 927 (1983).

50. Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material, 40 C.F.R. § 230, 230.10(a) (1986).

51. *Id.* at § 230.2(q) and 210.10(a)(2).

52. *Id.* at § 230.10(a)(2).

53. *Newport Galleria Group* v. *Deland*, 618 F. Supp. 1179, 1182 D.D.C. 1985).

54. *Id.*

55. *Id.* at 1183.

56. *Id.*

57. See *Bersani* v. *United States Environmental Protection Agency*, 674 F. Supp. 405 (N.D.N.Y. 1987), *aff'd sub nom. Bersani* v. *Robichaud*, 850 F.2d 36 (2nd Cir. 1988). The appellate court upheld the power of EPA to veto 404 permits, and also affirmed the EPA's decision to measure practicable alternatives at the time a project enters the market place. The project proponents filed a petition for certiorari to the United States Supreme Court on December 1, 1988 to challenge the market entry approach to determining practicability.

58. *Bersani*, 674 F. Supp. at 410.

59. *Id.*

60. *Id.* at 413.

61. *Id.* at 410–11.

62. *Id.* at 415.

63. *Id.* at 413.

64. *Id.* at 416.

65. *Id.* at 416–17.

66. *Id.* at 417–18. The district court's ruling on this issue was affirmed in *Bersani*, 850 F.2d at 43-45.

67. *Id.*

68. *Id.*

69. *Bersani*, 674 F. Supp. at 419-20, *aff'd*, 850 F.2d at 45–47.

70. *See* Court Upholds EPA CWA Section 404 Veto of Sweeden's Swamp Development, 8 *Inside EPA Weekly Report* no. 42 p. 2 (Oct. 21, 1987).

71. Executive Order 11988, sec. 1.

72. Executive Order 11988, sec. 2.

73. Executive Order 11988, sec. 2(a)(2).

74. Executive Order 11988, sec. 2(a)(3).

75. Executive Order 11990, sec. 1(b).

76. Executive Order 11990, sec. 2(a).

77. Executive Order 11990, sec. 2(a).

78. *See* Internal Water Resources Policies and Authorities Regulation; Cancellation of Regulation, 49 Fed. Reg. 24021 (June 11, 1984).

79. *Cape May Greene, Inc.* v. *Warren*, 698 F.2d 179, 186 (3rd Cir. 1983).

80. County of Bergen v. Dole, 620 F. Supp. 1009, 1061 (D. N.J. 1985), *aff'd*, 800 F.2d 1130 (3rd Cir. 1986). *See also Ashwood Manor Civic Association* v. *Dole*, 619 F. Supp. 52, 84–85 (D.C. Pa. 1985).

81. For example, the Beaver Creek Coal Company in Utah mitigated impacts of mining operations by creating a new wetland area approximately 30 miles from the mine site. Mutz and Dalton, Mitigating Impacts of Coal Mining in Utah in Proceedings: National Wetland Symposium, Association of State Wetland Managers, Inc. at 182-83 (1986).

82. In Colorado, the proposed Two Forks dam will mitigate its wetland impacts by restoring 310 acres of degraded wetlands. Corps of Engineers, Final Metropolitan Denver Water Supply EIS, vol. II, app. 1-A at A-52-55 (1988).

83. *See* DuPriest and Christenson, Constraints on Mitigation Banking: Oregon's Mitigation Banking Act of 1987, 10 *National Wetlands Newsletter* 9 (1988).

84. *See* 42 U.S.C. 4331, *et seq.* (1986).

85. NEPA reads in relevant part:

> The Congress authorizes and directs that, to the fullest extent possible: (1) the policies, regulations, and public laws of the United States shall be interpreted and administered in accordance with the policies set forth in this chapter, and (2) all agencies of the Federal Government shall—. . .
>
> (C) include in every recommendation or report on proposals for legislation and other major federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on—
>
> (i) the environmental impact of the proposed action,
>
> (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,
>
> (iii) alternatives to the proposed action,
>
> (iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and
>
> (v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented. . . .
>
> (E) study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources . . .

42 U.S.C. § 4332 (1986).

86. *See, e.g., Fritiofson* v. *Alexander*, 772 F.2d 1225 (5th Cir. 1985) (Corps decision not to prepare EIS error because project may have cumulative impacts not considered in Corps determination); *Colorado River Indian Tribes* v. *Marsh*, 605 F. Supp. 1425, 1431 (C.D. Cal. 1985) (NEPA requires Corps EIS when effects may be significant); *Texas Committee on Natural Resources* v. *Marsh*, 736 F.2d 262 (5th Cir. 1984) (EIS for flood and water supply project adequate); *Baltimore Case and Electric* v. *National Resource Defense Council*, 462 U.S. 87, 103 S. Ct. 2246 (1983) (NRC finding that storage of nuclear waste has no significant impact upheld as within the bounds of reasoned decision making).

87. *See Jones* v. *Gordon*, 792 F.2d 821, 827 (9th Cir. 1986) (EIS may be necessary for permit to allow zoological parks to capture killer whales for study and display); *Vieux Carre Property Owners, Residents and Assoc., Inc.* v. *Pierce*, 719 F.2d 1272, 1279 (5th Cir. 1983) (decision not to prepare EIS for urban renewal project held reasonable); *Township* of *Lower Alloways Creek* v. *Public Serv. Elec. & Gas Co.*, 687 F.2d 732, 742 (3rd Cir. 1982) (EIS not required to NRC to expand existing spent fuel pool); *Winnebago Tribe* v. *Ray*, 621 F.2d 269, 271 (8th Cir. 1980), *cert. denied*, 449 U.S.836 (1980) (Corps EIS not required for powerline crossing river).

88. *See City of Alexandria* v. *Federal Highway Admin.*, 756 F.2d 1014, 1017 (4th Cir. 1985) (rejection of "reasonableness" standard); *City of West Chicago* v. *United States Nuclear Regulatory Comm'n*, 701 F.2d 632, 651 (7th Cir. 1983) (adopting "arbitrary and capricious" standard); *Grazing Fields Farm* v. *Goldschmidt*, 626 F.2d 1068, 1072 (1st Cir. 1980) (adopting "arbitrary and capricious" standard); *Cross-Sound Ferry Servs., Inc.* v. *United States*, 573 F.2d 725, 732 (2d Cir. 1978) (adopting "arbitrary and capricious" standard).

89. 40 C.F.R. § 1502.14.

90. The CEQ regulations require the Agency to:

> (a) Rigorously explore and objectively evaluate all reasonable alternatives, and for alternatives which were eliminated from the detailed study, briefly discuss the reasons for their having been eliminated.
>
> (b) Devote substantial treatment to each alternative considered in detail, including the proposed action so that reviewers may evaluate their comparative merits.
>
> (c) Include reasonable alternatives not within the jurisdiction of the lead agency.
>
> (d) Include the alternative of no action.
>
> (e) Identify the agency's preferred alternative or alternatives, if one or more exists, in the draft statement and identify such alternative in the final statement unless another law prohibits the expression of such preference.
>
> (f) Include appropriate mitigation measures not already included in the proposed action or alternative.

40 C.F.R 1502.14 (1986).

91. 33 C.F.R. § 320.4(a)(2) (1986).

92. 40 C.F.R. § 230.10(a)(2) (1986).

93. 40 C.F.R. § 230.10(a)(4) (1986).

94. 33 C.F.R. § 320.4(a)(2)(ii); 40 C.F.R. § 230.10(a) (1986).

95. 40 C.F.R. § 230.3(q); 40 C.F.R. § 230.10(a)(2) (1986).

96. 40 C.F.R. § 230.10(a)(2) (1986).

97. *Louisiana Wildlife Federation* v. *York*, 761 F.2d 1044, 1047 (5th Cir. 1985) ("practicable alternative" is not the same as "profit maximizing alternative").

98. *See, e.g., Newport Galleria Group* v. *Deland*, 618 F. Supp. 1179, 1182-83 (D.D.C. 1985) (EPA determination that alternative exists upheld); *Suffolk County* v. *Secretary of the Interior*, 562 F.2d 1368, 1382 (2d Cir. 1977), cert. denied, 434 U.S. 1064 (1978) (Secretary of Interior has power to grant permit for pipeline even if pipeline currently economically and technically unfeasible); *Pennsylvania Protect Our Water and Environmental Resources* v. *Appalachian Regional Commissioner*, 574 F. Supp. 1203, 1233 (M.D. Pa. 1982), aff'd 720 F.2d 659 (3rd Cir. 1983) (study of feasibility of ski area sufficient because it demonstrates good faith consideration of action).

99. *See Friends of the Earth* v. *Hintz*, 800 F.2d 822 (9th Cir. 1986).

100. *Id.* at 833.

101. *Id.*

102. *Id.*

103. *Id.*

104. *Id.* at 834.

105. *See Louisiana Wildlife Federation* v. *York*, 761 F.2d 1044 (5th Cir. 1985).

106. *Id.* at 1047.

107. *Id.*

108. *Id.* at 1048, citing 40 C.F.R. § 230.10(a)(2)

("practicable" means capable of being done after taking into account costs, existing technology and logistics *in light of overall project purposes*) (emphasis added).

109. 40 C.F.R. § 1502.16 (1986).

110. 40 C.F.R. § 230.11(g) and (h) (1986).

111. *See Pennsylvania Protect Our Water and Environmental Resources* v. *Appalachian Regional Commission*, 574 F. Supp. 1203, 1232 (M.D. Pa. 1982).

112. *Winnebago Tribe of Nebraska* v. *Ray* , 621 F.2d 269 (8th Cir. 1980), *cert. denied*, 449 U.S. 836 (1980). *See also* Corps of Engineers, Procedures for Implementing the National Environmental Policy Act, 53 Fed. Reg. 3120 (1988).

113. *Id.* at 273.

114. *Save the Bay* v. *United States Army Corps of Engineers*, 610 F.2d 322, 327 (5th Cir. 1980), *cert. denied*, 449 U.S. 900 (19--).

115. *Id.* at 327, n.3.

116. *See e.g., Colorado River Indian Tribes* v. *Marsh*, 605 F. Supp. 1425, 1430-32 (C.D. Cal. 1985) (rejecting Winnebago and Save the Bay; requires EIS whenever impact may be major.)

117. *Hart and Miller Islands Area Environmental Group* v. *United States Army Corps of Engineers*, 505 F. Supp. 732, 752 (D. Md. 1980) (Corps decision to issue permit under Rivers and Harbors Act upheld).

118. *Watershed Association Rescue* v. *Alexander*, 586 F. Supp. 987, 994 (D. Neb. 1982) (court finds Corps EIS for levee in Missouri River adequate).

119. The Corps of Engineers, in determining which cumulative impacts are to be analyzed, adopts the standard set forth in *Fritiofson* v. *Alexander*, 772 F.2d 1225 (5th Cir. 1985). Impacts of other projects must be considered in a Corps environmental evaluation if those projects are clearly related to the project under evaluation. The Corps must consider impacts of all such projects, not just those under its jurisdiction. Further, it must consider the cumulative impact of all past, present and reasonably foreseeable projects.

120. 40 C.F.R. § 1508.25(a)(3) (similar actions may be considered in the same EIS).

121. See, e.g., *Kleppe* v. *Sierra Club*, 427 U.S. 417, 413-14 (1976) (determination of extent and effect of cumulative impacts is task assigned to special competency of appropriate agencies).

122. 51 Fed. Reg. 41206, 41208 (Nov. 13, 1986). Cf. 33 C.F.R. § 320.4(r), 40 C.F.R. § 1502.14(f), 1502.16(g) and (h) (1986).

123. *Texas Committee on National Resources* v. *Marsh*, 736 F.2d 262, 268 (5th Cir. 1984) (Corps EIS for flood and water control project found adequate).

124. *Quinones-Lopez* v. *Coco Lagoon Development Corp.*, 562 F. Supp. 188 (D.P.R. 1983).

125. Council on Environmental Quality, Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations, 46 Fed. Reg. 18026, 18031 (1981).

126. *Id.*

127. *Methow Valley Citizens Council* v. *Regional Forester*, 833 F.2d 810, 819 (9th Cir. 1987), *cert. granted*, 108 S. Ct. 2869 (1988); *Oregon Natural Resources Council* v. *Marsh*, 832 F.2d 1489, 1493-94 (9th Cir. 1987), *cert. granted*, 108 S. Ct. 2869 (1988).

128. *See, e.g., State of Missouri ex rel. Ashcroft* v. *Department of Army*, 672 F.2d 1297 (final EIS by Corps for generator at dam sufficient since viable alternatives were not available, mitigation plan was adequate, and procedural requirements were met).

129. 40 C.F.R. § 1502.22 (1986). *See also* 40 Questions, 46 Fed. Reg. at 18032.

130. *Id.* at (a).

131. *Id.* at (b). *See also Oregon National Resource Council* v. *Marsh*, 832 F.2d 1489 (9th Cir. 1987), *cert. granted*, 108 S. Ct. 2869 (1988) (EIS for three dams in Rogue River Basin inadequate).

132. *See also Sierra Club* v. *Sigler*, 695 F.2d 957, 970 (5th Cir. 1983) (EIS for oil distribution system inadequate).

133. *Save our Ecosystems* v. *Clark*, 747 F.2d 1240, 1244 n.5 (9th Cir. 1984) (worst case analysis inadequate for herbicide spraying program).

134. *Southern Oregon Citizens Against Toxic Sprays, Inc.* v. *Clark* 720 F.2d 1475, 1478-79 (9th Cir. 1983), *cert. denied*, 469 U.S. 1028 (1984) (worst case analysis required for herbicide spraying program).

135. *National Wildlife Federation* v. *United States Forest Service*, 592 F. Supp. 931, 942-43 (9th Cir. 1984).

136. *Residents in Protest—I-35E* v. *Dole*, 583 F. Supp. 653, 662-63 (D.C. Minn. 1984).

137. 40 C.F.R. § 1502.22 (1988).

138. *Methow Valley Citizens Council* v. *Regional Forester*, 833 F.2d 810 (9th Cir. 1987); *Oregon Natural Resources Council* v. *Marsh*, 832 F.2d 1488 (9th Cir. 1987).

139. *Methow Valley*, 833 F.2d at 817-18.

140. *Oregon Natural Resources Council*, 832 F.2d at 1496-97.

141. *Id.* at 1497 n.8.



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ISBN 0-916055-04-3
Libr. Congress 89-051028