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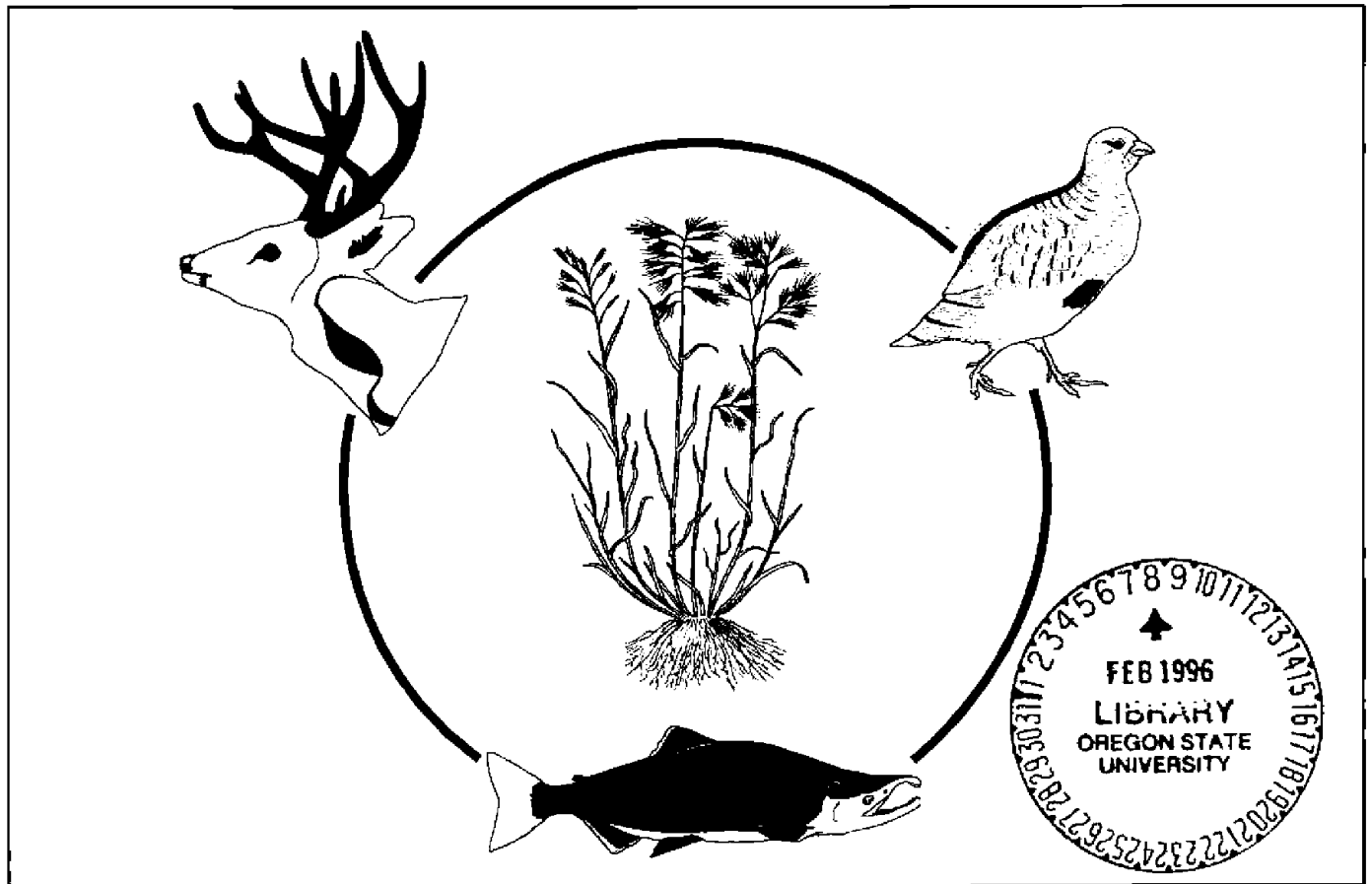
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Proceedings of a Symposium on

Sustaining Rangeland Ecosystems

Eastern Oregon State College ♦ La Grande, Oregon ♦

29–31 August 1994



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Oregon State University Extension Service

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Sustaining Rangeland Ecosystems

Eastern Oregon State College ♦ La Grande, Oregon ♦

29–31 August 1994

Edited by

W. Daniel Edge

Extension wildlife specialist

Oregon State University

and

Sally L. Olson-Edge

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MISSION AND GOALS OF THE ORGANIZING GROUPS

Blue Mountains Natural Resources Institute

Mission: *to enhance the long-term economic and social benefits derived from the area's natural resources in an ecologically sound and sustainable manner.*

The BMNRI mission will be achieved through research, development, application, demonstration, and education programs. There are currently 81 partner organizations that have (1) agreed with the mission statement, (2) agreed that cooperation is the key to solving our natural resource problems, and (3) agreed to work together when it is in everyone's best interest.



Goals

- ◆ Compile basic biological and ecological information needed to improve forest and rangeland health and vigor.
- ◆ Develop technology to guide intensive multi-resource management and policy for sustaining long-term productivity and ecological values in the early decades of the 21st century.
- ◆ Develop new technology that will enable forest and range managers to emphasize multi-resource benefits, reduce the hazards of fire and insect and disease outbreaks, and accommodate potential climate change.
- ◆ Develop long- and short-term forest management practices for use by land management agencies and landowners in concert with public values.
- ◆ Rapidly convert results of research into applicable technology.
- ◆ Establish mutually beneficial relations with individuals and groups to inform them of new research, development, and management direction, and to obtain responses and advice from them.
- ◆ Stimulate cooperative research and development among universities and other federal and state agencies.
- ◆ Enhance the long-term economic and social benefits derived from the region's forest- and rangeland-associated resources in cooperation with county and regional economic strategies.
- ◆ Demonstrate the application of technology and resource knowledge.
- ◆ Focus research on management for production of multiple resource benefits such as water, fish, grazing, wildlife, timber, and recreation.
- ◆ Provide an unbiased forum for open and objective debate, discussion, and consensus on policy and management issues.

Pacific Northwest Section of the Society for Range Management

Vision: *Properly functioning ecosystems providing for sustainability of watersheds, plants, animals, and people.*

Mission: *Promote ways to maintain or enhance the integrity of the ecological community critical to the watersheds, plants, animals, and people that depend on rangelands for their sustenance.*

Goals

- ◆ To maintain a high degree of professionalism among the membership through workshops, symposia, written materials, and training sessions.
- ◆ To provide information to the public and rangeland users about the values and management of rangeland resources.
- ◆ To forge relationships with other natural resource-based organizations.



American Fisheries Society, Oregon Chapter

Policy: AFS promotes the scientific management of aquatic resources for the optimum use and enjoyment by people of this continent. Included are sport and commercial fisheries in both fresh and marine waters for aquatic plants and animals. Included also is the promotion of the best possible quality of the aquatic environment consistent with the use for fish production. Scientific management of these resources is best achieved by promoting the theory and application of all appropriate branches of science including the social as well as the natural sciences and the applied as well as the basic.

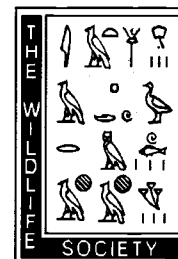


The Wildlife Society, Oregon Chapter

Mission: *Serve and represent wildlife professionals in all areas of wildlife conservation and resource management.*

Goals

- ◆ Develop and maintain a program that facilitates professional development of natural resource professionals.
- ◆ Promote sound stewardship of wildlife and their habitats through the use of sound ecological information.
- ◆ Increase awareness and appreciation of wildlife through education.
- ◆ Develop an active and diverse membership and maintain an organization that provides excellence in member services.



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INTRODUCTION TO THE SUSTAINING RANGELAND ECOSYSTEMS SYMPOSIUM

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On 29–31 August 1994 the Blue Mountains Natural Resources Institute, the Pacific Northwest Section of the Society for Range Management, the Oregon Chapter of The Wildlife Society, and the Oregon Chapter of the American Fisheries Society sponsored the Sustaining Rangeland Ecosystems Symposium in La Grande, Oregon. At least in Oregon, this was the first effort where the different societies came together to address the rangeland resources that we all care about. The organizing committee spent many hours of lively discussion informing and educating each other of our particular personal and professional viewpoints. We sought to present a balanced program with the best collection of speakers we could find. In general, speakers were asked to address topics from their disciplinary or managerial perspective. Within each session the goal was to present a diversity of viewpoints.

Speakers also were given the option of submitting a written paper for inclusion in these proceedings. Many of them took advantage of this offer and you see the results here. In the event a paper was not submitted, we have included the abstract published in the program. To the extent the speaker presented what was in the abstract, you should get a good idea of what was discussed.

Rangelands are an important part of the western landscape. Here in the West, if it is not forested, cropped, or in cities and roads, it's probably rangeland. We wish to be clearly understood that what we are talking about is a kind of land and not any particular use of that land. Society has used rangelands for commodity production, recreation, water production, fish and wildlife habitat, and a whole variety of other purposes. We sought to expose the audience to many of those uses and to related issues. The purpose of this symposium was to give resource professionals and others interested in rangelands different perspectives on various topics and to examine different approaches to finding solutions to natural resource issues. We didn't expect to find the solutions at the symposium. We did expect to learn together by

understanding viewpoints different than our own and to recognize that these differences arise out of each individual's values.

For example, one of the major issues is how riparian areas are managed. Much of the Columbia River Basin is involved in how human activities impact Chinook salmon (*Oncorhynchus tshawytscha*) survival. Some of the runs of this anadromous fish are listed as either threatened or endangered under the Endangered Species Act. The impacts of large domestic and wild ungulates on fish habitat and water quality need to be addressed as well as other issues related to the recovery of these runs, such as irrigation withdrawals, Columbia and Snake river dams, sport and commercial fishing, ceded rights to Native Americans, municipal water use, hydroelectric power use, timber harvesting, and on and on. The point is that there are many interests involved in salmon recovery and the solution must involve all players. At the local level, we have to take care of our part of the world. At the symposium, we sought to examine diverse views on the impacts of these uses, on feasible solutions, and on how some groups have come together to find politically, ecologically, socially, and economically acceptable solutions. This is but one issue in a landscape filled with issues.

As representatives of the Pacific Northwest Section of the Society for Range Management, if only "range type" speakers and a few nominal "others" had been invited, our comfort level would have been much higher (i.e., "preaching to the choir"). I suspect the same would be true for American Fisheries Society and The Wildlife Society members. Although we did not expect it, we suspect that the overwhelming response to this symposium was because it should have happened long ago. Almost 500 people with diverse backgrounds came from the U.S. and Canada to attend some or all of the symposium. Each of us needs to break out of our comfortable homes in our narrow disciplines and seek to really understand where our partners are coming from—to really seek it out. It's not easy nor should it be. Pointing fingers will not lead to long-lasting solutions. If you point you should be able to offer an ecologically, economically, socially, and politically acceptable solution.

Hopefully the interactions that occurred at the symposium will make us question all of the assumptions we hold as truths. For example, if you believe that grazing cattle is inherently good for society—a basic assumption—you should be able to sit back and examine that belief based on the information presented. Can ranchers really graze cattle in

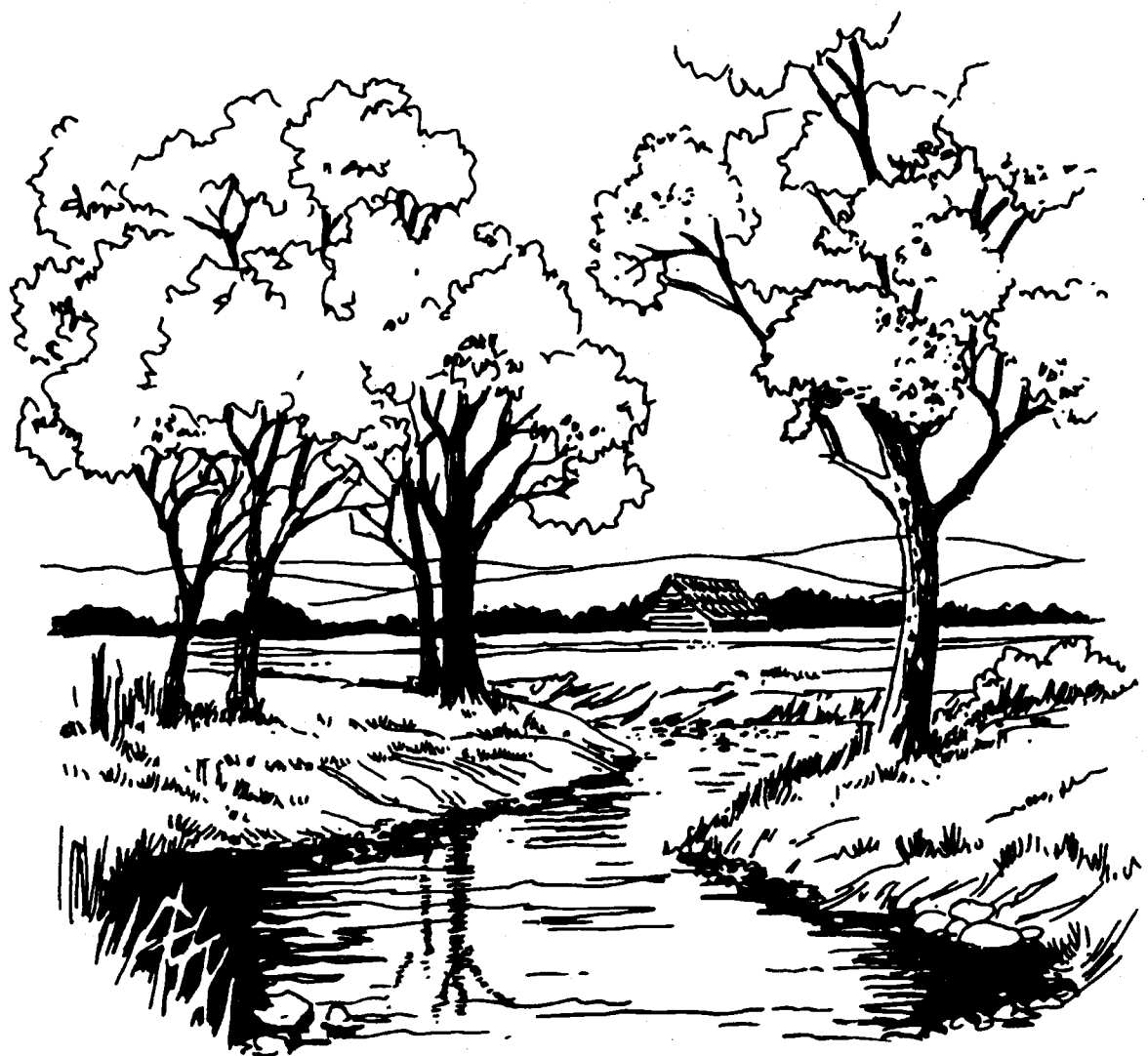
¹Symposium Co-Chair. Tanaka is Deputy Manager, Blue Mountains Natural Resources Institute; Associate Professor, Department of Agricultural and Resource Economics, Oregon State University; and Past President, Pacific Northwest Section of the Society for Range Management. Pyke is Senior Rangeland Ecologist with the National Biological Service Forest and Rangeland Ecosystem Science Center stationed at Oregon State University.

riparian areas and have those habitats and stream channels improve, as Wayne Elmore showed, or should cattle be removed from the ecosystems, as Joy Belsky stated? Even if Wayne is "right," what do we do with the managers that can't or won't do any better? Do we legislate the solution as Dick Springer wants, or do we allow the free enterprise system to operate? If legislation is only needed to punish the ranchers not taking care of the ecosystem, how do you make it so the law doesn't punish good managers? Well, we hope you get the picture—everything we have heard during the symposium is tied together in an incredibly complex web.

What is it that society wants from our natural resources? How do we as managers, scientists, landowners, and the interested public give them what they want? How do we find out what they want? If we truly want to think globally and people still want to eat red meat, live in wood houses, wear leather shoes, or go fishing and hunting, how do we take care of our part of the world and not just export our insatiable appetites to other regions of the world? The *Oregonian* (Portland, Oregon, newspaper) has had many

advertisements recently from British Columbia inviting U.S. residents to go salmon fishing there because the U.S. didn't allow fishing down here this year. As we stop timber harvest, what happens to the forests in New Zealand and Siberia? We don't know the answers to these questions, but each of us certainly has an opinion. And that's the point; as we search for solutions we hope each of us can seek to understand the other person's views and values.

These proceedings represent the end of the symposium effort, or is it the beginning? We tried to provide the audience with diverse viewpoints on a variety of natural resource issues. It was interesting to watch the audience during most of the sessions. At times portions of the audience would perk up while others would settle deep into their seats. At other times, another portion would perk up. That was one goal of this symposium. We hope that same sense will carry over to these proceedings. In the larger scheme of things, this symposium is just another small step along the path to better ecosystem-level management. Good luck on your journey.



WHAT IS A HEALTHY RANGELAND, AND HOW WOULD WE KNOW ONE?

RANGELAND MANAGEMENT: PAST, PRESENT, AND FUTURE IN SUSTAINABLE SYSTEMS

THADIS W. BOX, P.O. Box 1280, Mesilla, NM 88046

Abstract: Rangeland management in North America had its beginning in the increased livestock populations and the severe drought periods of the late 19th century. The declining carrying capacity led to the development of research to increase forage production and decrease competition from wild and feral animals. Ecological concepts were introduced to land managers in the early 20th century by scientists at the universities of Chicago and Nebraska. But the goal of rangeland managers continued to be maximum forage production until the early 1970s. Although ecosystem concepts are >60 years old and papers relating ecosystem management to multiple use of rangelands have been around for 3 decades, it has taken pressure from environmental activists to cause range managers to move from goals of forage production to those of ecosystem health. The societal desire for sustainability offers a challenge to the profession; it can be the goal that brings range managers together.

Key words: culture, ecology, range management, rangelands, societal values, sustainability, sustainable development.

I appreciate being with range managers. Since my retirement from Utah State University, I have been running with different kind of folks. I have been working at New Mexico State University in the area of sustainable systems, mostly sustainable agriculture. I am a sometimes farmer growing pecans and chilies on a small farm in the historic district of La Mesilla. I am on the town council, and one of our concerns is farmland going into housing. I am experimenting with specialty crops that could help the small, historic farms be profitable and delay subdivision. I needed this opportunity to think about rangelands.

Range management is my first love. And the ecological training I received has been the basis for my becoming a New Mexico guru in sustainable whatever.

My early training provides strange echoes in my current work. One echo is from the very first professional paper I ever gave. It was in 1958 before the Texas Academy of Science, entitled "The Multiple Use of Rangelands: a Problem in Ecosystem Management." I have been told it was among the first papers to link multiple use to ecosystem management. But because it was given by a graduate student in an applied field at a state academy meeting, it attracted little attention or comment. When I tried it on my professors in a seminar, they tolerated me but showed no enthusiasm. I was tempted to dig it out and read it here; I may have finally found my audience.

Five years ago I retired as Dean at Utah State University. I went to New Mexico State University to teach a seminar on sustainable systems, to think, and to rehabilitate myself from administrative life. One weekend I climbed a mountain and sat in a rock shelter near the place where the oldest corn in the United States was found. As I gazed out over the lush irrigated farms, the housing developments, and the intersection of two busy interstate highways, I wondered if our civilization would go the same way as those who made the petroglyphs in the shelter I had invaded.

Coming down the mountain, I took a shortcut across a dry, barren, west-facing slope. There, with no trees in sight, was an ancient stump with weathered axe marks still showing. As the sun went down I sat and wrote:

Stump near Solidar Canyon

on desert ridge

bare

save yucca

cacti

and woody scrub

a stump clings

relic of a gentler time

viejos

cannot remember cedar

on that dry west-facing slope

*through centuries
the tree grew
it fell
in modern times*

*it stood proud
against drought
and twisting wind
a rare
dark green dot
on a purple hill*

*a pioneer
climbed that hill
swung his axe
removed the life
that clung to stone*

*did it make
vigas for adobe hut
spokes for wagon wheel
fire to warm a newborn babe
in rare Mesilla snow*

*the axeman
judge him not
he was a product
of a harsher time*

The Native Americans who first tilled our soil, the pioneers who brought European ways, and those of us using rangeland today are all products of our times. Land use is dictated, in part, by our cultural and social values and our landbase will be subjected to new uses as those values change.

Range managers need to think about change, about future land use, and about sustainability. We need to back off from cows and grass and Lahontan cutthroats and neotropical migrants and think about where we fit in the cultural demands on land.

Although we are ecologists who study and teach change in biotic communities, we often ignore cultural change all around us. I speak as one who lived 30 years of happy frustration as research scientist, teacher, department head, and dean. Throughout it all, I was a card-carrying range manager working for the land. I worked as students changed, as research funding patterns changed, as society itself changed public attitudes about rangelands and land use.

I have seen the effects of cultural change on people's lives. I have watched as changing values destroyed the careers of distinguished wildlife scientists, and drove dedicated regional foresters into retirement before their time.

I have seen the white man's legal system fail to resolve disputes over Hopi and Navajo land. I have had my last Ph.D. student, head of the Botany Department at the National University of Somalia, write me, "Thanks to God, only one of my children has starved."

And I believe all of these have made me a better range manager. I am considerably different from the kid who came out of the cedar breaks of central Texas, but situations have changed me so I am better equipped to serve the land.

THESIS

My topic today deals with rangeland management: what it was, what it is, and what it can contribute in the future. My thesis is that range management developed as the conservation arm of the livestock industry, and some range managers are still there. Today we are divided between the "cows and grass" folks and "ecosystem health" enthusiasts. We are searching again for a common cause to bind us together. In the future we must walk a narrow line between giving people what they want from the land and leaving options open for evolving cultures. Perhaps this future challenge will give us new life.

I will present my view on the past and present status of rangeland management. I will speculate on what I think the real sustainability issues are and how they relate to cultural change. I will not give you my college professor lecture on natural processes and ecosystems—you are the experts. I will not even argue the case for range management, but will leave that to you who are practicing professionals. I will paint with the broad brush of societal needs and sustainable rangelands as I

1. Review the history of range management through its formative years and through its maturing phase.
2. Give you my view on the status of range management today.
3. Discuss the human motivation of the past 2 decades and how it has led to societal concerns and cultural change affecting rangeland management.
4. Discuss the concept of sustainable development as it relates to range management.
5. Look at some factors affecting future land use.
6. Try to relate these broad factors to rangelands and people.
7. Close with some ideas about sustainable systems, cultural change, and range management.

NEW LAND MANAGEMENT

Range management is managing ecosystems for sustainable use, but many times emotional, marginal issues sidetrack us. We divide society over environmental issues rather than seek a sustainable future. Sophisticated groups are trying to remove commodity use from the public lands.

Slogans such as "cattle-free by '93" or "no more moo by '92" attract headlines. The spotted owl becomes a surrogate for old-growth timber. Animal welfare groups and wild horse enthusiasts spend time and resources protecting feral horses that in turn destroy public rangeland. In the end we spend more on wild horses than on battered women. What sets our priorities?

At a conference on endangered species in Phoenix, I wrote the following.

Endangered Arizona

Mexican spotted owl
Gila trout
Northern goshawk

creatures
cowboys
timber beasts
threatened

Arizona snowbirds
arrive on dead dinosaurs

Braceros
die in boxcars

A rabbitbush makes
the endangered list

Chrysothamnus molestus

Chrysothamnus molestus, there should be a way to balance conservation with social justice.

From among all the emotion, a "new land management" is evolving—using land for societal values. There is a call to shape the future conditions of landscapes for a full diversity of life, ecological processes, human values, and resource uses. This will mean balancing science with social values, economic feasibility, institutional traditions, and political muscle.

The "new land management" is a recipe for sustainable rangeland use, but in this country it has largely been associated with protectionist causes. It has most often been directed at concerns dealing with wetlands protection, endangered species, or biological diversity.

It has not become the watchword, as many of us had hoped, for agriculture, range management, or world aid organizations. We have yet to relate new land management and sustainability concerns to cultural values, equity issues, and social justice. To have sustainable development we must take the next step.

Where does "new land management" or sustainable development fit into lives of range managers? We are ecologists who know land sustains our bodies, our children, our culture—we belong to the land. Native cover and grazing programs we design lead to stable systems that are good for the land. We are proud our work supports wise land use.

But land use objectives for everyone are about the same—wise resource use—but we differ on what wisdom to use. To a Hopi, San Francisco Peak is a holy place—a place for spiritual renewal to sustain his culture. To a white recreationist, it is a ski slope, a summer cabin, or wilderness—a retreat to sustain another very different set of val-

ues. To a forester, it is a place to grow trees; to a shepherd, it is a place to grow sheep. It is a place to support commodity production to satisfy yet another culture of consumers. Wise use for each group is to sustain the use that perpetuates its cultural values.

Only when we are forced to think globally and beyond our own culture does wise use include managing for options to be kept open for new or future uses. In other words, to think about sustainability and where range management fits into the broader scheme we have to think outside our own biases and training.

RANGE MANAGEMENT—THE FIRST 50 YEARS

When the first European explorers entered the rangelands of the American West, they saw free land and "inexhaustible grass." As soon as it was practicable, livestock were moved onto the range. The first livestock men came from humid areas, and overestimated the ability of the land to sustain large numbers of livestock. Throughout the West, within 2 decades of the arrival of European livestock, there were reports of overgrazed rangelands. Range management began near the end of inexhaustible grass.

Just 100 years ago the newspapers of this country carried dramatic stories of the failure of the range. A sample is the story written by Don Biggars of San Angelo, Texas. "The winter of 1886 was very severe, and in the spring of 1887 occurred, beyond a doubt, the awfullest die-up ever known in the United States. From the Canadian border to the Rio Grande the range country was covered with carcasses . . . Over these bodies the snow drifted and sifted between them, soon leaving a frozen mass, over which hundreds of living cattle walked, tumbled over the fence, and drifted away. This awful spectacle was to be repeated again in 1894" (Biggars 1901:24–25).

Ranchers asked the government for help. Politicians responded. The U.S. Department of Agriculture (USDA) mailed questionnaires, dispatched botanists to do field surveys, and established range experiment stations (see Chapline et al. 1944). We in range management proudly trace our roots to the work of these early botanists. But let us not forget, our field came into being because of political response to emotional newspaper articles. And I suspect we will survive in the future only if we can change and adapt to emotional articles coming from our new clients today. Suffice it to say now that we were born from a political attempt to save the cattle industry. We will survive if we can respond to a new emotional, political attempt to save ecosystems.

The Coming of Science to Range Management

The work of the early botanists was empirical and based on observation and experience. There was no unifying theory on which to base the management of the complex range communities. The development of ecology gave range manag-

ers the theory they needed. Succession was first described in 1899. The first 2 decades of the 20th century was an exciting time for range managers. Students, primarily from the Chicago (Cowles) and Nebraska (Clements) schools, found their way into range management. Art Smith used to tell that James Jardine said he could not sleep after taking classes at the University of Chicago. He lay awake trying to relate what he was learning in a big city school to the overgrazed rangelands of the Utah mountains. It was these students who first put science into range management. I will comment on only 2 of them, Arthur Sampson and James Jardine.

Sampson, a product of the Nebraska school, is considered by many to be the father of range management because of his many contributions in teaching and research. His USDA bulletin (Sampson 1919) relating succession and grazing made his theories widely available to academics and practitioners. He followed this with the first textbook in range management. From the first, he assured that the Clementsian paradigm of ecology would become the guiding light of our profession.

Jardine, a Utah State and Chicago product, made his contribution in the application of range management on public lands. As inspector of grazing, he developed early grazing survey methods and management techniques for the U.S. Forest Service.

In 1919, the same year Sampson published his succession and grazing bulletin, Jardine and Hurtt (1919) published a bulletin on range livestock production. From the many workers worthy of comment in the early years, I chose these 2 because their bulletins, published the same year, gave our profession a set of guidelines for managing rangelands based on the best science of the time. I argue that 1919 was the year when science became widespread in our profession.

Evaluating Range Health

I will comment only briefly on the historical development of range condition methods because there are other papers on the subject at this conference. Jardine developed the range reconnaissance method in 1911. Later methods of the public land agencies used some modification of his scorecard to include field data collected on plants and soils and an evaluation of environmental factors. However the data were collected or recorded, the end product was a subjective evaluation of a site's ability to produce forage for livestock.

Early work on private lands followed that developed by the U.S. Forest Service. However, shortly after the establishment of the Soil Conservation Service, workers here in the Pacific Northwest and in the Great Plains began relating range condition to plant succession. Again, many pioneers could be mentioned, but it was publication of Dyksterhuis's (1949) paper that institutionalized the use of succession and livestock grazing in condition evaluation.

Two major points emerged from the first 50 years: (1) the early influence of science came primarily from the Clementsian paradigm of ecology, and (2) range manage-

ment in its formative years was geared mainly to increasing livestock production. That heritage continues to mark us today.

RANGE MANAGEMENT MATURES—THE SECOND 50 YEARS

The second 50 years has been a time of maturation, reluctant acceptance of new ideas, and change. I will comment on 4 events.

First, The American Society of Range Management was formed, giving our profession a set of objectives, a code of ethics, and forums for both written and oral communication. It united us in a common cause, expanded our vision, and led to the acceptance of new concepts. The charge to the Society for Range Management was not just cleaning up the grammar, or acknowledging that range management is bigger than America, but an act of inclusion for both people and ideas from all over the world.

Second, range management embraced sciences other than ecology and animal husbandry. Social sciences were brought into our field, new science accepted, and new knowledge developed. The process has been slow, especially when it conflicts with our dogma, but we have changed.

Range management has become global in scope. Scientists in many countries work with rangelands. As our profession works with new cultures, both cultures benefit.

Finally, the environmental movement prods our conscience and demands that we change. We have the attention of the general public and we may not know what to do with it.

I will demonstrate the gradual change in range management by looking at the definitions of our profession written by a scholar (Art Smith) in the 3 editions of his textbook.

In the first edition (Stoddart and Smith 1943), range management was defined as the science and art of planning and directing range use so as to obtain maximum livestock production consistent with the conservation of range resources. It goes on to say "This definition implies a sustained yield of livestock over a long period of time." Note that the main objective was to produce livestock.

Twelve years later, the second edition (Stoddart and Smith 1955) defined range management as the science and art of obtaining maximum livestock production from range land consistent with the conservation of land resources. It goes on to say "It is evident from this definition that range management is closely related to animal husbandry and plant ecology." Although still a livestock production field, you see a break from a single commodity and laying claim to being a land management field.

In the third edition (Stoddart et al. 1975), range management is the science and art of optimizing the returns from rangelands in those combinations most desired by and suitable to society through the manipulation of range ecosystems. It goes on to say "Range management is at once a biological, a physical, and a social science." Gone are the

concepts of “maximum” and livestock production as the major use. New knowledge, especially the social sciences, are brought front and center.

These definitions are important for 2 reasons. First, they catalog changes seen by one of our heroes, and second, because most people in this room—indeed most every range manager—has taken courses based on this book. It has tended to define our profession.

What would be a good definition today? Before we examine that, let’s look at the sustainability issue and how it relates to range management.

THE WORLDWIDE QUEST FOR SUSTAINABILITY

The quest for sustainability is a grass roots movement. It has many definitions, but all definitions have 4 central concepts.

1. There must be equity for today’s land stewards. Farmers and foresters must be able to make a good living. If they do not have a high standard of living, they will mine the land.
2. There should be equity for future generations. We must leave options open for our grandkids. We must not close out future uses. Sustainability suggests intergenerational transfers.
3. Long-term sustainability must replace short-term profit. We must keep the land productive. We must learn to live on the interest without depleting the principal.
4. Environmental enhancement: we must improve what has been given us. We need to leave the world better than we found it.

These are not new concepts. They are the same as those that Aldo Leopold and Hugh Hammond Bennett wrote about 60 years ago. They are the same as those I learned from Vernon Young and Laurie Stoddart when I was a young range manager.

The concepts are the same. But the world has changed. And I have changed. Then I had yet to earn my Ph.D. I did not even know where Somalia was. I had never looked into the eyes of a starving child. And I had never had a friend write “Thanks to God, only one of my children has starved.”

Our culture, like me, has changed because of what has happened to it. The history of conservation in the U.S. gives us an insight into the current quest for sustainability.

When the first European settlers invaded North America, we entered an “Era of exploitation.” To conquer the wilderness was right and honorable. Development of the new land was public policy. Forests were cut. Prairies were plowed. Buffalo were replaced with homesteaders. The railroad connected the Atlantic to the Pacific. A new nation raced to become an industrial giant and a world power.

About mid-19th century, a few people began to call for saving plants, animals, or land. We entered an “Era of preservation.” Yellowstone became our first national park. For-

est reserves were established. Public policy still embraced growth and development, but we saved a little of our resources.

Between the first and second world wars, we entered an “Era of reclamation.” During the dust bowl days of the ‘30s, the Soil Erosion Service was formed and the Taylor Grazing Act passed. Make-work projects of the Great Depression constructed terraces, planted forests, built campgrounds, established windbreaks. We tried to rebuild what we had depleted.

After World War II, the bomb made us aware of the possibility of nuclear destruction. We entered the “Era of environmental concern.” Rachel Carson’s book, *Silent Spring*, focused our fears and our attention on ourselves and our families. This book changed the conservation movement forever. What had been a land-based movement became a concern for personal health and safety. This new environmental awareness became the moving force for clean air, clean water, organically grown food, and other demands of urban-based citizens. It changed the way we think about land.

I think we may have now entered a yet another era, the “Era of sustainability.” It grew out of the Earth Day movement of the 1970s. Originally, the movement was led by powerless kids who distrusted society and its leaders. It was reactive in nature and spawned laws such as NEPA, NFMA, FLMPA, etc. Solutions were based on rules rather than reason. Litigation and lawyers dominated land use.

The Earth Day movement became muddled with an unpopular war, new sex mores, the free speech movement, changing gender roles, communal living, and other evidences of cultural evolution. It lost its power in many diverse but related movements for which leaders were not ready. Cultural values were being challenged in our society, but most did not view it as a fundamental new direction for land use. They saw it as simply an extension of the environmental movement.

The examples of cultural change I have seen in natural resource students over the past 3 decades cause me to believe that we are indeed moving into the beginning of the era of sustainability.

During the 1970s I taught an intimate little class called “Natural Resources and Man’s Future.” It was so popular that I, like the airlines, overbooked it by 15%, thinking that I would have enough absences for any given lecture to allow all to be seated. Instead, I often had students sitting in the aisles and standing at the back of the auditorium.

The 1970s kids were filled with idealism. They cared. They wanted to save the world. They did not want a job—at least the kind we had to offer in range management. Foresters and wildlife managers were bad guys who cut trees and wallowed in blood and guts. Students went into the Peace Corps, they demonstrated and marched against injustice, and they resisted those in power.

Today, these very people are in power. They are now in leadership positions from the district ranger’s office to the White House.

In 1970, students were driven by a fear of nuclear holocaust and found release in such events as Earth Day. The students of the 1980s also saw in "the bomb" a real likelihood that their dreams could be cut short, but they responded differently. Class size in the beginning natural resource course dropped. Students sought material wealth and wanted money. They were willing to take any job if it paid well enough. They were not concerned with social issues or the land. In the 1980s fear of extinction led to a "let's get it now" attitude. Concern for personal wealth replaced concern for society. BMWs and MBAs were dominant.

Military science as a major subject was more popular than range management, forestry, and all other fields of conservation combined. Rambo ruled. God lived on Wall Street and drank Perrier water. The ethic for the '80s was, "greed is good, rules are for fools, and he who has the most toys in the end wins."

The bubble burst in October 1987 when the stock market experienced its greatest 1-day loss since the crash of 1928.

What cultural values will the next generation bring now that the threat of nuclear destruction has diminished? I don't know. But whatever they are, the new cultural values will determine how we use our rangelands. Sustainable development depends on what we demand from the land. Sustainable development became a world issue with the awakening of global economic and environmental interdependence. As groups of nations moved toward "economic communities" they found that trade and national economies can be regulated only with great difficulty. Environmental regulation was even more difficult. Environmental disasters knew no national borders. They cut across political subdivisions.

We see the problem in microcosm in the south Mesilla Valley of New Mexico where I live—Juarez, Chihuahua, and El Paso, Texas, overshadow what is done in Las Cruces, New Mexico. What Las Cruces does dictates policy for the historic village of Old Mesilla. Whereas the town council of Mesilla strives to preserve the historic flavor of its town, actions in Washington and Mexico will ultimately determine how the resources of the village are allocated.

A number of international organizations are addressing the problem of sustainable development. The gap between the rich and the poor is increasing and land use is not sustainable. Several major conferences have tried to get global consensus on a plan of action that will allow the world to develop in a sustainable way.

Sustainable land use means implementing a policy that meets the needs of people today without destroying the resources that will be needed in the future. Development cannot be sustained on a deteriorating environmental base.

Sustainable land use depends, in part, on determining the ecological carrying capacity of the land, determining what people want and need from the land, and a political and economic system that matches what people want and need with the land's ability to produce the desired goods and services.

Whereas the potential ecological carrying capacity of the land remains relatively stable, the cultural and social demands on the land are constantly changing, causing the

actual carrying capacity to fluctuate widely through time. Therefore, the overriding element for those attempting to manage rangelands is coping with change. The key issues for range managers in sustainable development are

1. Determining what society wants from its lands with inevitable changing values, changing demographics, and changing economics.
2. Achieving orderly transition and community well-being in an internationalizing and amenity-oriented economy.
3. Developing common language, measures, and forums for identifying and evaluating trade-offs: ecological, economic, fiscal, human, and social.
4. Shifting from reductionist and disciplinary work to synthesis and interdisciplinary analysis of systems.
5. Defining the issues to reflect fairly the wants and needs of society while protecting the sustainable land base.

This is a long ways from our beginning as a "cows and grass" group. But unless rangeland use is linked to basic issues of equity, social justice, and community stability for poor people, sustainable development will fail.

FUTURE ISSUES AND RANGE MANAGEMENT

No one knows exactly what the future holds. However, I am certain that there will be several issues that will dominate much of our attention in the future. I will discuss 4 of these.

Demographics

First, the human population, especially its demographics, will affect sustainable land use. The primary question for my generation was, "Who will feed the hungry world?" We have made major accomplishment in this area, to the point where we have an embarrassment of surplus in some countries. But the problem of feeding the human population remains, only the time frame has changed. Even with our abundance of food, some 40,000 people die each day of starvation and disease. In a month, more people than live in New Mexico will die from nutrition-related ailments.

Sustainable rangeland use, equity in this generation, means feeding those less fortunate than we whether they are in Somalia, or Bosnia, or eastern Oregon.

Economic Trends

Rich countries are not growing—they are growing old. Poor countries have young populations. In the U.S., wealth is concentrated in a few, usually older people. The U.S. has moved from the world's largest creditor nation to its largest debtor nation. The global financial center has moved from Wall Street to somewhere on the Pacific Rim. Our markets and our labor are in poor countries, but they are unable to buy. Their standard of living must be raised if they are to

participate in sustainable development. Sustainable rangeland use, equity for future generations, depends on world peace and world trade.

Material Science and Technology

We live in a world where designers imagine a product, engineers specify the characteristics of the components, and chemists create the building materials from polymers, graphite, ceramics, or whatever combination of elements can produce the required strength and aesthetic qualities. No longer does the designer buy 2 x 4s and then let them determine the final product; the final product is based on the creator's imagination and skills. The demand for producing natural building products such as wood, wool, and cotton will not necessarily determine land use.

Sustainable rangeland use, long-term stability, means adapting new materials and adjusting land use through a combination of ecology, economics, and technology.

Philosophical Trends

Of the world's 10 largest countries, only 3 are "Christian" in philosophical thought. In the past, world development, sustainable or otherwise, has largely been the product of western thought patterns of growth and development. The philosophical implications of a global change away from Judeo-Christian attitudes about development will have profound effects on sustainable land use.

The most obvious trends are an increase in animal-rights activities and a wider acceptance of vegetarianism. However, much more important changes will occur with different concepts of equity, beauty, property ownership, productivity, and work.

Even now, work is not what we do, but is what we can imagine. Vladimir Horowitz, one of the greatest pianists of all time, died a couple of years ago. A clever computer programmer can make a synthesizer play Horowitz, Chet Atkins, Alabama, the Grateful Dead, or even Bob Wills. But she or he cannot make the computer imagine the music.

Science fiction writers tell us of transferring material directly from 1 brain to another. The android, Commander Data on *Star Trek*, has all the past knowledge and human experience stored on his computer chips, but he lacks human emotion and a philosophical base. A Mr. Data could provide all the information needed to make the world better, but he could not define better for us.

Sustainable rangeland use, environmental enhancement, will depend on what our concept of "better" is. Our philosophical base will be the key element, not our technology.

RANGE MANAGEMENT IN THE FUTURE

Earlier I told you I would work toward a new definition of range management. I suggest that range management is the manipulation of rangeland ecosystems to improve past damage, provide societal needs from those systems, and to

keep options open for future generations. This definition implies that long-term sustainability of the system has priority over short-term commodity extraction.

Although I lack the clarity of thought of an Art Smith, I hope I have conveyed the necessity of range management becoming a part of the larger scheme of things. Range management must be culturally acceptable and able to cope with societal change if we are to be a force in the future.

Sustainable rangeland use is linked to cultural demands. Balancing land capability with cultural demands will be controlled by what we can imagine, creativity, vision. And all these are enhanced by education.

What we need to do is to create new visions of what the world can be. We need to tie science and application together in the simple steps of education:

1. Identify the problem. What is causing nonsustainability on our planet, our rangelands, our backyard garden?
2. Set priorities. What problems should we tackle first that will really make a difference?
3. Improve our bag of tools. Do good science. Synthesize and integrate. Tie ecology, economic development, and social justice together. Accept social sciences as land management tools. Improve our application of science.
4. Inspire. Inspire to make something happen. Inspire to create new visions of what may be.

We are having trouble creating new visions because we are unable to relate to new clients, new cultures, new social values. Our traditional approaches have been tainted by our early devotion to livestock forage. We really believed that good range management was good wildlife management, and we implied that it was good for everything! We tied ourselves to the past. We acted as if society's main demand was still livestock products.

With the diminished threat of nuclear destruction, our new social values turn toward sustainability—of our income, our land, our lifestyles. New advocates for sustainability come from diverse groups with varying immediate goals. Environmental groups demand natural resource protection. Commodity groups want sustained production. The underemployed, the hungry, the have-nots wish for social justice and a sustained fair wage. Our clients are in the ghetto and the suburbs as well as on ranches.

Emotional headlines in 1894 got us started. Will emotional headlines from our nontraditional support today bring us back to reality? Our new support may embarrass us; it is not always scientifically credible. We often get bogged down defending practices or positions that are equally incredible. We mix scientific credibility with social acceptance or political correctness.

We forget that we, like the pioneer who chopped down the cedar tree, are products of a different time. Our success will be determined by our ability to adjust, change, lead.

Some say we are going round in circles. Instead, we are in a spiral. Concern for conservation is coming around again, but we are on a higher level, like the next step on a spiral

staircase. We are on a new plateau. We are no longer living in fear of communism or the bomb. Sustainability is a grass roots movement. Our science is better. Limited peace is upon us. We realize that people are an important part of this new sustainable land use.

If we concentrate on education, creativity, application, we can move to a yet higher plateau—a higher plateau where social justice is balanced with resource use, where development is truly sustainable.

New cultures that develop in the future will be able to reach their potential if we in this generation remember:

1. equity for today's generation,
2. a better life for our grandkids,
3. leave options open for those who follow us, and
4. leave the world better than we found it.

But we will not have, indeed we do not deserve, public support if we continue business as usual, continue to organize our programs around narrowly drawn issues such as producing a bigger calf crop, developing a new hybrid grass, or saving an endangered species. We will fail if we underestimate the broad support for sustainability and fail to serve those who live in cities.

The quest for sustainable land use is doomed if we ignore social justice in our sustainability equation whether it is keeping Ahmed Elmi's children alive in Somalia, getting single moms off welfare in La Grande, or keeping gang members from killing one another in Portland.

As range managers we have a special responsibility to make our culture sustainable. We are practicing ecologists who have scientific tools that can be put to use. As profes-

sionals we have stewardship of the rangeland base for the future of our culture. I pray that we in range management in this generation set the stage for a better world.

I feel incredibly fortunate to have been an actor in the range management drama. I am proud to have been a university teacher and a conservationist. I am struggling to be a different kind of teacher today. I appreciate your kindness in letting me spout my biases. Thank you for asking me.

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PATTERNS OF RETROGRESSION IN THE SAGEBRUSH STEPPE

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Abstract: Retrogression has traditionally been defined in terms of deviation from the climax plant community. However, there is increasing recognition that climax plant communities may be difficult to clearly define, and succession does not always follow linear pathways. Vegetation patterns are influenced by the natural disturbance regime, climatic variation, introduction of alien species, past and present management, and human activities. In the sagebrush steppe we can define 2 major patterns of retrogression: (1) woody plants (principally *Artemisia* spp. and *Juniperus* spp.) gain dominance on a site as perennial forbs and grasses decrease, and (2) introduced annual grasses and biennial forbs invade a site and gradually gain dominance. The first pattern is generally associated with a combination of overgrazing and reduced fires. The second pattern is frequently associated with the first pattern, except native herbaceous plants are replaced by introduced species such as *Bromus tectorum*. The build-up of fine fuels increases with the dominance of these exotic weedy species, increasing fire frequency that perpetuates these annual communities. In many cases, once these new steady states have been achieved, the return of these sites to the desired plant community may be difficult. I would like to propose that during retrogression, the threshold to a new steady state has been crossed when the desired native species show minimal response to favorable climatic conditions and the removal of anthropogenic disturbance.

Key words: climax plant community, disturbance, retrogression, sagebrush steppe, succession.

NEW CONCEPTS OF RANGELAND CONDITION

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Abstract: Range condition score or classification does not tell us, in a general sense, much of what managers and the public want to know about rangelands. Range condition is not a reliable indicator, across all rangelands, of biodiversity, erosion potential, nutrient cycling, value for wildlife species, or productivity. Succession, the basis for the current concept of range condition, is not an adequate yardstick for evaluation of rangelands. The Society for Range Management (SRM) established the Task Group on Unity in Concepts and Terminology that has developed new concepts for evaluation of the status of rangelands. These concepts are based on our agreement that the most important and basic physical resource on each ecological site is the soil. If enough soil is lost from an ecological site, the potential of the site is changed. The Task Group made 3 recommendations that were adopted by the SRM: (1) evaluations of rangelands should be made from the basis of the same land unit classification, ecological site; (2) plant communities likely to occur on a site should be evaluated for protection of that site against accelerated erosion (Site Conservation Rating, SCR); and (3) selection of a Desired Plant Community for an ecological site should be made considering both SCR and management objectives for that site.

Key words: conservation threshold, desired plant community, ecological site, range condition, soil erosion, sustainability.

Sustainable land use is the fundamental premise on which rangeland and other land management is based. The concept that we should manage land to maintain or enhance its productivity for future generations is not new. But seldom in the short history of range management has the "condition" of rangelands, especially public rangelands, attracted so much attention. One of the stated objectives of the sweeping changes in grazing regulations and grazing fees proposed in Rangeland Reform '94 was to "accelerate restoration and improvement of public rangelands" (U.S. Dep. Inter. [USDI]-U.S. Dep. Agric. [USDA] 1994:6), although no consistent criteria were provided for deciding whether such "improvement" had occurred.

Whereas nearly everyone agrees that early, uncontrolled livestock grazing resulted in major impacts on range soils and vegetation, there is little agreement on the present status and trends under current management. Most professional range managers and scientists agree with the widely quoted statement of Thad Box that "rangelands are in the best condition they have been in this century." Range condition data (e.g., Soc. Range Manage. 1989) indicate that trend in range condition is up or static on about 85% of U.S. rangelands, public and private. These data, combined with numerous photographic records and personal experience, lead to the conclusion that there has been general improvement in the condition of the rangelands since passage of the Taylor Grazing Act.

However, others disagree. Critics point out that the same data show that most of the public rangelands are in "poor" or "fair" condition and conclude that this situation indicates a failure of current management and a need for drastic action (e.g., USDI-USDA 1994). The data are used as the basis for claiming that soil erosion, wildlife habitat, biodiversity, and other values are being degraded or destroyed on our

rangelands as a result of livestock grazing (e.g., Comptroller General 1977, Dregne 1983, Wald and Alberswerth 1985). Even the Bureau of Land Management (BLM) stated that ranges in "fair" and "poor" condition were "producing far below their potential" and were, therefore, "unsatisfactory" (BLM 1979).

It was this kind of confusion and disagreement that led the Society for Range Management (SRM) to establish, first, the Range Inventory Standardization Committee (RISC) in 1978 (RISC 1983) and then the Task Group on Unity in Concepts and Terminology (UTG) in 1989. The recommendations in the report of the "Unity" Task Group (UTG 1991) were adopted by the SRM and are the basis for the concepts presented in this paper.

TRADITIONAL RANGE CONDITION ASSESSMENT

Current approaches to range condition assessment have their roots in the observations of Sampson (1919). He related stages of secondary succession to range condition classes produced by livestock grazing. Heavy grazing caused a shift to lower successional stages and reduction or absence of grazing allowed succession to proceed to higher stages. This model was based on the concepts of succession espoused by Clements (1916). Concepts of range condition and trend and range sites evolved during the next 30 years and were elaborated into operational procedures by Dyksterhuis (1949) and Parker (1954). Concepts and procedures have varied among the various agencies (U.S. Soil Conserv. Serv., BLM, and U.S. For. Serv.) and have evolved within agencies over time. These differences are 1 reason it is difficult to compare data among agencies or to establish changes over time. Nevertheless, all the approaches used have been founded on the

same basic model of Clementsian succession proposed by Sampson (1919), and this remains the basis for evaluating "ecological status" by all 3 agencies today.

In general, current approaches to range condition rely on comparisons of species composition (relative biomass) of present vegetation compared to the "climax" or "potential natural" vegetation for the site. Vegetation is rated as poor, fair, good, excellent (or as low, mid-, or high seral, or potential natural) according to its similarity to the climax. Implicit in this approach is that "climax" or "potential natural" vegetation is best in terms of stability, diversity, and productivity. Departure from the climax, or retrogression, is generally described as a result of livestock grazing. This retrogression occurs as a result of "years of overgrazing" (Dyksterhuis 1949) or of "grazing intensity" (Stoddart et al. 1975). Reduction or elimination of grazing will result in succession to a higher condition class, ultimately reaching "excellent" or "potential natural" condition; i.e., the model reflects a linear, reversible reaction of vegetation to the "disturbance" of grazing.

There are several problems with the traditional approach to range condition assessment that have been amply documented by several authors (e.g., Love 1961, Jameson 1970, Smith 1978, Westoby 1980). One problem is that vegetation changes may occur as a result of many factors other than grazing (e.g., fire, lack of fire, extreme weather events, climatic change, invasions of exotic species, etc.). Change and "disturbance" seem to be a natural feature of vegetation, and the concept of a stable "climax" on which the "balance of nature" paradigm is based may be an illusion (Johnson and Mayeux 1992).

Another problem is that even where livestock grazing may have been the cause of vegetation change, removal or reduction of livestock grazing will not result in a return to the "climax" or "original" vegetation. In grasslands the Clementsian model of predictable and reversible succession seems to apply fairly well. Under heavy grazing, taller perennial grasses give way to shorter perennial grasses and eventually to annuals and forbs; removal of grazing results in a return to the taller perennial grasses in a relatively short time. However, when shrubs or trees replace the grasses because of heavy grazing (or other "disturbances"), the changes in vegetation may not be spontaneously reversible.

Finally, similarity of species composition to that of the climax has no consistent relationship with soil protection, value for wildlife habitat, biodiversity, or biomass productivity. Soil may be adequately protected from loss by erosion by vegetation that has little resemblance to the "climax." An extreme example would be seeded stands of exotic species such as crested wheatgrass (*Agropyron desertorum*) or Lehmann's lovegrass (*Eragrostis lehmanniana*). Because wildlife species have habitat requirements that involve both species composition and vegetation structure, 1 vegetation type obviously cannot be best for all wildlife. Shifts from grassland to shrubland, as have happened in the Southwest, for example, have been beneficial to many species of wildlife and probably have resulted in overall greater numbers

and diversity of wildlife than existed under "pristine" conditions. In considering biodiversity, one must specify the scale of interest (West 1993). Species diversity in plant communities is often, if not usually, greater in "seral" stages than in the "climax" stage. Invasion of exotic species may increase diversity rather than decrease it (Johnson and Mayeux 1992). At the landscape level, plant species diversity (and therefore probably animal species diversity) will obviously be greater where a variety of plant communities (seral stages) occur than where the whole landscape is occupied by the same community. Thus, the fact that rangelands have a diversity of "condition classes" may be an indication of higher biodiversity than if all were in "excellent" condition. The statement that ranges in poor or fair condition are producing far below their potential or have lost productive potential is not necessarily true. In Arizona, range condition class was found to be correlated to livestock forage production but not to total biomass production across a wide cross section of range sites (Frost and Smith 1991). Much of our research and experience in revegetation throughout the West shows that "poor condition" ranges are as productive as ever if the "undesirable species" are removed and "desirable" ones re-introduced.

Various interest groups use range condition reports to infer that (1) a large portion of rangeland in the U.S. is in poor or fair condition; (2) this condition is the result of livestock grazing and improper management either in the past or present; (3) fair- and poor-condition rangelands have lost productivity, are low in diversity, are poor habitat for wildlife, and are "unsustainable"; and (4) reduction or removal of livestock would result in the restoration or improvement of these rangelands. Whereas some of these conclusions are true in some cases, they are not true for a large percentage of the rangelands classified in poor and fair condition. Quite simply, there is no way that such conclusions can be drawn from range condition data because the procedures used to assess range condition currently do not produce the information required to reach such conclusions. Current range condition assessment methods do not provide answers to the questions that Congress and the public want answered about the status of our rangelands.

BASIC PREMISES OF THE UNITY TASK GROUP

The UTG was formed in 1989 to consider the terminology, ecological concepts, and use interpretations of ecological data relating to range classification, inventory, and monitoring, and to seek agency commonality and unity in technology and methodology relating to rangeland condition and trend. The UTG was comprised of representatives from relevant federal agencies and several universities. In approaching their task, the UTG developed several basic premises on which its recommendations are based. These were:

1. Range condition assessment should be based on sound ecological principles and scientific information. Traditional range condition assessment relied heavily on the Clementsian concept of climax and succession. These concepts were largely rejected as general theories by ecologists during the 1970s and 1980s (see Smith 1989 for a review). Alternative models of vegetation dynamics were proposed, but none has been generally accepted. The UTG decided that a new approach to range condition assessment should be based on the best ecological understanding currently available but should not be tied to a specific model of succession.
2. Site potential must be recognized in evaluating range condition status. Differences in soil, topography, and climate are the major determinants of the kind and amount of vegetation that can be produced on a given piece of land, and also the "natural" levels of soil erosion that can be expected. Failure to recognize these site differences results in classifying some land in "poor" condition when it does not have the potential to be any better. This premise is well established in the range profession and is recognized in most (but not all) current range condition assessments.
3. "Sustainability" is the fundamental goal of rangeland management and sustainable management of rangelands depends primarily on conservation of the soil. Management should not result in irreversible reductions of soil productivity if that can be avoided (UTG recognized that landscape evolution results in degradation of some sites, and also that economic feasibility must be a consideration). The primary cause of irreversible loss of soil productivity on most rangelands is erosion by wind and water. Thus, "sustainability" should be evaluated objectively, independent of the suitability of vegetation for any particular use or combination of uses. This principle was based on the work of Ellison (1949).
4. If current vegetation on a site meets the requirement of providing adequate soil protection, its desirability should be determined by how well it meets other management goals, not by its presumed successional status. "Pristine" vegetation probably did not reflect a stable condition and will not be "restored" by protection from disturbance. The presumed pristine or climax vegetation is not necessarily "best" for any land use or ecological attribute and therefore is not a useful standard for setting management goals or assessing range condition.

Based on these 4 premises, the UTG developed the following guidelines for range condition assessment.

Ecological Site

Rangelands should be classified and mapped using ecological sites as a basis for range condition assessment, monitoring, and management planning. Ecological site is defined as "a kind of land with specific physical characteristics which differs from other kinds of land in its ability to produce dis-

tinctive kinds and amounts of vegetation and in its response to management." Ecological sites should be correlated with phases of soil taxonomic units.

Ecological sites are essentially synonymous with the concept of range sites as used for many years by the Soil Conservation Service and other agencies. Range sites have traditionally been defined on the basis of differences in species composition or production of the climax community for the site. With the UTG definition of ecological sites, any site difference that results in a significant difference in vegetation or management response would be the basis for describing a different site. Knowledge of the climax or potential plant community might be helpful, but not necessary. Ecological site was used rather than range site to make clear that this classification system can be used on woodlands, forestlands, or other lands that some might not consider to be "range", and it is useful for all uses and values derived from rangelands, not just for livestock grazing purposes.

Site Conservation Rating

To assess the "sustainability" of rangeland management, the UTG developed the concepts of Site Conservation Rating (SCR) and Site Conservation Threshold (SCT). SCR was defined as "an assessment of the protection afforded a site by the current vegetation against loss of potential." SCT was defined as "the kind, amount, or pattern of vegetation needed as a minimum on a given site to prevent accelerated erosion." The "threshold" in this case is in the rate of soil erosion. Vegetation that provides protection equal to or in excess of that necessary to prevent accelerated erosion would be above the threshold and would be rated as "satisfactory" or "sustainable." Vegetation that does not provide adequate protection would be rated "unsatisfactory" or "unsustainable."

Assuming that most rangeland sites experience some level of natural or geologic erosion, accelerated erosion would be an increase in that rate of erosion that would eventually result in loss of productive potential of the site. In other words, it is unsustainable. There are some sites, e.g., badlands, where lack of precipitation, soil characteristics, or erosion because of offsite factors, make the concept of sustainable productivity unworkable, but these situations are a relatively minor part of the total rangeland.

It is not feasible to measure erosion rate directly to arrive at an SCR. Therefore SCR will have to be based on assessment of attribute(s) of vegetation, or perhaps soil surface features, which can be directly observed in the field and which are indicators of the degree of protection from erosion. The UTG did not specify what attributes should be observed, because these may vary in different ecological regions and from site to site within a region. On many ecological sites, basal cover of perennial vegetation may be a good indicator of degree of erosion protection. For example, on a range site in Arizona, it seems that basal cover of perennial vegetation of about 7% is required to prevent accelerated erosion (Watters 1993), i.e., basal cover could be the

basis for the SCR and a cover of 7% would constitute the SCT. In other situations, different attributes such as community type or structure, plant spacing, or plant and litter biomass, may be appropriate.

These criteria for SCR and SCT will have to be worked out by research and professional judgement for each ecological site and should then be incorporated into the ecological site description. Criteria selected should be objective and quantitative enough to serve as a basis for monitoring so that trends in the SCR can be established as a measure of management effectiveness.

Desired Plant Community

On any given ecological site there may be several vegetation community types, depending on the history and current status of management and natural influences such as fire history. Each of these is capable of being produced at any location on the ecological site if the necessary management actions are taken. The Desired Plant Community (DPC) is defined as "of the several plant communities that may occupy a site, the one that has been identified through a management plan to best meet the plan's objectives for the site." In most cases, a plant community that does not have the capability to protect the site against accelerated erosion (i.e., is below the SCT) would not be chosen as a DPC.

This concept originated with the BLM in an effort to establish a vegetation goal that is relevant to management objectives. The "state and transition" model of vegetation change (Westoby et al. 1989) and the threshold concept of vegetation change (Friedel 1991, Laycock 1991) are similar to and compatible with the DPC concept described above. The various plant community types possible on an ecological site correspond to the various "states", and the management actions required to move from 1 community to another are the "transitions." Selection of a DPC depends on the relative utility of each state for the uses and values desired for the site, and also the feasibility (economic, legal, and technological) of implementing the required management to change present vegetation to a more desirable type.

Recognizing the variability of rangeland vegetation over time in response to various influences, the UTG emphasized that the DPC should be described in fairly general terms. For example, desired plant composition should probably be described more in terms of species life forms or functional groups than by individual species. Also, the DPC should be selected from community types that have actually been observed to exist on the ecological site. In other words, DPC should not be described by taking the most desirable attributes of various communities and combining them into some artificial "ideal community."

Management effectiveness can be assessed by a Vegetation Management Status (VMS) rating, which would describe how nearly the present vegetation resembles the DPC. More importantly, trend in VMS, described as toward the DPC, away from DPC, or static will indicate success of current management in reaching management objectives.

Some people have expressed concern that the DPC represents a moving target; i.e., that the DPC will change as management objectives change, and thus the ability to hold agencies accountable for long-term management effectiveness will be weakened. We are not too concerned about this situation for several reasons. First, in our view the main concern that people have for the condition of the rangelands is reflected in the assessment of SCR, i.e., how well our options for the future are being maintained. This assessment is not subject to changes in management priorities since, presumably, sustainability is a fundamental objective not affected by changing values or economic considerations. Second, VMS will be determined based on quantitative field observations of specific attributes of vegetation, thus trend in these attributes can be tracked even if the DPC is changed.

RANGELAND HEALTH

The term "range health" has been used for a long time in referring to range condition assessment. This term was compatible with the super organism view of Clements and others regarding the nature of plant communities and ecosystems because it implies that such systems, when undisturbed by "outside" influences, function in a delicately balanced equilibrium much as a plant or animal does. "Disturbance" from outside, i.e., unusual natural phenomena or human activities, upsets this balance much as a disease infects an organism. This view of community or ecosystem function is incompatible with most modern ecological viewpoints, as discussed earlier in this paper. Unfortunately, the term "range health" has been given a new lease on life by the publication of the National Research Council's (NRC) *Rangeland Health: New Methods to Classify, Inventory, and Monitor Rangelands* (NRC 1994).

The NRC and UTG reports are similar in some aspects. For example, the NRC report rejects the concept that similarity of present vegetation to the climax should be used as a basis for assessing "range health" (NRC 1994:88). The NRC report also states that assessments of "range health" should be independent of assessments of the proper use of rangelands (NRC 1994:95). The NRC report states that assessments of soil stability and "watershed function" are the most important criteria in the assessment of range "health" (NRC 1994:132). All of these statements are basically in agreement with the conclusions of the UTG (UTG 1991). However, there are major differences between the 2 reports.

The NRC report does not support the concept of assessing range condition with due consideration of site differences; 1 standard is to be applied to all rangelands. Criteria for evaluating "range health" is based on a scorecard that includes multiple factors that may or may not be applicable or measurable in all situations. Reliance on "judgement" is repeatedly mentioned. Objective and quantitative measures are de-emphasized. Such approaches do not furnish a reliable basis for monitoring trends over time. In fact, the NRC report does not give any "new methods to classify, inventory and monitor" rangeland condition. It

addresses only a scorecard approach to assess "rangeland health" based on criteria that the report itself admits are largely lacking scientific validation or adequate testing. To emphasize the concept of "range health" is a return to outdated ecological concepts. Because range health has not, and cannot, be objectively defined, there will be an irresistible tendency to judge "health" by comparison to imaginary pristine or "protected" conditions. That is precisely the problem we have with current approaches to range condition assessment, and the one the UTG hoped to remedy.

A guiding premise of the UTG has been that concepts and methodology of range condition assessment must change and adapt as new knowledge and understanding is acquired. Each new effort to improve on past methods is only an "approximation" that awaits further change and improvement. The guidelines put forth by the UTG may be altered in the future. Nothing in the NRC report has indicated that they should be altered now.

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BLENDING NEW KNOWLEDGE WITH OLD PARADIGMS: BY DESIGN OR DECREE?

NEW CONCEPTS IN LANDSCAPE ECOLOGY FOR MANAGING WILDLIFE ON RANGELANDS

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Abstract. Landscape attributes of habitats, such as patch size, spatial heterogeneity, and fragmentation often are primary determinants of wildlife abundance and distribution. Habitat disturbance, both natural and human caused, directly influences both vegetation and landscape attributes and subsequently has an indirect impact on wildlife. Therefore, understanding the effect of disturbance on landscape attributes of habitats provides additional knowledge for managing wildlife in shrubsteppe rangelands. I examined the relationship of disturbance, primarily wildfires, to landscape attributes of habitats. I then demonstrate how landscape attributes influence wildlife distribution. Because of increasing use of Geographical Information Systems for data management, analyses of landscape attributes should be possible on many rangelands and will benefit current land management practices that emphasize ecosystem-level approaches.

Key words: habitat disturbance, habitat fragmentation, landscape ecology, patch size, wildfire.

Landscape ecology is the study of the spatial pattern of environments across large areas (Naveh and Lieberman 1984, Forman and Godron 1986). The concept that spatial pattern of the environment influences processes such as the spread of disturbance and affects patterns of animal movements and distribution is not new. However, lack of quantitative methods and techniques to characterize landscape attributes, such as patch size, habitat fragmentation, and patch connectivity, has hindered investigations in landscape ecology and subsequent application at spatial scales most suited for resource management. Consequently, spatial management of range habitats and wildlife often has been based on tradition or subjective judgement rather than on strong scientific foundation (Coughenour 1991).

Landscape ecology recently has undergone rapid advances because of concurrent developments in techniques to delineate habitats, and in management and statistical analysis of spatial data. Habitat characteristics of large areas now are routinely determined at a fine-grained resolution by remote sensing capabilities of satellites (Lillesand and Kiefer 1987). Management of spatial data in Geographical Information Systems has facilitated theoretical development and testing of mechanisms by which spatial distribution of resources govern ecological processes (e.g., Milne et al. 1989, Milne 1992). In addition, spatial statistics (O'Neill et al. 1988a, Palmer 1988, Legendre and Fortin 1989, Turner and Gardner 1991, Rossi et al. 1992) now permit quantitative

analyses of landscape features. As a result, studies of landscape ecology now can provide important contributions to resource management.

Here, I first define landscape ecology and habitat features. I then review the interaction of landscape attributes and disturbance, and describe fire patterns in the Snake River Plain from a landscape perspective. Finally, I examine the response of wildlife to landscape features and demonstrate the relationship between habitat fragmentation and breeding passerine birds in shrubsteppe. My purpose is to demonstrate how concepts derived from landscape ecology can benefit current management practices that emphasize ecosystem-level approaches.

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BACKGROUND AND DEFINITIONS

Landscape ecology is the study of the influence of spatial pattern of habitats on ecological processes (Naveh and Lieberman 1984, Forman and Godron 1986) and how pat-

tern and process change with scale of investigation (Allen and Starr 1982; Meentmeyer and Box 1987; O'Neill et al. 1988b, 1991; Wiens 1989a; Turner et al. 1991; Levin 1992). A basic premise of landscape ecology is that landscapes are composed of discrete, smaller patches containing homogeneous characteristics (Naveh and Lieberman 1984, Shugart and Seagle 1985). Processes such as disturbance or dispersal among populations are described by within- or across-patch interactions throughout the landscape (Turner et al. 1989).

Scale is an important component governing the context of the relationship between ecological process and landscape patterning and species response (O'Neill et al. 1988b). Processes often operate too slowly at large temporal scales and over too great an area at large spatial scales to be measured or managed, yet still constrain boundaries for processes at finer scales (e.g., hierarchy theory; Allen and Starr 1982). Conversely, details at fine scales, although important to individual plants or animals, often provide few significant insights into general processes that operate at the population level (Wiens 1989b). Therefore, investigation of multiple scales is important to determine the scale in the landscape at which processes most strongly interact with an organism (O'Neill et al. 1988b, Levin 1992).

Patch Characteristics

Patches contain individual or sets of characteristics that are constant within the patch. Patches often represent vegetation species or community type but can be any relevant feature, such as soil, climate, geochemistry, or hydrology, or can describe abstract conditions within patches, such as population sources or sinks (Fahrig and Paloheimo 1988, Pulliam 1988, Danielson 1992). The difficulty for the ecologist is to describe patches in characteristics important to the species, rather than from human perspectives (Hansson and Angelstam 1991).

Patches are defined by size, area, thickness, and perimeter. The perimeter:area ratio estimates the amount of edge to interior of a patch; patches with low perimeter:area ratios should be less influenced by the greater intensity of ecological processes that operate at edges of habitat patches. Shape (index of deviation from a circle) (Patton 1975) and fractal dimension (Krummel et al. 1987; Milne 1988, 1991, 1992; Sugihara and May 1990; Palmer 1992) also have been used to describe patch geometry.

Landscape Characteristics

The pattern of patches within the landscape provides the foundation for study of landscape heterogeneity and fragmentation (Turner and Gardner 1991). Landscape heterogeneity is the mixture of patch types and sizes within the area of study and is related to the grain (size of smallest resolvable unit) and extent (dimensions of the area of study) of the investigation. The frequency distribution of patch sizes relative to scale of investigation within the landscape often is used to estimate landscape heterogeneity (Groom and Schumaker 1993).

The concept of habitat fragmentation is similar to island biogeography theory (MacArthur and Wilson 1967, Urban and Shugart 1986, Harrison 1994). Fragmentation results when human-caused or natural disturbance divides contiguous habitats into smaller areas of suitable resources surrounded by hostile environments (Fahrig and Paloheimo 1988). In fragmented habitats, patch dispersion (or isolation) and connectivity (also called percolation dynamics) (Gardner et al. 1987, Gardner and O'Neill 1991) are critical features that affect animal movements, gene flow, population survival, and flow of disturbance between suitable patches along corridors in the landscape.

LANDSCAPES AND DISTURBANCE

Disturbance is "any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment" (White and Pickett 1985:7). As a result of disturbance, a community is deflected from some predictable course (Pickett and White 1985).

Disturbance can be described by the frequency (probability of a patch being disturbed), intensity (probability that a disturbance will spread to an adjacent patch), and severity (probability that additional disturbance in that patch is unlikely) (Turner and Bratton 1987, Turner and Dale 1991). Disturbance can be broadly classed either as a disturbance that crosses patches (e.g., wind throw, grazing, some fires) or is confined to a single patch type (e.g., pest outbreaks, spread of pathogens, some fires).

Patch Characteristics and Disturbance

Patch size and shape strongly influence the spread of disturbance. Smaller patches facilitate greater invasion of disturbance because of the increased amount of perimeter to area compared to larger patches. As a result, proportion of interior, or quality, habitat is reduced in smaller patches (Temple and Cary 1988). Disturbance from agricultural or urban development changes patches from a natural complexity to simplified shapes and smoothens contours (Krummel et al. 1987, O'Neill et al. 1988a).

Landscape Characteristics and Disturbance

The type of disturbance is important in understanding the influence of landscape heterogeneity on disturbance spread. Landscape heterogeneity either increases or has little effect on disturbances that cross patch type. For example, domestic livestock grazed and obtained energy in grasslands that were both highly disturbed and resilient in the barrier islands of Georgia (Turner and Bratton 1987). Livestock then rested and created disturbance that altered community structure in nearby forested regions. The heterogeneity of the landscape facilitated disturbance in the forested regions because of the spatial relationship of grassland to forested patches (Turner and Bratton 1987).

Landscape heterogeneity retards the spread of disturbance when it cannot cross patch types. In large, relatively undisturbed regions, disturbance is confined to small patches and has little influence on the large patches in the landscape. As the intensity of disturbance increases, the patches that are disturbed become closer together and eventually coalesce, thus increasing the connectivity and the spread of disturbance through corridors. Size of undisturbed patches decreases, increasing the perimeter:area ratios and further promoting the spread of disturbance.

Fire in the Snake River Plain— Landscape Perspective

Sagebrush (*Artemisia* spp.) and saltbush (*Atriplex* spp.) shrubsteppe regions dominated the Snake River plains before the mid-1800s (e.g., Frémont 1845, Yensen 1980, Young 1989). The landscape consisted of shrub patches that often covered hundreds of thousands of contiguous hectares. Frequency of fire strikes was likely similar to today; however, large patches of shrubs were resistant to burning and fire disturbance primarily created small patches of sites for regeneration in the landscape. Therefore, the landscape consisted of a mosaic of large shrub patches intermixed with smaller, disturbed patches in various states of shrub regeneration (Young et al. 1979, Anderson and Holte 1981). Regeneration was relatively rapid because of the low frequency of patch reburning and the close proximity of a shrub patch to supply seed.

Exotic annuals that were highly flammable became part of the system around the turn of the century (Yensen 1980) and increased the intensity of the disturbance. With increased intensity and larger burn areas, the patch size of shrubs decreased, and the proportion of perimeter to area increased. Fragmentation of shrub patches accelerated the invasion of exotics into the remaining shrub patches. In addition, both the area of disturbed patches and their connectivity increased to further promote the spread of fire. In a positive feedback mechanism, smaller patches of shrubs, higher rates of invasion, and larger patches and connectivity of exotic annual patches increased the size of fires. Although frequency of fire ignition was the same, the intensity increased and the likelihood of a patch burning changed from approximately 70–100 years between fires (Piemeisel 1951, Wright and Bailey 1982) to <10 years (Young and Evans 1978, Whisenant 1990).

LANDSCAPES AND WILDLIFE

Our understanding of the population dynamics of wildlife often depends on the spatial arrangement of landscapes (Fahrig 1991). Distances that individual animals must move to obtain food, hide from predators, or disperse into new patches are influenced by the mosaic of habitats within the landscape. At a level more relevant to management, rates of colonization and extinction, and persistence of populations are strongly affected by the landscape (Quinn and Hastings 1987, Opdam 1991, Pulliam et al. 1992).

Patch Characteristics and Wildlife

Patch size and shape influence species dynamics at both individual and population scales. The greater intensity of ecological processes at the patch edge, such as predation, parasitism, or invasion of disease, create a gradient of habitat quality within the patch. As a consequence, individual productivity is higher in the patch interior than edge for species that depend on resources within the patch (Temple and Cary 1988). Population productivity in smaller patches is lower compared to large patches because of high perimeter:area ratios and low quantity of interior habitats. The risk of population extinction to stochastic events is more likely in small than in large patches (Burkey 1989). Determining the minimum patch size is a critical goal of conservation biology for maintaining biodiversity and populations of threatened and endangered species (Shaffer 1981, Samson et al. 1985, Caswell and Cohen 1993). However, recent models suggest that current estimates vastly underestimate minimum areas needed for population survival and that spatial scale of conservation areas might be as large as a factor of 10^{3-4} times the lifetime ranges of individuals (May 1994).

Landscape Characteristics and Wildlife

The influence of habitat fragmentation, or landscape heterogeneity, on populations of species is related to the species' affinity to the fragmented resource. Species adversely affected often have narrow requirements, strong dependence on the fragmented resource (Urban and Shugart 1986, Opdam 1991, Rolstad 1991), and include many rare and endangered species. In contrast, benefiting species have high dispersal or pioneering capabilities, generalist requirements, and are relatively common (Fahrig and Paloheimo 1988, Burkey 1989, Palmer 1992).

Dispersal and reproductive rates of species and their degree of specialization and dependence on the fragmented resource (Urban and Shugart 1986, Fahrig and Paloheimo 1988), in context with patch size and interpatch distance (connectivity) of the habitats (Fahrig and Merriam 1985, Gardner et al. 1987, Burkey 1989, Wu et al. 1993) dictate benefits or losses because of habitat fragmentation. As fragmentation increases and more interior habitat is exposed to edge, both the quality of habitat and consequent species reproductive rates decrease (Temple and Cary 1988) or predation and parasitism increase (Johnson and Temple 1990). Lower productivity within the patch increases the likelihood of population extinction (Palmer 1992). With increasing fragmentation, the productivity within the patch becomes insufficient to maintain the population and the patch changes from a source to a sink. Maintenance or reestablishment of populations in highly fragmented landscapes depends on the species dispersal characteristics relative to patch dispersion in the landscape (Temple and Cary 1988).

Changes in the distribution of individual species caused by altered landscape structure subsequently changes community structure (Hansson and Angelstam 1991, Root 1993). Highest species richness should be found in landscapes that have an intermediate rate of disturbance (Horn 1975, Connell

1978, Caswell and Cohen 1993). In landscapes with little fragmentation or disturbance, communities should be composed of specialist species that have strong habitat requirements (Palmer 1992). In contrast, communities in highly fragmented or disturbed regions should be composed primarily of species capable of adapting to rapid change and highly variable environments, or have few habitat affinities and exhibit commonness (Southwood 1977). The subdivided habitat patches in highly fragmented landscapes are occupied by small, local populations that are absent most of the time because of extinction caused by stochastic events (Quinn and Hastings 1987, Burkey 1989, Palmer 1992). At some intermediate level of fragmentation, species richness will be highest because patches will be occupied both by colonizing and resident species (Horn 1975, Connell 1978, Caswell and Cohen 1993).

Breeding Birds in Shrubsteppe—a Landscape Perspective

We determined both local and landscape characteristics of habitats surrounding sites occupied by breeding species of shrub-obligate passerine birds in shrubsteppe habitats of southwestern Idaho. Shrub-obligate species, which included Brewer's sparrow (*Spizella brewerii*), a species in significant decline (Peterjohn and Sauer 1993), were highly sensitive to local vegetation characteristics as well as to habitat fragmentation and landscape heterogeneity (Knick and Rotenberry 1995). Shrub fragments larger than individual territory size influenced the presence (Fig. 1) and temporal persistence of shrub-obligate species. In contrast, breeding passerine birds typical of grasslands or adapted to disturbed environments were not sensitive to landscape attributes of the environment in our study (Knick and Rotenberry 1995).

We demonstrated the relationship between the pattern of landscape features and distribution of breeding birds in shrubsteppe habitats. However, we do not know the process(es) that influence these species' response to the habitat. Birds in fragmented habitats have exhibited lower reproductive rates, higher predation rates, and higher rates of parasitism (Wilcove 1985, Yahner and Scott 1988, Johnson and Temple 1990, Robinson 1992, Porneluzi et al. 1993, Paton 1994) and these mechanisms all may operate in shrubsteppe landscapes.

MANAGEMENT RECOMMENDATIONS

Natural disturbance and human landuse both interact with the spatial characteristics of landscapes. In addition, the spatial characteristics of landscapes have a strong influence on the distribution and abundance of wildlife. Therefore, analyses of landscape indices associated with fragmentation and disturbance may provide an understanding of factors that create the pattern (Turner and Gardner 1991) and the subsequent response of wildlife. Ecological consequences of fragmentation and disturbance can be identified not only for community structure, population

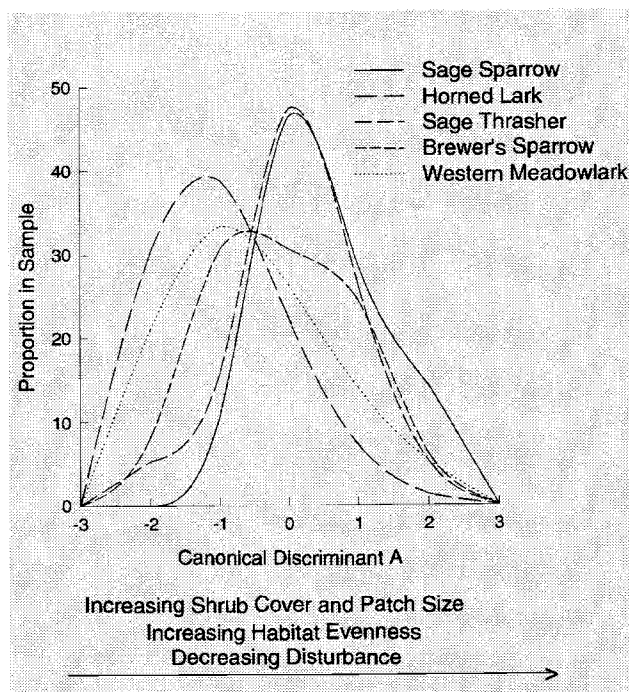


Fig. 1. First axis of a discriminant function analysis to separate species of breeding passerine birds in shrubsteppe habitats along a gradient of local vegetation and landscape characteristics. The first axis represents a gradient of increasing shrub cover, shrub patch size, and habitat evenness, and decreasing disturbance. Separation of species along the gradient was significant (Wilks' Lambda = 0.79, $P = 0.0004$).

response, and biodiversity, but also for predicting rates of future disturbance in development of habitat management plans for wildlife.

Disturbance that fragments habitats often has detrimental effects on biological diversity, the distribution and productivity of individual species, and subsequent community structure (Soulé 1986, 1987; Saunders et al. 1991). Therefore, understanding the effect of habitat fragmentation on biological diversity is of immediate concern because of current rates of disturbance and the intensity of land use on existing resources (Wilson 1988, Groom and Schumaker 1993). Although areas of fragmented habitats can be determined, minimum patch sizes required for conservation of many wildlife species still are not well known or may be largely underestimated (May 1994).

Geographical Information Systems now are routinely used by most resource agencies and spatial data sets are accumulating rapidly. Techniques to analyze landscape components, such as patch size and landscape heterogeneity, also are available. By understanding how landscape components influence the spread of disturbance, and animal distribution, movements, and population dynamics, managers can develop strategies for landscape management at the ecosystem level.

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ADAPTING TO CHANGE IN COMMODITY RANCHING

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Abstract: Cattle ranchers of the western United States tend to have a belief that their present economic resources and social attitudes should be permanent and endure despite changes in the economy and society as a whole. Ranchers' use of public lands as part of their grazing resource has led to confrontations between ranchers, who view themselves as traditional users, and the government and environmentalists, who view themselves as carrying out society's desired management of public lands. What all ranchers, and especially those using public lands, need to realize is that change is universal, constant, and rarely enjoyable. Any organism, species, family, or organization that endures is adaptable to changing conditions and attitudes. Secondly, to be sustainable in the long term, ranchers will need to view cattle not as their main product and interest, but rather, as a by-product of a healthy and diverse ecosystem. By concentrating their management and decision making on striving towards a more healthy and diverse ecosystem, ranchers will not only be economically more sustainable but socially and ecologically more viable as well. Lastly, in order to accomplish their ecosystem goals, ranchers will have to make better resource management decisions that solve resource problems rather than symptoms.

Key words: change, economic sustainability, public lands grazing, ranching, sustainable rangeland use.

Those who manage western rangelands are in the midst of a time of great change. The changes that we see going on now, whereas new and difficult, are not unusual in that the West is still an evolving place. Who is going to live here, what will they derive from the land, can they do it on a sustainable basis, are ongoing questions.

The fact that many ranchers, as current and historical users of public rangelands in the West, are finding themselves at risk of being displaced is not an unusual thing out here. The Indians, trappers, open-range sheep ranchers, 320-acre dry-land desert farmers, gold dredge operators, and blacksmiths can all testify to that. We must accept the fact that change is normal, constant, and ongoing. And that whether a change is social, economic, or ecological in nature does not change the severity or duration of the change.

Peter Senge (1990:154) in his book, *The Fifth Discipline*, says that "current reality itself is, for many of us, the enemy. We fight against what is. We are not so much drawn to what we want to create as we are repelled by what we have, from our current reality. This leads us to the mistaken belief that fundamental change **requires** a threat to survival. This crisis theory of change is remarkably widespread." Senge goes on to say that in his workshops he will ask participants how many **believe** people and organizations change, fundamentally, only when there is a crisis. "Reliably," he says, "75 to 90 percent of the hands go up. Then I ask people to consider a life where everything is exactly the way they would like—there are absolutely no problems of any sort in work, personally, professionally, in their relationships, or their community. Then I ask, 'What is the first thing you would seek if you had a life of absolutely no problems?' The answer, overwhelmingly, is 'change—to create something new.'" It turns out that we both fear and seek change.

Senge (1990) adds that resistance to change is neither capricious nor mysterious. It almost always arises from threats to traditional norms and ways of doing things. What we have to realize is that problems of one sort or another will always be with us.

Paul Hawkin (1987:37-38), in his book *Growing a Business*, says, "Understand in the beginning that you will always have problems. It is there that the opportunities lie. A problem is an opportunity in drag. A mess is a pile of opportunities in drag. Stay in the mess. Love that mess. It's the only way to straighten it out."

And Tom Peters (1987:45) in the book *Thriving on Chaos* writes, "There is no prescription which says it outright, yet it lurks on every page. The world has not just 'turned upside down'. It is turning in every which way at an accelerating pace."

To meet the demands of the fast-changing competitive scene, we must simply learn to love change as much as we have hated it in the past.

Learn to love change—you see learning to love change is a very difficult concept for me to accept. I am the fourth generation of our family to ranch on the same land. I take a great deal of pleasure in knowing that many of the same things that provided satisfaction to my grandfather are fulfilling to me as well. My ties to the land run deep. My conception of change means that I would have to abandon many of the things from which I derive satisfaction.

But Ed Simon (cited in Senge 1990:349), the President and chief operating officer of Herman Miller, a furniture manufacturer, disagrees. "Embracing change does not mean abandoning a core of values and precepts. We must balance our desire for continuity with our desire to be creative. We must learn how to not abandon that core, while simultaneously letting go of past ways of doing things. We must learn to operate in a continual learning mode, creating change."

To those of us in this room the relationship between grazing animals, land, and people is a rich and complex one. What Simon is saying is that we should not get too hung up on the color or species of our livestock, the kind of salt blocks we use or the brand of pickup we drive. What we should hold dear is the central idea that man, land, and animals can coexist in a healthy and diverse environment. Those are the core values we must not abandon.

Knowing that change is always with us, what must we do as range managers to ensure our sustainability?

First, we must have a vision of what we are striving for. This vision must describe the quality of life we seek, the kinds of benefits and products we wish to derive, and the kind of landscape that will sustain the production of those products.

With a vision to strive for, that is shared by all people in an organization, we can make sound decisions to bring it about and communicate in a way that keeps us on track. Without that vision we make decisions but we don't know where they are leading us. It is like going on a trip with no destination in mind.

Second, we must continually plan, monitor, and replan. We must learn to think about the future not just as a point in time but as a destination we are trying to achieve with our quality of life, our products, and our landscapes. With that destination in mind we can then work backwards to the present so that we know what we should be doing when, and if, our monitoring discovers we are off course; we can correct it.

Thirdly, we must realize that change is not always gradual. Sometimes Mount St. Helens erupts. Or a judge decides cattle should come off the national forests 2 months early. Some years it doesn't rain and sometimes the bottom falls out of the cattle market. Sudden detrimental change is what is life threatening to any organism or organization. The ability to survive great changes is what distinguishes the organizations that last for generations from those that are merely shooting stars.

Peter Senge (1990:288) cites a study by Royal Dutch Shell on corporate longevity that found the long-term survivors were the ones with the "ability to continually run 'experiments in the margin' to continually explore new business possibilities."

Examples of experiments we can do on our own rangeland are ways to increase the production on deeded land so that we can depend less on public lands. Ways that we can decrease our dependence on fossil fuels so that we are immune to increases in energy prices. Experiments with different ruminants to increase our marketing diversity. These are just a few of thousands of possible questions that we should be finding answers to.

Finding new ways to graze well, to use less fossil fuel, to produce healthier beef, to create more diversity on the land, actually deepens our commitment to the land and our ancestors. They did not arrive here with perfect knowledge of how to make a living from the land. The very fact that they came West proved they were experimenters. And the

experiment continues and will always continue. What is different now is that we must change the way we make decisions.

The type of decision making that settles a continent and creates towns where there was once wilderness is not necessarily the decision making that allows those things to endure in a healthy environment. Just as the type of actions that win wars cannot ensure peace, the decisions that create rural communities may not be what sustain them.

How do we make good decisions? We test them. That is the fourth thing we have to do to ensure sustainability. Allan Savory (1988:270) has created what are called 'Testing Guidelines' to ensure the quality of resource decisions. According to Savory (1988), we must test each of our decisions in several ways.

1. How does this decision affect the whole ecosystem? Will this decision lead us toward or away from our landscape vision?
2. Is this addressing the weak link in our operation? Should we be spending all this money spraying grasshoppers or would we be better off doing a better job of planning our grazing so that our plants were healthier and more productive?
3. Are we addressing the cause or the effect? Should we spend more and more money on scours treatments or should we develop a way to calve in cleaner areas or at a drier time of year?
4. Marginal reaction—does spending money on a new horse benefit the operation more than building more fences to better control livestock? We have to compare on paper the best place for our limited dollars to go.
5. The source and use of energy. Does this action require constant inputs of fossil energy or will it be a one-time occurrence? Can this action be accomplished with renewable sources of energy?
6. How does it affect your desired society and culture? Does building a drive-in movie theater in the lower meadow, while improving the profitability of your operation, really lead you towards the kind of life you desire?

Those are 6 questions we must ask ourselves each time we make a major decision on our operation. That is a far cry from our traditional decision-making process: will it cash flow, will our banker let us, and what will the neighbors think?

But that kind of traditional decision making has nothing to do with accomplishing our vision. To repeat Senge (1990:154), "we must be drawn towards what we want to create, not merely fight against what is."

We have to load our brains with new software to survive in the future. The software we have no longer works well enough. We must prove ourselves capable of adapting in order to be sustainable.

In closing, we must have a vision of what we are striving for; we must continually plan, monitor, and replan; we must be prepared for sudden change and, lastly, we must test

our decisions to ensure they really will lead us to where we want to go.

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ECOSYSTEM MANAGEMENT ON PUBLIC LANDS: AN ENVIRONMENTAL PERSPECTIVE

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Abstract: As federal land-management agencies move, often kicking and screaming, away from managing primarily for extractive commodities such as timber, minerals, and forage for livestock and towards ecosystem management, many are struggling to define the term "ecosystem management." Scientists and environmentalists hear "ecosystem management" and think "ecosystem" while natural resource managers and the industries profiting from commodity extraction think "management." Conservation biologists and environmentalists also have been struggling to define the term. Slowly they are arriving at a consensus (recently discussed by R. E. Grumbine in *Conservation Biology*) that the primary goal of ecosystem management is to protect "native ecosystem integrity over the long-term" This includes: (1) maintaining viable populations of all native species, (2) maintaining or restoring native ecosystem types across their natural range of variation, (3) maintaining the evolutionary potential of species and ecosystems, and (5) accommodating human use and occupancy within these constraints. Limits to management should be set by the natural biological and ecological properties of ecosystems, not by traditional "goods and services" for people. I will discuss how these goals apply to arid and semi-arid grassland and shrub-steppe ecosystems of the Intermountain West.

Key words: arid and semi-arid grasslands, ecosystem management, shrub-steppe.

FISH HABITAT NEEDS IN RANGELAND AQUATIC SYSTEMS

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Abstract: Rangeland systems are unique ecosystems supporting diverse aquatic communities. In stream systems these aquatic communities are linked to terrestrial systems at the riparian interface. Fish habitat is influenced and to a large degree created by conditions in riparian and upslope areas. Important considerations for fish needs in these systems are optimal temperature regimes, good water quality, the presence of suitable substrates for spawning, the presence of high-quality cover and rearing habitat, and an adequate food supply. I compare and contrast a number of aquatic systems in rangelands and suggest management strategies for the protection of fish habitat in these systems.

Key words: aquatic ecosystems, fish habitat, rangeland ecosystems, riparian areas.

MANAGING EXOTIC VERSUS NATIVE FLORA AND FAUNA

WHAT IS NATIVE?

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Abstract: Recent interest in the use of native species for rangeland restoration has emphasized how little we know about intraspecific variation in most range species. I discuss the different types of variation that occur within a species and, more importantly, why we should care that this variation exists. Although for most range species we have no information on the degree to which populations are locally adapted, it is often assumed that this type of "home team" advantage exists. I discuss the potential consequences of this assumption and how a plant's breeding system can affect the likelihood that adaptation occurs. I also examine the possibility that it often may be better to use a noninvasive exotic species in a restoration effort than inappropriate germplasm of a native species.

Key words: breeding system, gene flow, genetic drift, genetic pollution, intraspecific variation, local adaptation, phenotypic and genetic variation, selection.

There has been a recent surge of interest in the patterns, causes, and consequences of intraspecific variation for restoration projects in western rangelands. Although a fair amount of information is available on differences among species, much less information is available on variation within a species. Even for important range forage species, much of our information on intraspecific variation remains relatively anecdotal. As a result, current judgements as to what is native or what is "native enough" to use in the restoration of a particular site are often strongly influenced by preconceived notions rather than "hard" data.

PHENOTYPIC AND GENETIC VARIATION

In describing intraspecific variation, it is important to distinguish between phenotypic and genetic variation. Phenotypic variation is variation that can be quantified by physical measurements of the organism (phenotype). These measurements can range from parameters of plant phenology, such as flowering time, to allocation patterns, such as seed production or root:shoot ratios. Physiological traits such as photosynthetic rates or water-use efficiency are also phenotypic traits that often are of interest, although these data often are more difficult (and expensive) to obtain. As described in more detail below, the phenotype represents the interaction of a particular genotype and a particular environment. In a very real sense, the phenotype "emerges" from this interaction.

Although describing genetic variation as simply differences among genotypes or the frequency distribution of genotypes in a population is correct, it is not very informative or helpful to the resource manager. In general, the type of genetic variation that is of most interest to ecologists and restorationists is represented by variation in "quantitative" or "polygenic" traits. These quantitative traits often represent traits of ecological or adaptive significance such as growth rate, flowering time, etc. The phenotypic variation generated by genetic variation in polygenic traits represents the interactive and additive effects of many genes acting in concert. Phenotypic expression of polygenic variation usually takes the form of a fairly continuous frequency distribution of phenotypes. In contrast, variation in "major genes" often results in fairly discrete phenotypic classes. The classic example of this type of variation is Mendel's crossing experiments with garden peas. This type of variation is also quite common in flower color polymorphisms where there are discrete color classes (e.g., blue vs. white lupine flowers). For both polygenic and major gene traits it is often possible to ascribe adaptive significance to variation in genetic composition.

In contrast, "hidden" genetic variation, represented by variation in electrophoretic markers (e.g., allozymes) or DNA sequences, is usually considered "neutral" to selection. In other words, because variation in allozymes or DNA sequences usually have an undetectable effect on phenotypic expression, this type of variation is "invisible" to selection. The selective neutrality of this type of genetic variation makes it very useful for describing mating systems or evolutionary

processes such as genetic drift or gene flow. However, these types of genetic markers are usually (but not always) unhelpful in providing information on plant adaptation.

SELECTION AND LOCAL ADAPTATION

When considering issues of plant adaptation and evolution, an important concept that often is not appreciated is that the phenotype, and not the genotype, is the focus of natural (or artificial) selection. For example, in the development of a new crop variety, a plant breeder cannot select directly for a particular genotype. Rather, the breeder selects for a particular phenotypic value of a trait that she or he hopes represents a particular genotype and will "breed true" for that trait. The strength of this correspondence between trait phenotype and genotype is the heritability for that trait (Falconer 1989:163-166). The degree to which a trait is heritable is completely dependent on the interaction of genotypic variation and environmental variation. Certain traits that are highly heritable under one set of environmental conditions may exhibit low or zero heritability in another environment. This results from differences in the way the genotype and environment interact to "build" the phenotype (Lewontin 1974).

Whether they know it or not, managers interested in using germplasm that is locally adapted are interested in a particular type of genotype-by-environment interaction. In its local adaptation, the phenotypic trait of interest is some measure of plant "fitness" such as survival, growth, or reproduction. The particular genotype-by-environment interaction of interest is the situation where the local germplasm performs best (i.e., a "home team advantage"). Because it emerges from this interaction, local adaptation is a potentially changeable (even volatile) property. Local adaptation can disappear with changes in the environment, or in the genetic composition of a population, or both.

BREEDING SYSTEM, ADAPTATION, AND GENETIC DRIFT

The probability that selection can create a locally adapted population depends largely on the breeding system of the plant species in question. All else being equal, the probability for the development of locally adapted ecotypes is higher for inbreeding plants. Inbreeding decreases gene flow within and among populations. This reduction in gene flow lowers the probability that locally evolving "gene complexes" will be swamped by genes from nonadapted plants outside the local selective regime. Theoretical and empirical studies have found that even low rates of gene flow can effectively prevent selection from creating locally adapted populations. Management decisions as to allowable seed collection areas need to use the best available estimates of the degree of outcrossing in the species (or population) under management. For example, in outcrossing conifers, seed collection zones are fairly large (i.e., regional) whereas in a highly selfing

grass the proper collection area may be within a single hectare. This would be especially true if the grass population exists in some sort of specialized habitat (e.g., serpentine soils).

Although inbreeding can promote local adaptation, it also can facilitate population differentiation that results, not from selection, but from random processes (i.e., genetic drift). The clearest case of this type of nonadaptive differentiation occurs during genetic "bottlenecks" that may accompany the colonization of a new site. In this scenario, a particular genotype disperses into and colonizes, by chance, an open habitat. Because the colonist can self-pollinate and reproduce, a local patch of closely related (full sibs) plants develops that may be quite different genetically from the main population. An external observer, lacking knowledge about the past history of chance colonization, may erroneously conclude that this patch of plants is adapted to some local selective regime. The main point here is that very distinct genetic differences within and between populations do not always indicate the operation of selection (especially with inbreeders).

UNCONSCIOUS SELECTION DURING SEED COLLECTION AND INCREASE

Although more detailed information and guidelines on seed collection protocols can be found in Knapp and Rice (1994), the primary goal of field collections from a population should be to sample the whole population. Although this may sound simple, achieving this goal can be very difficult. Often collections are made only once from a population and thus may miss genotypes setting seed either before or after the collection date. For ease of collection, often only a small area of the population is intensively sampled. There is also a tendency to collect from larger, more obvious plants and to collect from easily accessible areas (e.g., flat terrain). Taken together, these sampling biases may significantly shift the genetic composition of the collection population relative to the field population. Shifts in both the mean and the variance (i.e., diversity) in the genotypic distribution of the population often can result. These genetic shifts are exacerbated by similar instances of unconscious selection that may occur within the agronomic environment of seed increase operations. Because of the economic pressure to mechanize and increase harvest efficiency, there is often the possibility for selective harvesting of only a subset of the planted population. Harvesting on a single day and at a single height, although more agronomically efficient, may result in a seed collection with low variation in both flowering time and plant stature. In other words, late-flowering, short-stature genotypes may not be harvested even though the genetic resources that they represent may be crucial to the long-term survival of the population when planted back into the "wild". The economics of seed production, where maximization of seed production per unit area is often the primary goal, may also result in major genetic shifts in the population. Under

benign agronomic conditions (e.g., plenty of water and nutrients), genotypes that grow rapidly when resources are abundant may produce a disproportionately large number of seeds. The resulting seed mixture will then be dominated by these "agronomic" genotypes that may perform poorly when planted back into the "wild" where resources may be in short supply. In this case, unconscious selection has acted to reduce the frequency of stress-tolerant genotypes that may be important for population persistence during "lean" years.

GENETIC CONTAMINATION OR "GENETIC POLLUTION"

As might be expected, the term genetic pollution often elicits a strong negative response, even when the precise meaning of the term is unclear. Genetic pollution can be thought of as a maladaptive shift in the genetic composition of a population. This shift is brought about by misguided management activities where inappropriate (in an adaptive sense) genotypes are introduced in sufficient numbers to "swamp" the resident population. The resident population is thought to represent a kind of genetic memory of past selective events; events that may occur very infrequently. In the scenario usually presented, the introduced genotypes grow rapidly for a few generations under relatively benign conditions and effectively reduce or eliminate the resident genotypes by competition or hybridization. An infrequent but severe selective event characteristic of the site then occurs (e.g., 17-year locusts or 50-year droughts) that completely eliminates the nonadapted introduced genotypes. As a result, both the resident and the introduced population are now gone. Although direct evidence for this type of genetic pollution scenario is scarce, data from provenance testing in conifers are suggestive. Millar and Libby (1989) cite an example from common garden studies of Douglas-fir (*Pseudotsuga menziesii*) where fast-growing coastal ecotypes were killed during infrequent bouts of low temperatures. The potential detrimental effects of genetic pollution when coupled with the irreversible nature of the process (it's very difficult to "weed out" genes) might argue for the use of noninvasive exotic species at a particular site until more in-

formation on the resident population is available. In any case, the fact that we cannot, at this point, cite many direct studies of genetic pollution does not mean that the phenomenon is unimportant. As this summary may indicate, many of the genetic questions relevant to restoration projects are not going to have easy answers. In fact, many of the most important questions revolve around genetic processes that are the most difficult to measure or study, such as gene flow rates or the importance of genetic pollution in long-term adaptation. Although precise measurements of such phenomena may not be forthcoming in the near future (if ever), we can use more easily obtained indices of genetic structure and process to make informed management decisions. For example, as noted above, even rough estimates of the breeding system of a plant can be of enormous help in deciding probable spatial scales of adaptation. In sum, deciding "what is native" will require (1) an appreciation for the importance of intraspecific variation, (2) the proper use of the best available (although imperfect) estimates of genetic parameters, (3) an understanding of the many trade-offs between genetic diversity and local adaptation, and (4) a willingness to use imprecise indices to make decisions that may have long-term and irreversible consequences. In other words, "business as usual" for a natural resource manager.

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VEGETATION MANAGEMENT AND WEED INVASION

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Abstract. The encroachment of alien weeds on western rangelands is one of the most perilous and perhaps least recognized problems facing land managers today. Oregon rangelands are threatened from ever-increasing numbers and distribution of exotic weeds. Weeds threaten Oregon's economy and environmental quality by reducing livestock forage, wildlife habitat, watershed potential, recreational opportunities, and property values. Weeds become established because they have evolved life strategies that allow them to capture resources (light, water, nutrients, and space) in sufficient quantities to successfully complete their life cycles. A knowledge of weeds is needed to learn how to exploit weak links in their life cycles for control using integrated methods of herbicide application, biological agents, and mechanical techniques. However, control of weeds without replacement and maintenance of more desirable plant communities can only produce short-term gain, and retrogressive succession will result in reinvasion of weeds.

Key words: control, exotics, management, plant communities, weeds.

Alien weed invasion is a major issue facing rangeland managers in the Pacific Northwest. Weeds affect natural resource management whether the issues are the protection of an endangered species, watershed management, soil erosion, or minimizing the impact of concentrated human activity.

The development of a sustainable weed management program requires an understanding of complex biological processes that influence the relationship between alien weed species and indigenous plant communities. Unfortunately, communication regarding this issue has been clouded by inconsistencies in successional theory (Smith 1988, Laycock 1991, Borman and Pyke 1994), resulting in a variety of viewpoints about the magnitude of the problem, the susceptibility of rangeland communities to weed invasion, and methods for managing weed infested rangelands. These views range from a generic belief that "climax" communities are closed communities and are not susceptible to weed invasion to an equally disturbing view that alien weeds invade regardless of management.

Plant invasion occurs when a species is introduced into a plant community and increases its population status from one of being rare to a more common occurrence (Crawley 1987). The process of invasion requires 3 concurrent events: (1) the community must be susceptible to invasion, (2) a compatible weed source must be present, and (3) available safe sites must exist within the community to provide the opportunity for invasion.

The susceptibility of a community to invasion is determined by the allocation of community resources among plants. The community resource pool (light, water, nutrients, and space) is finite and is used at specific times and in specific amounts by the plants within the community. The process of resource allocation is fluid, reflecting adjustments in population dynamics and species performance. Conse-

quently, the capacity of the existing plant community to use the available resources defines the availability of unused resources.

The structure of the biotic community determines the consistency and capacity of resource use. Communities that lack the structure (i.e., niche occupation) necessary to capture available resources or that are functioning below their capacity have an increased risk of plant invasion. An example of an inadequate community structure would include a community dominated by shallow-rooted species that lacks the capacity to capture resources located deeper in the soil profile. Similarly, a plant community dominated by decadent adults lacks the capacity to respond to newly available resources in a way similar to a fully functioning population with a complete complement of age classes. In either case the resource pool of the community is underused and the potential exists for a new plant species to exploit these unused resources.

Numerous factors influence the pattern of resource allocation within a community. Abiotic perturbations can have a direct effect on the timing and size of the available resource pool. Wet and dry climatic cycles, fire, or annual fluctuations in moisture and temperature patterns provide examples of abiotic factors that can modify both long- and short-term resource availability. Biotic factors such as grazing, natural enemies, and plant death also alter nutrient cycling and resource availability.

The opportunity for weed invasion refers to the events and conditions necessary for successful plant establishment. Obviously a weed source is required for successful weed introduction. However, beyond this obvious statement, a resource manager must have an understanding of the location, mode, and timing of the most likely sources of weed introduction. For example, a species having mechanical appendages for attaching to animals, such as cheatgrass

(*Bromus tectorum*), poses a much different strategy for introduction than a plant that drops its seed close to a parent, such as yellow starthistle (*Centaurea solstitialis*). In the former case, the rate of introduction is rapid, whereas the latter case results in a slower advancing front. Moreover, weeds with multiple methods of dispersal, such as leafy spurge (*Euphorbia esula*), pose a different threat of invasion than a species with a single method of reproduction.

The presence of a safe site forms the final component needed for successful plant invasion. Resource managers have historically recognized the linkage between weed introductions and obvious sources of community disturbance. However, we have been less aware of the importance of the timing, size, intensity, and duration of disturbances to plant community stability. Disturbances (large and small) are a natural part of all communities and play a vital role in providing safe sites for the establishment of population recruits (i.e., seedlings) and long-term community stability (Pickett and White 1985:3–10; Harper 1977:111–150, 705–778).

Successful plant establishment (alien or indigenous) requires that the plant occupy a safe site that is compatible with its requirements for survival. In saying this there is an inherent recognition that successful plant invasion means that a portion of the population recruits that would normally be occupying safe sites are, at least in part, being replaced by the recruits of the introduced species.

This observation raises a point regarding safe sites and the species that are vying to occupy them. Safe sites are entry points for plant invasion. When they are occupied by indigenous population recruits they serve to maintain the existing community patterns of resource capture, species performance, and structure. By contrast, safe-site occupation by an invading plant population will tend to modify community structure and bring about adjustments in resource capture and species performance.

In the Pacific Northwest, some of the more successful weed species tend to preempt safe-site occupation by indigenous species through early growth characteristics, resource capture, or a growth advantage that gives the introduced species access to new resources before its competitors. Species such as diffuse knapweed (*C. diffusa*) will tend to saturate

available safe sites through the fall, winter, and spring, establishing a hierarchy of seedling and juvenile size classes that use community resources as they become available.

Recognition of the process of plant invasion is critical to the development of sustainable weed management programs. Resource managers need to take a proactive role by managing community structure and function for efficient resource capture. Prevention programs need to be used to minimize safe site occupation by invading species and promote safe-site occupation by desirable population recruits. Finally, containment and control programs must include revegetation efforts that establish species with plant strategies and population traits that promote complete resource use and safe-site occupation. For example, selecting plants that offer contrasting above- and below-ground patterns of growth will tend to maximize community structure, enhance resource capture, and reduce the potential for weed invasion.

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RANGELAND SEEDINGS AND PLANTINGS: EXOTICS OR NATIVES?

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Abstract: Rangeland degradation commonly is caused by ≥ 1 factor, including cultivation and abandonment of land, establishment of competitive exotic annuals, fire suppression, improper livestock management, and subtle changes in climate. The natural changes in plant communities result in fluctuations among stable communities that can occupy that land. Simple removal of disturbances may not allow former communities to recover. Lands may degrade to such an extent that former communities may no longer be capable of existing on these sites. Revegetation objectives can range from a restoration of the native communities to a replacement of the current community with a set of plants not native to that site. In revegetation, diverse mixtures of species and plant life forms are encouraged because they prevent outbreaks of insects, and they provide habitats for a diversity of animals. Careful consideration should be made before using highly competitive exotic plants for revegetation that can spread quickly into surrounding native vegetation. I discuss new techniques in seed preparation and plant selection to increase native plant establishment. Native seed availability is often a problem, but with adequate planning the economic risk to the seed growers can be lowered, availability of seed will increase, and the cost of native seed should decrease. Native plant selections that can be used across many environmental conditions are compared to native genotypes specific to a site. I present general rules for collecting and increasing site-specific seed. In the future, weather models may help detect years when revegetation will succeed.

Key words: arid, competition, exotic, genetics, introduced, native, rangeland, reclamation, rehabilitation, restoration, revegetation, semiarid, seed collection.

Species composition and structural diversity of plant communities vary considerably over geological time scales largely because of fluctuations in global climates. In western North America, several cycles between arid and mesic vegetation have occurred in the last 40,000 years (e.g., Betancourt et al. 1990); however, human-induced changes were pronounced during the last 150 years. The major factors that contributed to rangeland degradation included cultivation and abandonment of arid and semiarid lands (Atheam 1986:85–86), establishment of adapted exotic annual plants, and shorter fire cycles on some sites, but on other sites fire suppression has led to an excessive buildup of fuel and changes in plant communities (D'Antonio and Vitousek 1992), overgrazing and improper season of use by livestock (Young and Sparks 1985:231–234, Elmore and Kauffman 1994), and subtle changes in climate possibly because of a human-induced rise in CO₂ or to a depletion in the ozone layer (Roundy and Call 1988, Archer 1994, Miller et al. 1994, Pieper 1994).

The degradation of rangelands was recognized in the early 1900s and scientists attempted to find plants to revegetate these lands; however, early attempts often failed because most of the available species for seeding lands were adapted to humid, not semiarid environments (Stoddart et al. 1975:474). In searching for species to revegetate degraded rangelands, the choice of native or introduced plants has been debated for >90 years (Kennedy and Doten 1901 cited in Stoddart et al. 1975:474). Out of this search, several introduced species were recommended as forage plants on a wide range of soils and climates (Kilcher 1969). Crested wheat-

grass (*Agropyron cristatum* and *A. desertorum*) and Lehmann lovegrass (*Eragrostis lehmanniana*) gained wide acceptance during this time in western North America because of their high seed production, viability, germinability, seedling drought tolerance, and grazing tolerance (Johnson, D. 1986; Anable et al. 1992).

The public began to enjoy rangelands for uses other than livestock production as people became more mobile and had greater recreational opportunities. These experiences led to a desire for lands to remain as natural as possible. Recently groups have taken sides on the issue of planting introduced species. They base their arguments on their different prioritized values (Johnson, K. 1986). Shifts in policy and in regulations regarding management of federal lands and of mined land reclamation reflect the public's concern over the continued use of introduced species and the loss of biodiversity. The U.S. Forest Service in the Pacific Northwest has a stated policy to "use local native plant species to meet management objectives" on national forests and grasslands (Memo. re: use of native and non-native plants on national forests and grasslands, from J. E. Lowe to Directors and Forest Supervisors, April 14, 1994). Introduced species can be used if there is a need to protect the site productivity of the resource, or as a nonpersistent aid to reestablishing natives, or if local native species are unavailable. The memo clearly says that the use of native plants is to become the standard practice in this region for revegetation. The Surface Mining Control and Reclamation Act of 1977 requires that a self-regenerating plant cover capable of natural succession be established after disturbance. Also, the concern that frag-

mented ecosystems are causing population declines in species (e.g., northern spotted owl [*Strix occidentalis*]) has lead U.S. federal land management agencies to abandon their former production-oriented management goals for objectives aimed at establishing or maintaining properly functioning ecosystems.

This paper is not intended to be a review of the pros and cons of introduced and native species. Rather, I intend to provide the reader with information to make informed decisions on whether to use native or introduced species for revegetation. There are times when the maintenance of the soil and of the surrounding ecosystem may favor the use of introduced species or mixtures of native and introduced species for revegetation of degraded lands, but caution must be used in the selection of the plant material so that ecosystem integrity is not lost. I review the literature to illustrate that native plants, with appropriate techniques and management, can revegetate rangelands, thus providing the flora that co-evolved with the existing climate, soils, and fauna. I present information on succession and human-induced stable states that influence revegetation decisions. I discuss the decisions managers will face regarding the use of native or introduced species for improving degraded rangelands, and discuss some cautions regarding aggressive species. Should a manager decide to seed natives, availability of seed may become an issue; I address this and compare choices of using a generalist or specialist genotype. I end with some considerations for lowering the risk of native plant failures.

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SUCCESSION AND HUMAN-INDUCED STABLE STATES

Clements (1916) developed a linear, bidirectional view of the plant successional process in which communities retrogress away from a climatic climax when disturbance occurs and progress toward the climax community when disturbance is removed. Not long after its development, rangeland ecologists began using it to evaluate grazed lands in the U.S. (Sampson 1917, 1919). The development of ecological condition classes for rangelands also incorporated this linear view of succession (Dyksterhuis 1949, 1958), leading to the acceptance of this model for evaluation of rangeland condition throughout much of the world (Heady 1975:9, Stoddart et al. 1975:187-194, Holechek et al. 1989:165-170) with some recent modifications of terminology (Range Invent. Stand. Comm. 1983).

Opposition to this accepted view was provided by those that did not find a systematic order to plant community development, but based their views on an individualist approach

(e.g., Gleason 1926, Egler 1952, McIntosh 1967). Alternative explanations for successional trajectories based on this approach were developed between 1970 and 1990 (e.g., Connell and Slayter 1977, Noble and Slayter 1980, Huston and Smith 1987). Westoby et al. (1989) documented the problem with the classical rangeland view of succession and posed an alternative view based on state-and-transition models. States are semi-stable communities that develop on a site depending on the timing, intensity, and severity of disturbances. Transitions are the changes in plant community composition from one state to another. Most transitions are reversible through natural climatic cycles (e.g., drought to wet years) or by the occurrence or removal of the disturbance (e.g., fire or livestock). Yet, occasionally a transition crosses a threshold that is difficult, if not impossible, to reverse (Friedel 1991). Some thresholds may require changes in regional climate for reversals to occur (Tausch et al. 1993). Thresholds related to changes in the physical or chemical properties of the ecosystem, such as soil loss, or a drop in the water table because of channel cutting of steams, may never reverse and result in land that may now support an entirely different plant community (Friedel 1991). This threshold would equate to the "threshold of rangeland health" (Nat. Res. Council. 1994) or to the Site Conservation Threshold (Task Group on Unity in Concepts and Terminology 1991) recently described in an attempt to overhaul rangeland inventory and monitoring techniques.

Rangelands approaching this threshold may no longer have the necessary components to recover because of losses of seed sources, granivores to disperse and bury seeds, or safe sites for establishment of seedlings. The classical view of succession states that merely removing the disturbance mechanism will allow succession to proceed toward a later seral community, but Daubenmire (1970) described 2 zooclimaxes for 2 grazing-induced communities in the Columbia Basin, cheatgrass (*Bromus tectorum*) or Kentucky bluegrass (*Poa pratensis*), that did not recover after removal of grazing. Others noted similar results elsewhere (Holmgren 1976 cited in Roundy and Call 1988, West et al. 1984).

Revegetation often attempts to bridge these transitions or thresholds so that recovery can occur. Revegetation during the 1930s focused on stabilizing eroding soils with little concern whether plants were native or introduced. When revegetated species are grazing-tolerant exotics and are strong competitors, natives only rarely establish within revegetated areas (Marlette and Anderson 1986, Chambers and Norton 1993). These competitive exotic species have created another human-induced stable state and if a threshold such as changes in soil physical or chemical properties has been crossed it will be difficult to reverse (Anable et al. 1992). One should use caution if considering revegetating with a competitive exotic when the native community at the site retains the potential to recover. Advantages gained by seeding a competitive exotic may carry tradeoffs such as reductions in native faunal components (discussed later).

IMPROVING DEGRADED LANDS: CHOICES AT THE CROSSROAD

Until the 1970s, most rangeland revegetation as a science was largely an extension of agronomic forage crops research geared toward establishing grasses as monocultures or simple mixtures on disturbed lands that would later be grazed by livestock. After passage of the Surface Mining Control and Reclamation Act of 1977 with its call for restoring diversity to the land, attempts were made to seed a wider variety of plant species and life forms. Our lack of understanding of the ecological processes and mechanisms that form plant communities often leads to revegetation and restoration failures (Jordan et al. 1987, Archer and Pyke 1991, Call and Roundy 1991, Pyke and Archer 1991). The decision process that the land manager must undergo to revegetate land largely remains the same and is presented in detail elsewhere (Redente and DePuit 1988, Roundy and Call 1988, Vallentine 1989); however, questions to consider during this decision process may influence the use of native or introduced species.

The decision process begins with site considerations. A thorough evaluation of the site should be conducted to learn what components of the plant community still exist on the site and what caused the site degradation. This evaluation should consider traditional measures like precipitation zone, soil classifications, evidence of active soil erosion, topography, and current plant species composition, but ideally it should also include some nontraditional measures of community function such as microbial function (Insam and Domsch 1988, Insam and Haselwandter 1989), potential for mycorrhizal fungi inoculation (Allen and Friese 1992), soil cryptogams presence and potential for recovery (Belnap 1993), structural and functional vital ecosystem attributes (Aronson et al. 1993a,b) and seed bank species composition (Young 1992). Information based on these criteria may help in determining (1) potential for the site to recover without revegetation, (2) potential of the site to support a former community, (3) species to use and the form of their introduction (seed vs. transplant), (4) methods for seedbed preparation and sowing, and (5) costs of the alternative treatments.

The information gathered in the field is used to establish objectives, to detail alternatives, and to detect risks of each alternative. For private land managers, this information will help in the preparation of an economic analysis of the revegetation for loan approval (Workman and Tanaka 1991). Values associated with increases in livestock forage are required to gain loan approval, but values for wildlife, fisheries, and recreation may also add to the benefits in some locations (e.g., Kreuter and Workman 1994). Until the world economic system accepts alternative means of placing values on ecosystem function, it may be difficult for private land owners to receive loans for ecosystem restoration unless the federal government establishes incentives for such improvements (Pearce 1992).

The land manager needs to consider as part of the planning process the type and feasibility of manipulations to meet their objectives. Five general alternatives exist for the land manager to choose a course of action (Bradshaw 1984a,b; Aronson et al. 1993a). The first alternative is to consider removing the disturbance, leaving other factors unchanged. This may be an appropriate approach to take in cases where plant species characteristic of healthy ecosystems are present in the community, but in low abundance. Remember, however, recovery by removing the disturbance is sometimes impossible without some action to open the community for new propagules or for present plants to respond. Even on degraded sites, where soil has not eroded, the best alternative when funds are unavailable for more costly approaches may be to remove the disturbance mechanism and continue to monitor the site for signs of degradation or recovery.

The alternative at the other extreme is restoration of a former ecosystem. The Society for Ecological Restoration defines this as "the intentional alteration of a site to establish a defined indigenous, historical ecosystem. The goal of this process is to emulate the structure, functioning, diversity, and dynamics of the specific ecosystem" (as cited in Aronson et al. 1993a:8-9). On sites where degradation has continued for so long that selecting a historical ecosystem to emulate may be difficult, Aronson et al. (1993a) propose a less strict goal termed restoration *sensu lato* that seeks to redirect ecosystem trajectories toward a previous ecosystem without a specifically defined community. This may involve reintroductions of indigenous components of the ecosystem that are key to its functioning and involve allowing the natural dynamics of the system to direct the eventual plant community composition.

Rehabilitation is the third alternative that seeks to repair the ecosystem functions with a goal of improving productivity for the people and animals using the ecosystem. This often means that a threshold of irreversibility may have been crossed such that historical communities can no longer exist in the current physical and chemical environment. With rehabilitation, an attempt is made using native species, but not necessarily those that have previously occupied the site, to increase the productivity of the site while repairing components of the ecosystem so further degradation is halted.

Replacement is typical of the historically successful revegetation projects in the western U.S. The degraded ecosystem is replaced with a substitute ecosystem that contains different species, including exotic species. It is often less structurally complex (e.g., monocultures or grassland), and may have higher above-ground primary production than the original functioning ecosystem.

The last alternative is a reallocation of ecosystem structure and function to produce a new ecosystem with a new human-induced use (e.g., conversion of degraded rangeland to irrigated cropland). This conversion typically requires continuous inputs of either energy, water, or fertilizers to sustain the production. This alternative will not be considered further in this paper.

The choice of natives or exotics in revegetation will often coincide with the chosen revegetation alternative. If an objective of revegetation is to increase forage production for livestock, then, as several studies have shown, exotic species sown in simple mixtures will ultimately achieve this goal (e.g., Mayland 1986). Monocultures of exotics, however, are more susceptible to outbreaks of insects that can destroy these plants and severely damage surrounding crops (Keller 1979, Clement et al. 1990, Armstrong et al. 1991). Also, monocultures or simple mixtures of forage grasses are generally not recommended if the objectives include enhancing faunal diversity (Reynolds and Trost 1980, Bock et al. 1986, Fielding and Brusven 1993); however, Smith and Urness (1984) provided an exception when the monocultures are small and are adjacent to native communities. The results of these studies do not conclusively show that native plant revegetation increases diversity more than exotic plants because most studies compared exotic seedings to intact native communities. This comparison confounds the effect of revegetation, despite the species origin, on the faunal diversity. In a study that compared a series of areas revegetated using largely native species of differing life forms with an intact native community, faunal diversity was lower on the revegetation sites (Parmenter et al. 1991). Studies of faunal diversity comparing intact native communities to areas revegetated with native plants or with exotics must be conducted to separate the effect of revegetation from the effect of the origin of species and conducted on communities with similar structural stages of successional development. Clearly, if the goal is to enhance diversity and the community still maintains many of the species found in an intact community albeit in inappropriate proportions (e.g., shrub-steppe that has converted to largely a shrub-dominant system), then manipulations to the intact community that do not destroy most of the existing plants should be favored over a total revegetation. Obtaining the desired structure is the most important element for achieving similar faunal diversity. Leaving existing plants (e.g., shrubs) and incorporating other desired species (e.g., grasses and forbs) could decrease the time required to obtain desirable habitats for animal populations to increase.

Seeding a diverse mixture of species to achieve a diverse mixture of established plants may fail if the manager does not consider the environmental and interspecific interactions that species will experience during establishment (Archer and Pyke 1991, Pyke and Archer 1991). Since biodiversity has become a critical policy element regarding the management of federal lands (Keystone Center 1991), criteria for selecting plants to use in achieving plant diversity goals need to be developed. The U.S. Department of Agriculture Natural Resource Conservation Service (NRCS) and the Agricultural Research Service are the 2 primary agencies that develop and release rangeland plants for commercial use. Their selection criteria rarely include the plant's ability to coexist with other plants or to have an intermediate competitive ability that would enhance the potential for coexistence. I suggest that quantitative measures of the ability

to coexist with common dominant plants be used as selection criteria focused on biodiversity. These criteria may be used for detecting the species' ability to coexist with weedy species that often dominate degraded lands.

Seeding a mixture of species to achieve a diverse plant community has been recommended (Monsen 1975, Plummer 1977), but the establishment success of many species is often lowered when they must compete with fast growing competitors, especially introduced grasses (Monsen 1975). Seeding the slower growing species in alternate rows, interseeding, transplanting or patch planting, and excluding or decreasing densities of highly competitive species are techniques that may be used to enhance their establishment (Brown and Hallman 1984, Nechaeva 1985, Petersen et al. 1986).

When the degradation is so severe that the community is dominated by highly aggressive weedy species, such as cheatgrass, medusahead (*Taeniatherum caput-medusae*) or knapweeds (*Centaurea* spp.), the introduced species establish quicker than natives and are more competitive than commercially available natives (e.g., McArthur et al. 1990, Aguirre and Johnson 1991). Variation in the ability of native plants to establish when competing with sagebrush (*Artemisia* sp.) can equal many competitive exotic perennials such as crested wheatgrass (D. A. Pyke and J. H. Richards, unpubl. data) thus providing hope that native plant accessions may be found that can establish and compete with weedy species. To the restoration purist, these native accessions would be viewed as nonindigenous genotypes if the accessions came from distant locations (e.g., >1.6 km from the site). However, if local accessions are not competitive or are unavailable, then this may be an alternative to sowing exotic species. Some native species have local genotypes that are successful in competing with exotic weeds. Squirreltail (*Elymus elymoides*, formerly *Sitanion hystrix*, Barkworth et al. 1983, Barkworth and Dewey 1985) reportedly establishes in stands of medusahead (Hironaka and Tisdale 1963, Daubenmire 1975) and may be a native species that can establish and compete successfully with exotics. Although the potential for finding natives that compete with weedy species exists, competitive exotic perennials still provide the best commercially available hope for keeping weeds under control.

Caution should be used when seeding competitive exotic species because traits that make them aggressive with weedy species can also make them aggressive with other desirable species. These traits can lead to an inability for other desirable species to coexist with these aggressive species. The use of competitive exotic grasses in seed mixtures for soil conservation in fire rehabilitation projects on public lands in the U.S. may reduce the establishment potential for native species in the future (e.g., Pellant and Monsen 1993). Though mixtures of species often are sown together, aggressive species dominate and may continue to spread within revegetation areas and into surrounding unseeded sites.

Documented examples exist for 3 species on the dominance and spread of aggressive exotics in arid and semiarid rangelands. Although crested wheatgrass is reported to re-

main within its original rows in many locations (Lorenz 1986, Gutknecht 1992), several studies have shown that it has spread into surrounding plots, seedings, and native communities, and is replacing itself by establishing seedlings (Hull and Klomp 1966, 1967; Harris and Dobrowolski 1986; Pyke 1990). Crested wheatgrass can eventually dominate a site as other seeded species are reduced in frequency and abundance (DePuit and Coenenberg 1979, Schuman et al. 1982, Redente et al. 1984). Lehmann lovegrass, an exotic from South Africa, is spreading rapidly over more area than it was originally seeded in Arizona (Bock et al. 1986, Cox and Ruyle 1986, Anable et al. 1992). Grazing does not seem to enhance the spread (Anable et al. 1992) because areas ungrazed for 30 years before Lehmann lovegrass was introduced now contain the same amount of the lovegrass as surrounding grazed areas. Yet, grazing cannot be eliminated as a contributing factor because before their exclusion from grazing these areas were heavily grazed (B. A. Roundy, pers. commun.). A third species that should be used cautiously is forage kochia (*Kochia prostrata*). This is a low-growing, chenopod shrub that was commercially released under the cultivar "Immigrant" for use in the Intermountain West (Stevens et al. 1985) and is being evaluated for use in greenstrips, vegetative fuelbreaks to reduce wildfire spread, by the Bureau of Land Management (Pellant 1990). It has been effectively used to control exotic annuals like halogeton (*Halogeton glomeratus*) and cheatgrass. In both reported cases, kochia increased in the seeded area and spread beyond where it was seeded, through an abandoned field dominated by cheatgrass, to a native juniper (*Juniperus* sp.) woodland site. The average rate of linear spread was estimated at 22 m/year (McArthur et al. 1990, Stevens and McArthur 1990).

In making a choice of species, one should also consider the ability of the species to regenerate itself on the site. Most released cultivars were initially selected using establishment and growth characteristics, but the ability to regenerate themselves from seed was rarely considered. Sustainable populations require viable seed production, seedling establishment, and adult plant survival to maintain themselves in an ecosystem. Native species often evolve seed dormancy mechanisms in response to adverse environmental conditions (Young and Young 1986:1). For example, using cultivars or collected seeds that possess or do not possess dormancy may lead to the seeds germinating at inappropriate times and failing to establish (e.g., Meyer and Monsen 1990). For forbs and shrubs, phenology of flowering may be an important trait to consider if the plant is an obligate outcrossing plant requiring insect pollination. Flowering before insects are available would lead to reduced reproductive success and to a potential decline in plant abundance. Using locally collected seeds or at least seeds from habitats and latitudes similar to the revegetation site may reduce establishment failures and population declines.

The site may need preparation before seeding occurs. This may include killing with or without removing the dead plants. Dead shrubs or trees could provide safe sites for ger-

mination and establishment of some species that germinate and establish better if sown at the soil surface. Woody vegetation, while alive, helps capture snow and organic material, and creates a nutrient-rich patch in the soil (Allen 1988). As the woody species die and seedlings germinate, the dead plants provide several years of protection for the seedling from trampling and grazing during early growth. Modifications to the soil may also enhance the available moisture for seedling establishment. These may include pitting, furrowing, and land imprinting (see citations in Roundy and Call 1988).

Sometimes seed germination and seedling establishment can be enhanced by treatments to the seed before planting. Seed priming is a seed preparation technique that partially hydrates the seeds so that physiological mechanisms of germination begin, but radicle emergence does not occur (Heydecker and Coolbear 1977). This technique may allow native seeds to germinate quicker and enhance their competitive relationship with weedy species. Seed priming of native rangeland species increases the germination rate to nearly that of some weeds (Hardegree and Emmerich 1992, Hardegree 1994).

Pelleting of hairy or fluffy diaspores is a treatment that has received mixed reviews. Ideally, pelleted diaspores are easier to drill and as they are moistened the pellet material will anchor diaspores in place. Hydrophilic pellets have largely proven to be ineffective, if not harmful to the seed (see citations in Pyke and Borman 1993). Fluid drilling is less costly than pelleting and potentially more effective. Diaspores or pregerminated seedlings are mixed with a hydrocolloidal gel, then sown into the soil (Booth 1985).

The placement of seeds in or on the soil is often done by 1 of 2 general approaches, drilling or broadcasting. Drilling is generally accepted as the best technique for relatively large seeds because it places seeds at their appropriate depth and in contact with the soil. The drill speed is an important criterion for achieving accurate seeding rates. A general rule of thumb is if you cannot walk fast enough to keep up with the drill, then the drill is being pulled too fast (McGinnies and Hassell 1988). Very small seeds like sagebrush and many forbs should not be sown deeper than 6 mm (0.25 inches) (Valentine 1989). Drilling small seeds over rough terrain may cause the seed to be buried too deeply and never emerge. In this case, a billion seeder, broadcasting the seed followed by cultipacking, harrowing, or dragging a chain over the surface may place the seed in better contact with the soil, but near the surface. Livestock can trample broadcast seeds into the soil, thus accomplishing the same goal as using tractor-pulled equipment (Owens and Brzostowski 1967, Howell 1976, Winkel and Roundy 1991, Winkel et al. 1991). If broadcasting seed, remember that the seeding rate should be increased by 25–75% over that recommended for drilled seed (Plummer et al. 1955, Keller 1979). This higher rate may be helpful in suppressing weedy species during the early years after seeding if establishment of the desirable species is increased (Pyke and Archer 1991). Snowbank seeding may be attempted in areas where seeds germinate after snow melt

in late spring. With this technique, seeds are broadcast or sown so that they penetrate the snow for protection from seed predators and hydrate for germination when the snow melts (Booth 1987, Pyke and Borman 1993).

Accurate monitoring of revegetation projects will help in future revegetation efforts, especially when using native species for revegetation. The recommended time to begin evaluating the success of any revegetation effort is the end of the second growing season (Roundy and Call 1988), but some useful information could be gathered during the interim. Excavations of seeds to decide the average depth of seed placement should be done immediately after planting. This will help detect if seeding depth was a factor if some species failed to emerge. Also, attempts to identify the species that emerged during the first year will help decide if species failed because they did not emerge, a factor implicated in the failure of many native species (Gutknecht 1992), or because they died after emergence. Evaluations at the end of 2 years should include (1) the numbers of plants establishing per area or per length of row, (2) a measure of species composition when seeding mixtures, and (3) a measure of the proportion of plants in each species that flowered as a measure of vigor. The measurements taken in the second year should be repeated annually through the fifth year and then repeated every fifth year to detect the persisting species.

If grazing will occur on revegetated areas, it should be restricted until plants are adequately established and are sexually reproducing. Some introduced species like "Hycrest" crested wheatgrass (*A. cristatum* x *desertorum*) can tolerate grazing 18 months after reseeding (Asay et al. 1985), but many native species may require 2–5 years before they can be grazed without harming the plant. If a mixture of species is a revegetation objective, then reintroduction of grazing animals should be based on when the last species is firmly established. Two rules can be applied to detect if species are ready for grazing. First, are most individuals of each species producing viable seeds, or for clonally reproducing plants, are rhizomes, stolons, or root sprouts evident? Second, are >90% of the individuals of each seeded species able to withstand being pulled from the ground during the normal grazing season for livestock? If the manager can answer yes to both questions, then a flexible grazing management system (Sharp 1983) may be conducted. The choice of the appropriate grazing season should be based on ecophysiological and morphological responses of plants to grazing and not based on carbohydrate reserves (Murphy and Briske 1992, Briske and Richards 1994).

NATIVE SEED AVAILABILITY

One of the greatest obstacles to revegetation with native seeds is finding a supplier with a sufficient quantity of the desired seed. Seed companies dealing in native seeds have increased in recent years in the western U.S. A market exists for the collection, propagation, and sale of native seed,

but as with any crop, there are certain risks that must be faced (Tomsho 1992). Some companies carry only released cultivars of native seeds. These are accessions (collections from a given population) of a species that grew well over a wide range of conditions and locations. Published information is available on the environmental conditions under which these cultivars can grow. Other companies will collect from local native plants and may increase the seed in a nursery, or sell it as freshly collected seed.

The development of better seed harvesting and cleaning equipment has decreased the processing time, and increased the ability to collect nearly all viable seeds. For example, seed strippers have increased the ability to collect seed from species with asynchronous maturation. This allows the removal of ripe seeds while maturing seeds are retained on the plant and harvested later.

Normally, seed merchants can sell more native seed than they have available; therefore, if land managers are considering native seed, they should place their requests early. Some companies, if given adequate time (2–3 years), will collect the seed and increase it. The plants that seed growers can grow easily and can depend on for large amounts of seed are often introduced species such as crested wheatgrass. If techniques for producing large amounts of native seeds are developed, then availability will increase and seed cost will decrease.

A major problem faced by seed growers that want to increase seed is dormancy. Economically, growers want to minimize the time from planting to seed harvesting. For species with long-lived seeds, dormancy may cause asynchronous germination creating a field of plants of differing ages and stages of development. This may result in many plants not producing seeds in the first 1–2 years. For some native species in the West, techniques for breaking dormancy have been developed (Young and Young 1986); for others these techniques must be developed before large amounts of seed become available.

Investing large amounts of money into research and development for native seed production is a risky venture for emerging companies. The federal land management agencies as major purchasers often purchase seed mixtures dominated by introduced species (Pellant and Monsen 1993) to reduce costs. With the onset of policy decisions like the Pacific Northwest Region of the U.S. Forest Service to use native species when possible, seed growers may find it more profitable to invest in research on native plants. Meanwhile, land managers may need to reduce the size of revegetation areas to fit the amount of native seed they can purchase annually.

An alternative that some land managers are using when they wish to use native seed is to contract for the collection and the increase of the seed. As part of the contract, the land manager will agree to purchase a fixed amount of seed each year for a fixed time and will be given priority for that amount of seed. After the seed grower supplies the land manager with the agreed amount, then the grower is free to sell any remaining seed at the current market price. This assures both

the manager and the grower of a known market for the seed for a fixed time, thus allowing the grower to carry some developmental costs and risks over several years. Some species, like short-lived perennials, may not be economically feasible in a seed-increase program; therefore, contracting for seed collections may be the best technique for obtaining seeds.

NATIVE SEED: GENERALISTS VS. SPECIALISTS

The common approach for developing and releasing seeds, whether native or introduced, is to find the best generalist accession of a species. This is the approach that has commonly been used by the NRCS (Fuller 1986). Accessions are collected from many locations and grown in a common nursery (initial evaluation) in spaced plantings so that seedlings can achieve their full growth potential. If a standard for that species is available, then the standard is also seeded and all accessions are compared to the standard. A standard is the same or similar species that is currently being used in that region for the prescribed conservation practice.

Those accessions in the initial evaluation that equal or exceed the standard in ≥ 1 characteristics relevant to their intended use are selected for advanced evaluations and for seed increase to prepare for field evaluations. Field evaluation plantings (also known as off-center plantings) are conducted in test plots on locations with slightly different soil and climatic conditions. Promising plants based on these evaluations enter the final evaluation phase where they are planted on private lands in several locations using specified techniques, but in areas where the conservation problem exists. After the 10-year evaluation in the final phase, the accession that did the best in several locations is then released as a commercial cultivar. Although this technique may identify the best generalist accession for a species, it also tends to reduce the genetic variability in the cultivar relative to the species as a whole.

An alternative approach is to release seed that is specific to a given site or location; these seeds would be specialists for revegetation. The NRCS is considering alternative plant releases for certification and plant production that are more specific to a given area than cultivars, but have gone through less rigorous testing. These would range from unselected seed identified only by the source of the collection population (source-identified) to varying degrees of selection for promising performance.

Source-identified seed may satisfy many concerns regarding genetic integrity of revegetation sites and their surrounding areas because seed would come from the site or from locations near the site. Local populations experience similar environmental conditions as the plants that once occupied the revegetation site; therefore, source-identified seeds may have experienced natural selection that would allow them to establish and persist at the revegetation site. When seed-

ing a site dominated by weedy species, you can collect seed from species that currently coexist with that weed to enhance the possibility of coexistence with the weed after revegetation because of the natural selection for traits that allow coexistence (Jaindl et al. 1994, Knapp and Rice 1994). For many of these reasons, the U.S. National Park Service attempts to use seed from the site of the revegetation when possible to accomplish revegetation goals.

If source-identified seed is unavailable, then the manager can collect seed and have it increased for revegetation purposes. Take care not to introduce unintentional selection during collection (Knapp and Rice 1994). Always collect from as large a sample of the population as possible, making certain that seed came from plants evenly dispersed across the population to eliminate collecting from closely related individuals. Collecting from hundreds to thousands of plants within the population and collecting along multiple transects that traverse the population would solve this problem. Try to sample from areas of local variation that may exist in the population. This may include collecting from sun and shade plants, or from differing slopes and aspects. The collector must resist always collecting from the larger plants or only from plants with a large amount of seed. Keep in mind that small plants that are producing seed may have passed through a selection process that allows them to persist in that site whereas other genotypes in the population might have been selected against. This type of selection has been noted in pasture plants in British Columbia (Aarssen and Turkington 1985) and may play a role in understanding the coexistence of species by sorting out complex competitive relationships among genotypes of different species within a population (Taylor and Aarssen 1990).

During the seed increase process some unintentional selection can occur as well. Knapp and Rice (1994) recommended using a site with similar environmental conditions as the revegetation site. Plants should be irrigated sparingly only to establish them or to carry them through a drought by keeping moisture near normal. Ample space should be given to each plant to eliminate density-dependent selection. They also recommended isolating plantations of the same species collected at different locations to prevent cross-pollination of different source populations. For wind-pollinated outcrossing species, this may require distances of 300–1,600 m (300 yards to 1 mile). For self-pollinating species, this is less of a concern, but unfortunately the mating system is unknown for many native species.

Intermediate alternatives between the selections for native generalists and specialists also exist. One alternative is to collect seeds from a number of sites and to bulk the seed before drilling on a revegetation site. This will allow the environmental conditions of the site to select appropriate genotypes for that site. This technique, however, may result in occasional die-offs of maladapted genotypes after establishment when extreme conditions continue the selection process.

LOWERING THE RISK OF FAILURE: THOUGHTS AND POSSIBILITIES

Clearly there are many genetic subtleties that should be considered when seeding native species. The relationship between winter temperature and snow depth in an area can influence the dormancy of the seeds from that area. Meyer and her coworkers have shown this in forbs and among subspecies of big sagebrush (*A. tridentata*) (e.g., Meyer 1992, Meyer and Kitchen 1992, Meyer and Monsen 1992). These genetic links between environment and germination provide strong support for using local seeds when possible or for clearly delineating the latitude, elevation, and climatic environment that seeds should come from to reduce the risk of failure.

When trying to restore or rehabilitate a site some species may be important for improving ecosystem function, but they will never be dominant species. Forb species within the big sagebrush-grassland communities seldom contribute >1% of the species composition (Daubenmire 1970), but forbs are a part of the diet for sage grouse (*Centrocercus urophasianus*) (Barnett and Crawford 1994) that are declining in Oregon (Crawford and Lutz 1985). Forb reintroductions into sagebrush-grass sites may be enhanced by transplanting them into the site and protecting them for several years from being grazed by wildlife rather than seeding them.

Looking into the future, long-term weather forecasting could be used to predict if precipitation conditions in a region like the northern portion of the Great Basin were expected to be adequate for revegetation to succeed. Clear relationships have been found between precipitation levels in various regions of the world and the El Niño Southern-Oscillation (ENSO) (Ropelewski and Halpert 1986, 1987). Recent developments in artificial intelligence methods allow reasonable predictions of drought or above-average annual precipitation from 3 months of data associated with the ENSO (Derr and Slutz 1994). In arid and semiarid areas, where above-average precipitation may be necessary to establish plants (e.g., Bleak et al. 1965, Romney et al. 1980), revegetation failures because of drought could be reduced by using models that predict growing season precipitation. In arid and semiarid regions, revegetation would only occur when higher than normal precipitation was expected. In drought years, when revegetation is not attempted, seed could be collected or increased in preparation for the next above-average precipitation year.

CONCLUSIONS

The degradation of many rangeland ecosystems during the early part of the 20th century and the inability of many of these ecosystems to recover, even with the removal of livestock, has placed land managers at a decision point. Should they attempt to restore a former plant community or should they revegetate the site with a new plant community? I will expand on an analogy of a painter restoring a masterpiece

(Aronson et al. 1993a) to explain the difficulty land managers face in attempting to revegetate a plant community. As part of an inheritance, the heir of an estate discovers a neglected gallery filled with paintings by many great masters; however, several paintings are in various stages of degradation. A painter is hired to repair these paintings so that the gallery can again be used for enjoyment, study, and potentially for profit. If enough outlines and original colors are available, then restoration of a painting is possible, but once the outlines and colors are lost, the painter can no longer be confident that the restoration will be accurate. The heir must settle for the hired painter's interpretation of the original based on the evidence that remains. Sometimes, however, the center of the canvas is blank with only hints of the original along the edges. The heir recognizes this problem, but limited funds prevent the heir from merely purchasing another masterpiece to replace the damaged one. So the heir provides the painter with 2 alternatives. The painter may attempt to restore the canvas based on the edges that remain and on the painter's knowledge of how the master painted, or alternatively the painter may elect to paint a new painting that will complement the remaining masterpieces in the gallery.

In this story, the heir is analogous to a new land owner of private lands, or to the public and the public policy makers. The gallery is analogous to the collective rangelands within a given area. Each painting is a separately managed landscape that must be properly maintained for it to continue to exist. Those paintings that retain enough outlines and colors are the lands that through proper management and some additional assistance can be restored to their normal range of variability, whereas those where no outlines remain are like many degraded areas that have gone through such drastic changes that accurate restoration is not possible. On these lands, the land manager may not have the economic or ecological resources to restore an original assemblage of species, but could probably introduce a new set of species to restore a structural and functional ecosystem that complements the surrounding landscape. This is the revegetation challenge that we face as land managers, scientists, and benefactors of rangelands. We need to consider the short- and long-term impacts of our revegetation decisions on the sites we wish to repair and on the surrounding landscape, so that our revegetation complements the natural structure and function of the total ecosystem.

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EXOTIC VERSUS NATIVE FISHES IN RANGELAND STREAMS

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Abstract: It is well known that alien species are most successful in habitats disturbed by humans. Alien species are pests because they displace native species and disrupt coadapted interactions among native species and disrupt ecosystem processes. In aquatic systems, the effects of alien species result in the formation of fish communities of lower value that are resistant to change. This is of serious concern if the intent of watershed restoration is to regain our highly valued native fishes. Land use east of the Cascades is deleterious to keystone species of stream systems: trees of the riparian zone, aspen (*Populus tremuloides*), alder (*Alnus* spp.), willow (*Salix* spp.), and cottonwood (*Populus* spp.) as well as the native conifers. Trees control stream temperatures and influence runoff patterns that in turn govern fish community structure including the distribution, the extent, and the intensity of negative impacts of exotic aquatic organisms on native fishes and amphibians. Alien organisms on the eastside comprise both coldwater and warmwater fishes and diseases. Data show that alien species are hybridizing with native fishes and are competing and preying on native species and that disease is spreading. Case histories will be given as illustrations of the extent of the present problem.

Key words: community ecology, ecosystem, native fish, nonindigenous aquatic organisms.

RIPARIAN REHABILITATION WITH NATIVE VEGETATION

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Abstract: Land use practices during the 1800s and early 1900s resulted in riparian areas throughout much of the West with reduced vegetation often dominated by exotic herbaceous species. Rehabilitation with native vegetation can enhance restoration of properly functioning riparian zones. Physical characteristics determine the capacity of each stream zone to develop a riparian vegetation community. The most important physical factors are the extent of water fluctuation and persistence. Site-specific prescription grazing designed for management goals often will result in riparian improvement and a reappearance of native species without additional intensive restoration activities. If changes in management alone are insufficient to allow a reestablishment of native vegetation in an acceptable period of time, then artificial methods may be necessary. Techniques for establishment of woody cuttings, transplanting dry root stock, and seeding herbaceous plant materials have been suggested in a number of symposia proceedings and by contractors active in the field. Suitable plant materials, protection from animal damage, and maintenance are generally required to protect the investment.

Key words: cuttings, dry root stock, grazing management, maintenance, native vegetation, protection, riparian rehabilitation, seeding, transplanting.

Arid-land riparian degradation as we think of it today can be attributed largely to extensive beaver (*Castor canadensis*) trapping in the early 1800s, and, during the latter part of the nineteenth and early twentieth centuries, to concentrations of livestock and cultivation on homesteads established in riparian areas, and season- or year-long grazing (Apr–Oct) by extensive livestock operations (Elmore and Beschta 1987). Beaver ponds expanded flood plains, dissipated erosive power of floods, and acted as deposition areas for sediment and nutrient-rich organic matter. Beaver trapping resulted in dams not being maintained and giving way. Loss of the beaver dams concentrated stream energy in discrete channels, causing erosion and downcutting that reduced the flood plain and resulted in the loss of riparian vegetation on the former flood plain. Homesteaders often settled in riparian areas. Cultivation of their crops and concentration of their livestock greatly impacted riparian vegetation with resulting erosion and downcutting, and loss of flood plain with associated vegetation. Year- or season-long grazing by extensive livestock operations allowed the livestock to concentrate their foraging in riparian areas, particularly during the hot season, with similar results.

These historical patterns of land use left most riparian areas in the arid portions of the Pacific Northwest in a degraded state with altered vegetation and channel morphology. With that as a background context, the purpose of this paper is to discuss riparian rehabilitation with native vegetation.

POTENTIAL VEGETATION FOR A SITE

Rehabilitation with native or any other vegetation requires that we understand the site potential so that we are managing for an appropriate plant community. Attempting to “restore” an area to a community it is unable to support wastes resources. During the last 10 years, riparian zone classifications have been developed for portions of the Northwest. However, additional work is needed.

Crouse and Kindschy (1984) devised a method for predicting riparian vegetation potential based on their observations in southeastern Oregon semiarid systems. The method is based on physical characteristics of stream riparian zones, such as extent of water level fluctuation, persistence of flow, scouring, and soil type.

Physical characteristics determine the capacity of each stream zone to develop a riparian vegetation community. The most important physical factors are the extent of water fluctuation and persistence. Soil type is another influencing factor but the stream gradient and flow regime generally dictate the soil composition. Crouse and Kindschy's (1984) key to riparian vegetation types is an example from southeastern Oregon (Table 1).

Kovalchik (1987) describes the general geographic, topographic, edaphic, functional, and floristic features of riparian ecosystems for the Deschutes, Ochoco, Fremont, and Winema national forests in Central Oregon. Youngblood et al. (1985) developed a community type classification for riparian ecosystems of eastern Idaho and western Wyoming. They discuss vegetation composition, productivity, soils, and successional status relevant to the community types in the area.

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Table 1. Key to riparian areas of southeastern Oregon (after Crouse and Kindschy 1984).

- 1a. Stream flow intermittent.
 - 2a. Water not in soil all year—mullein (*Verbascum thapsus*), low sagebrush (*Artemisia arbuscula*), biscuit root (*Lomatium* sp.).
 - 2b. Water in soil all year.
 - 3a. Stream gradient <1%; dry in mid-summer except for isolated pools—dense mats of sedges (*Carex* spp.), grasses, and forbs around pools; few or no woody species.
 - 3b. Stream gradient >1%—herbaceous sage (*A. ludoviciana*), mullein, sparse willow (*Salix* spp.).
- 1b. Stream flow perennial.
 - 4a. Stream flow does not vary seasonally (springfed).
 - 5a. Soil highly alkaline—alkali bullrush (*Scirpus* spp.), greasewood (*Sarcobatus vermiculatus*), buffaloberry (*Shepherdia argentea*), salt cedar (*Tamarix gallica*).
 - 5b. Soil not highly alkaline—densely matted sedges, forbs, grasses, cattails (*Typha* spp.); few or no woody species.
 - 4b. Stream flow varies seasonally.
 - 6a. Water level fluctuations extreme; severe scouring common—vegetation limited to sparse stands of grasses, forbs, and sedges; woody plants found only in areas protected from scouring.
 - 6b. Water level fluctuations moderate.
 - 7a. Soil extremely rocky; gradient generally >5%—narrow band of willow, mock orange (*Philadelphus lewisii*), chokecherry (*Prunus virginiana*), sparse stands of grasses and forbs.
 - 7b. Soil fine in texture; gradient generally <5%—tree willow, cottonwood (*Populus trichocarpa*), alder (*Alnus tenuifolia*), aspen (*Populus tremuloides*) (> 1,500 m), dogwood (*Cornus* sp.), mock orange and other shrubs, dense stands of grasses, sedges, and forbs.

NATURAL RESTORATION THROUGH GRAZING MANAGEMENT

Natural restoration of native plant species in riparian zones is the most practical and efficient method of assuring riparian rehabilitation with native vegetation when the vegetation is present to respond. Changes in grazing management can provide important opportunities to improve the ecological condition of stream systems while meeting the requirements of riparian vegetation (Elmore 1992). Exclusion of livestock is proposed by some as necessary to affect recovery of riparian areas. Exclusion may be effective, but it is generally unnecessary (Elmore 1992). Prescription grazing, a management scheme designed for a specific site and set of management goals, often will result in riparian improvement and a reappearance of native species. Livestock grazing is a compatible use in riparian-wetland areas when the functions of the riparian system (sediment filtering, streambank building, water storage, aquifer recharge, energy dissipation during storm events, etc.), potential of the site, and the needs of the riparian vegetation guide the development of the grazing management strategy (Hansen 1992).

Vegetation community type potential for the site will be a major factor determining an appropriate grazing prescription for a given site. In general, the primary consideration will be whether the site has potential for woody vegetation or if it is a herbaceous site.

If the potential of the site is for woody vegetation, then grazing management should allow development and maintenance of different age classes (e.g., seedlings, saplings, poles, and mature trees; seedlings, saplings, and mature age classes of shrubs) of the key woody plant species (Hansen 1992). To initiate reestablishment of woody species on a site, grazing management must focus on timing of use to minimize shrub use. Based primarily on observations, spring use by livestock in riparian zones tends to be generally the most beneficial time of use for woody plant reestablishment. During this time, herbaceous vegetation is in its vegetative phenological stage of development and is highly preferred by herbivores, so use of woody species will be minimal if any. Winter use by livestock also can allow woody plant reestablishment if use of the riparian zone itself is minimal because water is available elsewhere, or because drainages are colder than adjacent uplands and livestock stay out of the drainage (Elmore 1992). Midsummer through fall use tends to be detrimental to reestablishment of woody species because herbaceous species have generally matured and have lower palatability than the woody species, which will tend to be overused.

If the site potential is primarily herbaceous, then the primary consideration for a grazing prescription must be to allow sufficient stubble height or regrowth to trap and hold sediment deposits during run-off events (Clary and Webster 1989, Meyers 1989, Elmore 1992). Some sedges and grasses will continue to grow until the end of October if moisture is available. Regrowth of 30–45 days frequently will restore enough bank cover to trap sediments and protect banks

(Elmore 1992). Under fall or winter grazing, 4–6 inches of stubble height has been suggested as necessary for bank stabilization and sediment trapping (Clary and Webster 1989, Meyers 1989).

Several riparian areas in the Prineville District, Bureau of Land Management (BLM), that had originally been surveyed by BLM personnel during the late 1970s and early 1980s, were resurveyed during the summer of 1994. Preliminary analysis of Bear Creek indicates tremendous improvement, largely as a result of changes in grazing management. On the BLM-managed sections of Bear Creek that were evaluated, the wetted area increased by 148%. This indicates a substantial increase in area covered by riparian vegetation, largely native grasses, sedges, and rushes. Litter also increased substantially on the original wetted area as well as the new wetted area. Communities of native vegetation that were absent during the initial survey were present during the 1994 survey. With proper grazing management, the riparian zone improved considerably in terms of wetted area, additional litter that provides soil protection during runoff, and a natural reintroduction of native plants and plant communities (data analysis currently in progress).

In addition to proper grazing management, livestock operators can facilitate riparian vegetation establishment by collecting seeds from established plants in portions of the riparian zone where they exist, and placing them in suitable sites in riparian zones where they do not exist. Regular monitoring of riparian improvement will allow the manager to identify and correct problems early, and identify and collect seed when it is ready. The seed can be placed where it is needed during the inspection tour.

ARTIFICIAL REVEGETATION

Artificial methods for restoring native vegetation in riparian zones should not be attempted without an appropriate change from the management that produced or maintained the degraded condition of concern. Unless there is an urgency or desire to establish a particular kind of vegetation for a specific reason, transplanting or reseeding should not be attempted for at least 1 year (Kindschy 1987) and perhaps for 4–5 to as many as 8–10 years following management change to evaluate the need for reintroducing native species (W. Elmore, BLM, pers. commun.). In most cases, given sufficient time, an appropriate change in management will result in the reappearance of native species appropriate for the site (W. Elmore, pers. commun.; H. Winegar, BLM, pers. commun.). With continued sediment deposition and bank-building, particularly along low-gradient channels, water tables rise and ultimately may reach the root zone of plants on former terraces or flood plains (Elmore and Beschta 1987). The change in species composition to native vegetation (primarily sedges and rushes) occurs as this process progresses (M. Borman, unpubl. data). On sites suitable for shrubs and trees, natural establishment from seed in riparian zones requires a combination of conditions. Field observations indicate that for willow seedling establishment an ap-

propriate seedbed, bare soil such as gravel bars and areas of silt deposition with little or no competition and with adequate drainage, must be present during a relatively narrow window of opportunity during the spring when seed is viable. A water table that drops too quickly for root systems to keep up during the summer will eliminate seedlings. A scouring flood within the first 5 years of establishment will likely eliminate unprotected seedlings and saplings. If the site is incised, continued silt deposition may kill seedlings until the site is aggraded enough to provide sufficient bank drainage. As the site improves, the banks often aggrade to a height somewhat above the flood plain. The flood plain itself will expand and be able to store additional water. As the banks aggrade above the flood plain and the flood plain expands to hold more water, the banks are better drained and provide a suitable site for willow establishment and maintenance.

If changes in management alone are insufficient to allow a reestablishment of native vegetation in an acceptable period of time, then artificial methods may be worth attempting for specific sites and for specific reasons. A desire to have a resilient vegetative community capable of protecting the riparian zone sooner rather than later might influence the time frame considered acceptable.

If riparian sites have been altered to the extent that original vegetation is no longer adapted to the disturbances, attempts to restore the original complement of plants may not be practical. However, unless a grouping of plants similar to the original community can be established, aquatic and terrestrial resources may not be fully restored (Platts et al. 1987). Along silt transporting streams it may be necessary to establish earlier seral species to initiate aggradation of the riparian zone. As the riparian zone aggrades through silt trapping, it will provide site conditions, primarily a higher water table, sufficient for later seral species to establish and occupy the site.

Control of weeds often is required before planting or transplanting. Control of noxious weeds may be sufficient in and of itself to justify planting or transplanting. Besides occupying sites that should be supporting more desirable plants, weeds often do not provide adequate soil protection or enhance aquatic habitat. They may be spread by the stream to occupy downstream disturbances and interfere with the establishment of more desirable species. Herbicides are effective, but contamination of the stream must be avoided. Hand spraying, wick application, or dripping herbicide on individual plants may be effective and safe. Although weed control is not the topic of this paper, it is an important consideration and where weeds are a factor, they must be addressed.

Carlson et al. (1992) provide a description of the criteria that should be considered for revegetation of riparian areas in the Intermountain area. They provide useful descriptions of (1) geomorphic valley form, stream type, and community type with descriptions of the kinds of vegetation that should be considered and the revegetation potential; (2) types of channel vegetation planting such as pole planting, stump or post plantings, and bioengineered vegetative structures;

and (3) channel vegetation practice specifications including plant material considerations, and planting configuration, methods, and dates.

There are basically 3 methods to artificially establish (reestablish) native vegetation in riparian zones: (1) using cuttings, (2) transplanting dry root stock, and (3) seeding.

Cuttings of Woody Vegetation

Using cuttings to establish woody vegetation such as willows and cottonwood has been shown to work well (Smith and Prichard 1992). If possible, collect native cuttings before leafing out from locations close to the planting site. Cuttings should be cut at a 45-degree angle and either planted directly or stored in buckets of water for a few days before planting. Adding root stimulant will enhance survival of those stored in water (Smith and Prichard 1992). The terminal end of the plant is sometimes pruned to prevent flowering and direct more activity towards root growth. If pruned, the top of the plant should be painted to prevent excessive loss of moisture (Smith and Prichard 1992). At higher elevations, successful plantings usually take place after snowmelt and peak runoff (Smith and Prichard 1992).

Conroy and Svejcar (1991) found that transplanting location was the most important factor in successful establishment of unrooted Geyer willow (*S. geyeriana*) cuttings in northern Sierra Nevada riparian zones. Survival of the willows planted were highest (87%) on the streambottom, intermediate (34%) on the streambank, and lowest (3%) on the stream terrace. Soil moisture was correspondingly highest (53%) on the streambottom, intermediate (44%) on the streambank, and lowest (36%) on the stream terrace 75 days after planting. At the same time, depth to water table was least (27 cm) at the streambottom, intermediate (73 cm) on the streambank, and greatest (126 cm) at the stream terrace. Soil moisture and depth to water table seemed to best explain survival results. Individual species respond differently to waterlogged conditions, and these differences should be considered. Svejcar et al. (1992) suggested that although competition may be a critical factor for transplanted willow survival on some sites, the abiotic environment is probably the overriding factor. A rather rapid drop of the water table during late spring-early summer would require a willow transplant to break dormancy and initiate root growth rapidly during that period. Willows initiated leaf growth during early to mid-April but photosynthetic rates remained low until early June. The willows were apparently using stored carbon during the early phase of growth. Maximum photosynthetic rates occurred in either July or August when air temperatures increased. According to Svejcar et al. (1992), willow cuttings may be dependent on stored carbon longer than previously assumed with limitations to root growth before the midsummer decline in soil moisture. The implication is that limited early root growth may be responsible for poor establishment of willows in areas where the water table drops much below the cutting placement depth during midsummer. Additional research on shoot and root growth of willow cuttings would be helpful in developing willow planting recommendations.

Smith and Prichard (1992) suggested that successful plantings at higher elevations usually take place after snowmelt and peak runoff, and before greenup at lower elevations.

Hoag (1992) described Natural Resource Conservation Service (NRCS [formerly SCS]), Aberdeen Plant Materials Center establishment trials for primarily willows at the American Falls Reservoir in southeastern Idaho. Resulting recommendations were that cuttings be ≥ 2.5 cm in diameter to resist wave action before water drawdown. They should be long enough to reach the midsummer water table to ensure the cuttings have ample water to sprout and to put most of the roots below the root systems of competing vegetation. It also allows the cuttings to be tall enough to avoid shading from weeds and grass.

Guidelines for successful pole plantings developed for New Mexico (Swenson 1988) include the following points that may be relevant to the Northwest as well:

1. Select sites with sand, gravel, or small cobble soils above and in the water table. Avoid sites with continuous clay or silt soils, or where lenses of clay or silt are >30 cm.
2. Before planting, measure monthly water table fluctuations for ≥ 1 year.
3. Cut poles from stands of open-grown, young, rapidly growing trees, using only wood that is ≤ 4 years. Remove side branches, leaving only the tip and next 2 lower side branches.
4. Cut poles when completely dormant.
5. Auger holes to the depth of the lowest anticipated growing season water table.
6. Place the poles in the augered holes the same day they are removed from the soak, if soaked. Set the butt at the lowest anticipated growing season groundwater depth. Select poles of a length that provides 1.5–2.0 m above the soil surface.
7. Back fill the holes carefully to avoid air pockets. The use of dry surface soil is recommended.
8. Place tree guards around poles if rodent or rabbit damage is anticipated.
9. As buds begin to swell along the pole, during the spring, wipe them off the lower two-thirds of the pole.

Transplanting Dry Root Stock

According to Monsen (1983) and J. Davis (Tree of Life Nursery, Lostine, Oreg., pers. commun.), transplanting seedlings is the most practical means of establishing shrubs and trees. Although most riparian sites receive supplemental ground water, not all areas remain wet enough to assure the establishment of newly transplanted stock. Cuttings can be rooted in a nursery bed or under greenhouse conditions. Willow or poplar cuttings are better able to establish if planted as rooted stock. When planted, all stock should be dormant and in good condition. Most planting stock should be of sufficient size to survive the harsh conditions that often occur. Usually large plants, 2-0 nursery stock or 45- to 50-cm container-grown plants survive better than smaller stock.

However, larger transplanted trees tend to lose many feeder roots during the transplanting process (J. Davis, pers. commun.). Tree or shrub seedlings may be a better choice than saplings or cuttings for mass restoration plantings because of their greater root-to-transpiring surface ratio (J. Davis, pers. commun.). Plants should have a satisfactory root system to be able to grow quickly and become fully established. Most transplant stock can be nursery grown within 1–2 seasons. Most transplanting failures result from improper handling of stock and planting practices. Container stock should be hardened before field planting. The hole in which the root stock is planted should be somewhat larger than the existing root mass to avoid breaking or forcing the roots to grow inward or upward. Additional space may be necessary if additional soil mixture or enhancer is deemed desirable to aid establishment. Dry root stock plantings will usually require special care (watering) for survival. Plantings that are delayed until late in the spring are subjected to drying soil conditions and desiccation from high temperatures. J. Davis (pers. commun.) has suggested that fall is the best time to transplant woody deciduous plant materials in riparian zones. Roots are able to start growing during the fall and continue until the ground freezes. Root growth resumes when the ground thaws in the spring and the plant has an opportunity to develop a much more extensive root system before the lowering of the water table by midsummer.

Transplant stock should not be planted directly into established stands of understory competition. Weedy vegetation should be removed by scalping or herbicide application. Using a hand sprayer to treat a spot about 76 cm in diameter with a herbicide should be sufficient to eliminate competition and facilitate transplanting. Adding an agricultural dye to the herbicide solution marks the spray area and aids in relocating the planting spots (Monsen 1983).

When choosing planting locations, microsites can be important. Examples of sites with higher potential might include soils moistened by capillary water near in-stream pools, northern sides of downed logs or debris (shade, moisture, organic matter buildup), and the northern side of stumps and rocks for protection from solar radiation (J. Davis, pers. commun.). To establish later successional species, a site under the canopy of existing pioneer vegetation may provide suitable conditions.

Seeding Herbaceous Plant Materials

The need for reseeding with herbaceous plant materials is probably relatively rare. Site conditions, primarily location of the water table, generally preclude establishing later seral species in degraded riparian areas. Earlier seral species will likely be necessary to enhance the potential for establishment. With a change in management, they will probably establish within a reasonable period of time without a reseeding or transplanting effort. However, if reseeding is deemed necessary, guidelines have been suggested.

According to Monsen (1983), areas not subjected to flooding should be fall planted. If spring or summer precipitation can generally be counted on, spring seeding may result in acceptable establishment. Where flooding occurs and spring and summer precipitation cannot be counted on, planting should be done as soon as possible after the water recedes. Drill seeding or using a cultipacker is recommended where possible (Monsen 1983); however, riparian sites are often narrow, irregularly shaped corridors that are inaccessible to conventional planting equipment (Platts et al. 1987). Because of the need to retain protective plant cover, Platts et al. (1987) suggest interseeding, selective, or delayed plantings. These procedures impact small areas that can be treated in sequential intervals to retain existing plant cover and encourage natural recovery. Transplanting small segments of sod or plugs of various grasses, *Carex*, or broadleaf herbs can be accomplished without extensive site preparation.

Plant Materials

Platts et al. (1987) provide tables of (1) distribution and rooting characteristics of select native herbs for riparian sites (Platts et al. 1987:111–112 [Table 25]); (2) grasses recommended for direct seeding and transplanting riparian sites (Platts et al. 1987:116–117 [Table 26]); (3) broadleaf herbs recommended for planting of riparian sites (Platts et al. 1987:118, [Table 27]); and (4) woody species recommended for riparian disturbances (Platts et al. 1987:120–122, [Table 28]).

Carlson (1991) discusses selection, production, and use of riparian plant materials for the western U.S. by the NRCS, Plant Materials Centers. Common native woody species recommended for riparian revegetation projects in the western U.S. are identified by climate area including the Pacific Northwest and Intermountain areas. According to Carlson (1991), species established in the field by rooting from dormant cuttings, stumps, or poles are the most likely to be produced in large quantities for riparian revegetation projects involving NRCS input. These are primarily cottonwood and willows. Dogwood (*Cornus* sp.), hardhack (*Spiraea* sp.), snowberry (*Symphoricarpos* sp.), and grape (*Vitis* sp.) can be established in the field under favorable conditions. Other species identified must be produced from seed or vegetatively in nurseries before outplanting in the field, which greatly increases their cost if larger stock is used (Carlson 1991).

Natural Resource Conservation Service procedures for providing plant materials to riparian restoration projects include a preference for obtaining material from local sources when possible and developing cultivars from populations collected within a target use area with evaluation in a common garden nursery (Carlson 1991). The cultivar of a vegetatively propagated species, such as willow, may be a single clone with traits desired for the intended use, a mixture of clones within a single desirable population, or a composite of clones from several populations. Woody plant cultivars

propagated from seed may represent a superior population, a composite of several populations, or a polycross of selected individual plants within and among populations.

Protection

Protection of the plant materials may be necessary to reduce damage from beaver, deer (*Odocoileus* spp.), elk (*Cervus elaphus*), livestock, and rodents.

Protective browse screens around the revegetation material may protect young saplings from deer, elk, and other browsing herbivores. Plastic tree guards can be particularly effective. Tared paper tree wrap is also a possibility for stem protection. Chemical protection is temporarily provided by an egg solids, nicotine, and bloodmeal mixture that is sprayed on the plant (J. Davis, pers. commun.). Other commercial products that deter animal use of the plants are available.

Installing raptor perches may help control rabbit and rodent populations, which should help reduce herbivory on revegetation material.

Maintenance

Considering the investment in artificial restoration, after-planting maintenance should be considered. J. Davis (pers. commun.) provides the following maintenance recommendations by season:

1. Late winter-early spring: pruning for height, damage repair, or stand flexibility; fertilization; plant protection from animal damage; repair of instream structures and exclosure fencing.
2. Mid- to late spring: pruning; fertilization; wildlife protection; repair of instream structures and exclosure fencing; mulching existing plantings.
3. Early summer: irrigation of cuttings and difficult microsite plantings; fertilization; directive pruning; repair of fencing, instream structures; mulching; soil and leaf analysis for fertilization monitoring.
4. Midsummer: final fertilization; intensive irrigation; remulching; plant protection from wildlife; fence and instream structure repair; removal of unwanted plants; pruning for directed growth.
5. Fall: mulching; wildlife damage protection; deep fertilization of plants after leaf fall; repair of fence and instream structures.

Slow-release fertilizers with trace elements can provide the additional boost necessary for plants to achieve their full growth potential in raw mineral soils. Inoculation of the planting hole with soil that has been removed from a healthy riparian stand can provide the necessary bacteria and rhizobia to the roots of newly planted stock. On poor soils, supplemental fertilizer may prove beneficial for up to 10 years. Organic matter can be more quickly introduced if compost, manures, peatmoss, bark, sawdust, or sewage sludge is introduced into the soils at the time of transplanting.

Mulch provides some weed suppression, reduces evaporation loss, and provides insulation from both solar heat and winter cold. Water table fluctuations may require supplemental irrigation. Deep irrigation will help encourage deep rooting of the plant.

Pruning may be helpful to direct growth, repair damage from snow, water, animals, and to preserve flexibility by removing larger stems during dormant seasons.

CONCLUSIONS

To accomplish riparian rehabilitation with native or any other vegetation, it is first necessary to assess the site potential to determine what kind of plant community is appropriate for the site. Persistence and extent of fluctuation of flow will often be the major factors. They are likely to encompass other relevant factors as well.

Proper grazing management is usually effective and sufficient to accomplish riparian rehabilitation with native species. Experience in Oregon with grazing management designed for specific riparian sites has indicated a great deal of potential for riparian improvement while the units including the riparian zones continue to be grazed. Riparian zones have increased in size (acres of wetted area), and native riparian plant communities have reappeared where grazing management was appropriate for the site.

Assuming site conditions are appropriate for artificial revegetation techniques, artificial revegetation can be effective if management goals require a faster time frame than management changes alone can accomplish. Artificial revegetation is subject to failure if not done carefully. Maintenance should be a part of the program. However, artificial revegetation is relatively expensive when compared to grazing management adjustments and sufficient time for the desired response is considered.

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FERAL EQUIDS IN THE WESTERN U.S.— A CONTINUING CONTROVERSY

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Abstract: Passage of the Free-Roaming Wild Horse and Burro Act in 1971 afforded feral equids on federal lands a degree of protection not enjoyed by most native ungulates. Nearly a quarter of a century later these exotic animals remain a contentious element in the management of western rangelands. Approximately 47,000 wild horses (*Equus caballus*) and burros (*E. asinus*) currently inhabit lands administered by the Bureau of Land Management and U.S. Forest Service, accounting for roughly 18% of the total ungulate biomass on the public lands. Populations exceed appropriate management levels in many herd areas. Removals in FY 1994 will probably exceed 95% of the expected annual increment, but the overall population remains nearly 70% above the appropriate management level. Research has focused on population dynamics of these animals, census procedures, and techniques of nonlethal herd reduction. Currently, promising methods of fertility control have been developed, although large-scale implementation remains problematical. In at least one location, predation by mountain lions (*Felis concolor*) is capable of limiting population growth of feral horses. A real need exists to determine the appropriate levels of equids that can be carried in multi-herbivore assemblages of native and domestic ungulates without detriment to rangeland and associated (i.e., riparian) ecosystems.

Keywords: *Equus caballus*, *E. asinus*, feral equids, fertility control, predation, population dynamics.

In 1971, the U.S. Congress passed unanimously a rather remarkable piece of legislation. The Free-Roaming Wild Horse and Burro Act (WH&B Act)(PL 92-195) effectively elevated 2 non-native species to the status of "national heritage animals" (Thomas 1979) and afforded them a level of protection not enjoyed by most native species. The law made it illegal to chase, capture, or kill feral horses and burros on Bureau of Land Management (BLM) or U.S. Forest Service (USFS) lands and banned commercial use of meat or other products derived from these animals. It recognized feral equids as "an integral part of the 'natural system'", and mandated their management "in thriving ecological balance with other legitimate uses of public lands." It designated responsibility for management of the animals to the BLM and the USFS, but provided these agencies with no cost-effective means of managing excess numbers. Because nearly 95% of the feral horses and burros inhabit BLM lands, it serves as the lead agency responsible for the animals' management (Boyles 1986).

From the outset the strict protection afforded feral equids has been a source of continuing and often emotionally charged controversy. PL 92-195 marked the entry of animal welfare-animal rights interest groups as a significant force in the arena of wildlife management. Horse protection advocates have played a pivotal role in influencing the federal agencies' implementation of the provisions of the act, most significantly pressuring the Congress and BLM to impose a moratorium on the destruction of healthy animals as a population reduction tactic. On the other hand, livestock interests contend that the numbers of feral equids on federal lands is excessive and the animals remove forage that could be used by cattle.

Approximately 65% of the feral horses occur in Nevada with an additional 14% in Wyoming. Virtually all of the feral burros occur in Arizona, California, and Nevada. The act does not protect feral equids inhabiting other federal lands, such as national parks and recreation areas, wildlife refuges, and military reservations. However, efforts to reduce or eradicate the animals from these lands have routinely met with strong opposition from animal rights advocates.

One measure of the controversial nature of the WH&B Act is the litigation it has generated. Since its passage there have been 44 district court suits and >200 appeals of BLM decisions (Pogacnik 1994). The law has been challenged and upheld by the U.S. Supreme Court (Kleppe v. New Mexico, 1976). In that decision the high court did not address the purported distinction between feral animals and native wildlife (Bean 1977).

Two subsequent pieces of legislation contained amendments to the WH&B Act that dealt with the problems posed by burgeoning populations and disposal of the animals removed. These were the Federal Land Management and Policy Act of 1976 (PL 94-579) and the Public Rangeland Improvement Act of 1978 (PL 95-514).

The objective of this paper is to examine the current status of feral equids and their impact on the sustainability of rangeland ecosystems.

PERTINENT RESEARCH FINDINGS

At the time of the passage of the WH&B Act we knew almost nothing about the ecology of feral equids or the number of animals occupying western rangelands. Agency-sponsored research during the intervening 2 decades has contributed significantly to our knowledge, particularly with respect

to 3 principal areas: (1) determination of demographic characteristics, (2) development of census procedures, and (3) fertility control. This information has defused some of the controversy that initially existed with respect to these questions.

In contrast to the 1970s, there is reasonable consensus among scientists and special interest groups on both sides of the issue that wild horse populations in most locations increase at rates approaching—and in some cases exceeding—20% per annum (Wolfe et al. 1989, Garrott et al. 1991). Following standardization of aerial survey procedures in the mid-1980s resulting from research conducted by Siniff et al. (1982), the agencies' estimates of horse and burro population trends enjoy greater credibility than previously. As will be explored below, fertility control currently is recognized as a potential means of limiting population growth in feral horse populations. One aspect that has received relatively less attention is that of the impact of feral equids on the ecosystems they inhabit.

REMOVALS AND CURRENT POPULATION STATUS

Since 1973 the BLM has captured and removed nearly 142,000 wild horses and burros from public lands to control excess populations. Because the destruction of healthy animals is prohibited, the primary vehicle for the disposal of captured animals is the Adopt-A-Horse program. Under this program nearly 123,000 animals (approx. 87% of those removed) have been placed into private care (Pogacnik 1994).

Until recently the BLM's approach to managing feral equids was largely reactive, emphasizing removal of excess animals after populations exceeded appropriate management levels (Pogacnik 1994). This type of "crisis management" frequently led to situations where the number of animals removed was greater than the adoption demand and resulted in huge costs for feeding and veterinary care as well as considerable negative publicity. Faced with the escalating costs of maintaining the excess horses in holding facilities, in the mid-1980s the agency entered into a fee-waiver program. This resulted in placement of some 20,000 horses with large-scale adopters. Eventually, many of these animals were sold to slaughterhouses, which generated additional negative publicity.

In 1990 the U.S. General Accounting Office (GAO) (U.S. Gen. Accounting Off. 1990) reviewed the BLM's management program for feral horses. Its principal finding was that existing information was insufficient to determine (1) the carrying capacity of the range for feral horses, (2) the extent of degradation caused by the horses, and (3) the appropriate numbers of animals that should be removed from individual herd areas. The GAO observed that the agency was unable to provide demonstrable evidence that rangelands had improved as a result of horse removals.

Largely in response to these criticisms, in 1992 the BLM adopted a more proactive approach with its implementation of a Strategic Plan for Management of Wild Horses and Burros on Public Lands. This plan recommends the use of fertility control measures to reduce population growth to levels where removals are required only once in ≥ 5 years instead of the present 3-year cycle. Pending availability of an efficacious and cost-effective fertility control procedure, selective removals of younger animals (i.e., those in their peak reproductive years) are being employed as an interim measure to depress the growth rate in horse populations (Pogacnik 1994).

The WH&B Act mandates the federal land management agencies to maintain a current inventory of the numbers of feral equids on the lands they administer, with the BLM serving as the lead agency. Aerial censuses are conducted on each of the 196 herd management areas (HMAs) on a rotating (triennial) basis.

Based on the results of the most recent census conducted in 1993, the BLM estimated the total number of horses and burros on the public lands at 46,500 animals (39,000 horses and 7,500 burros) at the beginning of FY 1994. This represents an 8.3% decrease from a comparable figure for FY 1992, largely because of aggressive removals during the previous 2 years. However, the 1994 population was nearly 19,000 animals above the appropriate management level of approximately 28,000 animals. The projected removal of horses and burros from lands administered by the BLM during FY 1994 is 8,000 animals. Assuming an average increase rate of 18%, these removals represent 96% of the projected annual increment to the initial population, producing a current population of approximately 47,000 animals.

ECOLOGICAL RELATIONSHIPS

The language of the WH&B Act declares feral equids to be "... an integral part of natural ecosystems" to be managed "... to achieve a thriving natural balance on the public lands". What the latter verbiage means is not specified and relatively little research has been conducted to determine the nature and magnitude of effects on the ecosystems they inhabit. These effects can be grouped conveniently into 2 categories: (1) interactions with other vertebrate species, and (2) impacts on the structure and function of ecosystems.

Ungulate Interactions

Most of the work has focused on resource use and potential competition between equids and native ungulates. Several studies have determined the food habits of sympatric herbivores by means of microhistological analysis of fecal samples and computed estimates of dietary overlap (Table 1). In most cases, comparisons were made using forage classes (i.e., graminoids, forbs, and browse), which will generally yield higher indices of overlap than if calculated on an

Table 1. Indices of dietary overlap (by forage class) between feral equids and native North American ungulates.

Combination	Location	% Dietary Overlap				
		Spring	Summer	Fall	Winter	Annual
Horse-pronghorn	Oregon ¹		7		26	
Horse-pronghorn	Nevada ²		13			
Horse-pronghorn	Wyoming ³	<1	4	10	<1	4.0
Horse-pronghorn	California ⁴	15	10	7	20	12.7
Horse-mule deer	California ⁴	23	13	9	22	16.7
Horse-mule deer	Colorado ⁵		1			
Horse-elk	Wyoming ³	26	14	70	52	40.5
Horse-bighorn	Montana ⁶					68.0
Burro-bighorn	Arizona ⁷					44.0
Burro-bighorn	Arizona ⁸	40	50			
Burro-mule deer	Arizona ⁷					12.0

¹ McInnis and Vavra (1987)	⁴ Hanley and Hanley (1982)	⁷ Potter and Hansen (1979)
² Meeker (1982)	⁵ Hansen et al (1977)	⁸ Seegmiller and Ohmart (1981)
³ Olsen and Hansen (1977)	⁶ Coates and Schemnitz (1989)	

individual species basis (Laundre 1994). In certain instances the equation used to calculate resource overlap was not specified.

Not unexpectedly, the results of these studies reveal minimal to moderate overlap between horses and browsing ungulates such as pronghorn (*Antilocapra americana*) and mule deer (*Odocoileus hemionus*) (Hanley and Hanley 1982, McInnis and Vavra 1987) with more substantial overlap between horses and grazers, namely elk (*Cervus elaphus*) and bighorn sheep (*Ovis canadensis*). The degree of overlap differs seasonally and by location. For example, Smith (1986a) noted that a few palatable shrubs such as winterfat (*Ceratoides lanata*) and horsebrush (*Tetradymia canescens*) may comprise 20–40% of the diet of feral horses in some areas. Overlap between burros and bighorn sheep is generally higher, in the magnitude of 40–60%.

It is generally acknowledged that dietary similarity does not translate *a priori* into resource competition. The species involved may forage in spatially segregated subhabitats, in which case they are not truly sympatric. Moreover, the nature of behavioral interactions will determine whether the competition is of the exploitation or interference type. Berger (1986) postulated that exotic ungulates can serve as either actual competitors or they may facilitate the foraging effectiveness of some native ungulates. The latter outcome can occur as the result of habitat modification (i.e., herbivory by one species increases the availability of resources for other species) or because of enhanced protection from predators.

Support exists for both scenarios, and the question assumes particular importance with respect to interactions between feral equids and bighorn sheep. Seegmiller and Ohmart (1981) determined a relatively high degree (40–50%) of dietary overlap between burros and desert bighorn sheep, but

observed no interference competition for access to either food or water. However, they predicted a competitive equilibrium would occur, in which the burros—by virtue of a larger population size and more aggressive demography—would displace the sheep in all but the most rugged terrain, which could not be exploited efficiently by the burros.

Although based on very small sample sizes, Coates and Schemnitz (1994) reported that male mountain sheep in association with feral horses foraged farther from escape terrain, thereby allowing them to use areas with a higher composition of grasses than areas used by conspecifics. The association also seemed to preclude aggressive encounters among male mountain sheep, thus giving them a higher foraging efficiency.

Ecosystem Impacts

Large herbivores can impact ecosystem structure and processes in a variety of ways, notably by: (1) changing vegetation species composition and structure, (2) reducing dead herbage and litter, (3) soil compaction and associated changes in infiltration and runoff, (4) possible changes in nutrient cycling regimes, and (4) changes in faunal composition and abundance as the result of these alterations.

These changes have not been explored adequately with respect to feral equids. Smith (1986b) postulated that the greatest impact of feral horse grazing would be on the grass component of selected habitats. He noted that ecological condition of ranges subjected to heavy use could decline to communities dominated by unpalatable shrubs, as could degradation of watershed conditions (i.e., reduced ground cover, soil disturbance, and compaction). However, such changes may have occurred as the result of grazing by other species. A substantial body of information currently exists pertinent

to the impact of domestic livestock, and, albeit to a lesser degree, some native ungulates on ecosystems. It is probably safe to generalize that the most important habitat modifications resulting from forage removal and trampling are likely to occur in fragile arid and riparian ecosystems. The condition of riparian areas has considerable implications for neotropical migrant birds (Knopf et al. 1988).

Because sizeable populations of burros occurred in areas administered by the National Park Service (i.e., Bandelier Natl. Monument, Grand Canyon Natl. Park, Death Valley Natl. Monument, and Lake Mead Natl. Rec. Area), numerous studies have been commissioned to investigate the impacts of burros on soils, vegetation, and native fauna. Unfortunately, the results of this rather extensive body of work reside largely in the "gray literature" such as unpublished theses, dissertations, and agency reports. As such they are difficult to access and frequently have not been subject to peer review. Douglas and Hurst (1993) reviewed this literature and compiled an annotated bibliography. Although not unanimous, the results of these studies considered cumulatively suggest several negative impacts of burros on relatively fragile desert ecosystems. These include (1) soil compaction and accelerated runoff as the result of trailing, (2) destructive foraging on certain shrubs and other plant species, (3) decreased plant species diversity and vegetation cover, and (4) decreased densities and species diversity of small mammals (Carothers et al. 1976).

Perhaps the most contentious aspect of burro impacts involve their interactions with certain high-profile vertebrate species. Burros and desert tortoises (*Gopherus agassizii*) are sympatric in portions of their respective ranges, and the U.S. Fish and Wildlife Service (U.S. Fish and Wildl. Serv. 1993) has identified several threats to the tortoises that are attributable to burros. The most significant are the elimination of native perennial grasses and the establishment of non-native annual weeds as well as soil damage. The Recovery Plan for the desert tortoise (U.S. Fish and Wildl. Serv. 1994) specifies no equid grazing in Desert Wildlife Management Areas, and the BLM is making provisions for complete removals from these areas. Quite probably these plans will meet with some public opposition and perhaps litigation.

Predation

Predation by large carnivores is generally considered as having negligible demographic impact on feral equids. However a recent study (Turner et al. 1992) documented that predation by mountain lions (*Felis concolor*) was limiting the growth of a population of feral horses on the California-Nevada border. During the 5 years of the study, cougars removed approximately 50% of the annual foal cohort during the first 6 months of life and was the principal factor responsible for a first-year survival rate of only 27%. The

predation process was mediated by seasonal prey-switching between horses and mule deer. Anecdotal reports indicate that similar phenomena may occur in other locations.

CONTRACEPTION AS A POPULATION MANAGEMENT TOOL

Interest in manipulating reproduction as a nonlethal solution to the problems of overabundant horse and burro populations dates back almost to the passage of PL 92-195. Garrott et al. (1992a) reviewed the subject of fertility control in detail; my coverage will be of necessity brief.

Male-based Approaches

The potential for male fertility control enjoyed early popularity because horses are polygamous with dominant males controlling harems of many females. Theoretically, treating these dominant males would inhibit reproduction in most females in the population. Two approaches have been explored experimentally. One involved the use of an injectable steroid that rendered males temporarily infertile (Turner and Kirkpatrick 1986), and the second tested vasectomies as a means of permanent sterilization (Eagle et al. 1993). Although both studies demonstrated reduced foal production attributable to treatment, Garrott et al. (1992a) concluded that the degree of suppression in foaling rates obtained by treating only dominant males is limited because the behavioral assumptions underlying the approach are subject to variation. These include harem stability, the tenure of the dominant male, and his ability to exclude other males from breeding. The questionable nature of these assumptions has been demonstrated in field studies of social structure (Nelson 1978, Miller 1979) and paternity (Bowling and Touchberry 1990). The results of a modeling study by Garrott and Siniff (1992) demonstrated that male-oriented contraception could disrupt the normal seasonal foaling pattern.

Female-based Approaches

Two procedures for female-based fertility control have been investigated in meso-scale field trials. One involves the use of surgical implants of a synthetic estrogen (essentially identical to that used in human birth control pills), which have been shown to prevent pregnancy for ≤ 3 years (Plotka et al. 1988, 1992). Field trials of this technique indicated reductions in the foaling rates of treated females of approximately 80% for 2 years posttreatment with continued but more modest depression of fertility in the third and fourth years. Aside from the necessity for field surgery, a disadvantage of this approach was that of the potential negative effects on horses and the environmental of the relatively large doses of synthetic steroids required (Gillis 1994).

An alternative procedure involves the use of immunocontraceptives. The contraceptive vaccine is derived from the zona pellucida, a protein membrane that coats mammalian eggs. The underlying premise of the vaccine is that females of a target species injected with the zona pellucida of another species produces an immune response. The resultant antibodies block fertilization in the target species. Kirkpatrick et al. (1990) tested a vaccine for domestic horses (Liu et al. 1989) derived from porcine zona pellucida (PZP). They inoculated free-ranging horses on Assateague Island National Seashore with vaccine delivered remotely by means of a dart gun. Foaling rates among treated animals were significantly lower than pretreatment levels and those of control animals.

Currently, the immunocontraceptive procedure enjoys a socio-political advantage with the BLM and animal-welfare and horse-advocacy groups because the vaccine can be delivered remotely, obviating the need for surgery. The principal drawback of the procedure is that multiple inoculations (≥ 2) are required initially with annual booster shots thereafter to maintain depressed fertility for >1 year. This translates to treating the animals annually. However, researchers are currently experimenting with a pulse-released microsphere vaccine, which ultimately could provide 2–3 years' contraception with 1 injection.

Despite the highly touted nature of fertility control, it is not a panacea. Modeling studies conducted by Garrott et al. (1992b) have demonstrated that for herds increasing at rates of 15–20% annually, treatment of a large proportion ($>50\%$) of the females in the population would be necessary to reduce the increment significantly. Accordingly, contraceptive programs cannot be expected to eliminate the necessity of removing excess animals from overabundant populations.

CONCLUSIONS

Passage of the WH&B Act essentially relegated the feral equid problem to the socio-political realm. Administration of the act's provisions has been an exercise in dealing with the increasingly protectionist tenor of American society. The strictures against nondestructive disposal of excess animals has forced agencies with a traditional commodity orientation to seek innovative means of population management. In this vein I concur with Wagner's (1983) assessment that the agencies' performance in complying with the mandates of the act has been generally satisfactory.

Despite the controversy that has beset the feral equid issue during the past 2 decades, some agreement has emerged on the part of rational segments of various interest groups. Specifically, there exists reasonable consensus that horse populations in many locations should be contained or reduced, provided that livestock numbers are reduced concurrently. The latter proviso is particularly contentious and has been the source of numerous recent appeals on the part of horse advocacy groups.

Whereas the removal and nondestructive disposal of excess horses and burros has been criticized as a relatively expensive program (see Godfrey and Lawson 1986), its costs are small compared to many other federal programs. More importantly, Berger (1991) argued that the expenditures of the BLM for management of "exotic" species (including domestic livestock) exceed those devoted to the stewardship of sensitive endemic species. Through better fiscal management and coordination, the costs to gather feral horses and prepare them for adoption have decreased in recent years from approximately \$1,000 to 650/animal. In contrast to earlier years, the BLM currently is able to dispose of most animals removed from the ranges through the adoption process.

The agencies have established "appropriate management levels" (AMLs) with the objective of reducing equid populations to meet these levels. In Nevada, determination of AMLs by the BLM is based on evaluation of data obtained from monitoring vegetation (generally collected over a 3- to 5-year period) to arrive at a provisional carrying capacity. Numbers of horses and livestock are then adjusted to fit these levels, based on land-use priorities for the management unit. To date the BLM has completed this process for roughly 60% of the HMAs, specifically the larger and more controversial areas (i.e., those with threatened and endangered species or significant riparian issues. AMLs for the remaining smaller areas or those with limited resource conflicts are targeted for completion by the end of FY 1995 (Pogacnik, pers. commun.).

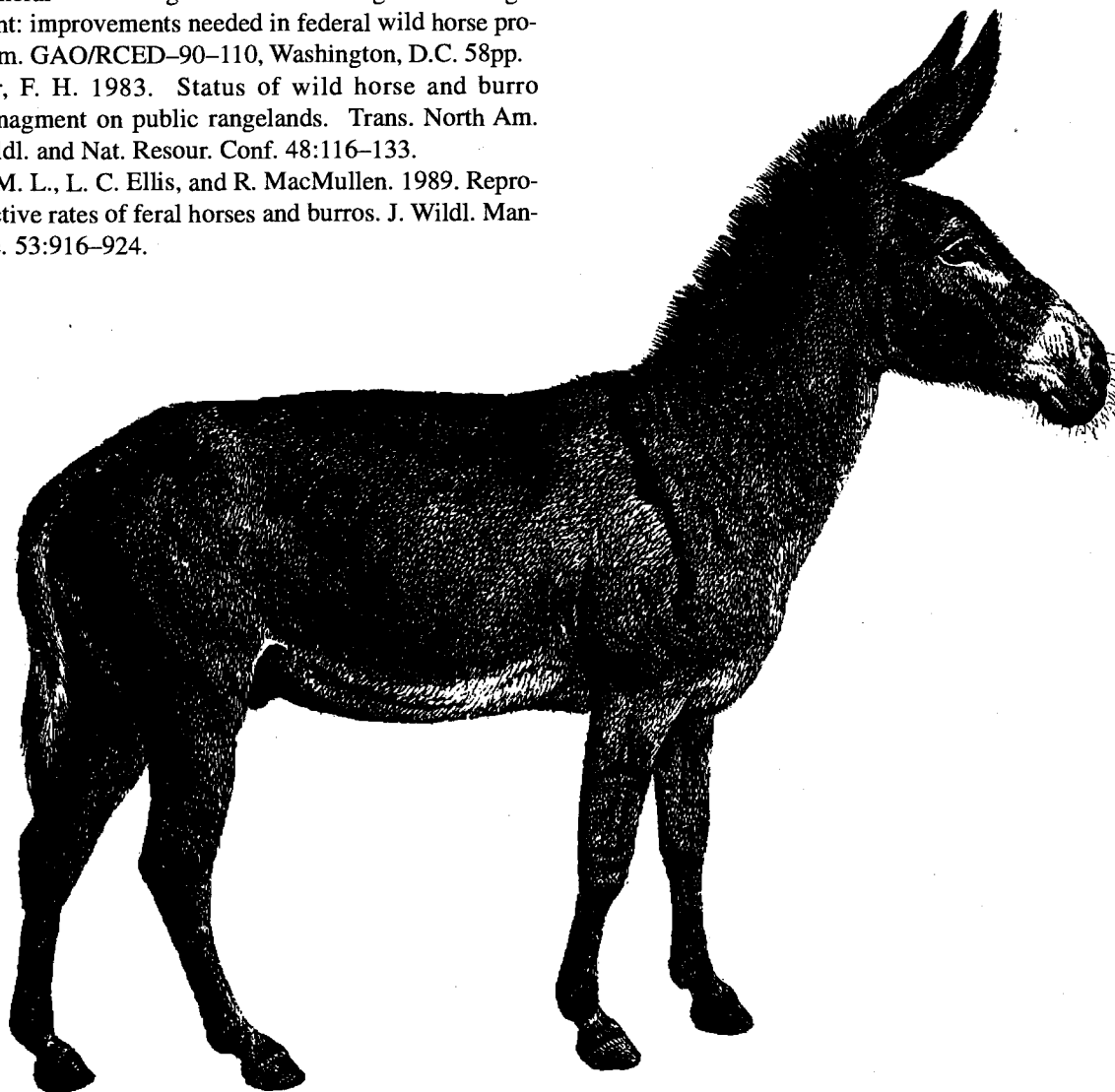
In my opinion, adequate research has not been conducted to separate the impacts of feral horses and domestic cattle on rangeland and associated ecosystems and determine carrying capacities for multispecies assemblages of herbivores. Some opportunity for adaptive management may exist here. Ecosystem condition should be assessed under current populations of feral horses on ranges with and without livestock. This would involve measurement of vegetation parameters and estimates of faunal composition and abundance. Following reduction of the horse populations to appropriate management levels, comparable measurements should be made to monitor the response of ecosystems. At the same time modeling approaches could be used to explore the anticipated effects of various levels of equids, native ungulates, and domestic livestock.

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PROBLEMS FACING BIGHORN SHEEP IN AND NEAR DOMESTIC SHEEP ALLOTMENTS

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Abstract: Bighorn sheep (*Ovis canadensis*) have coexisted with humans for 30,000 years but now face a precarious future. They are an ecologically fragile species, adapted to limited habitats that are increasingly fragmented. Of all livestock, domestic sheep pose the greatest danger to bighorn sheep. When bighorn sheep share rangelands with domestic sheep, all or most of the bighorn sheep die (most dieoffs are caused by *Pasteurella pneumonia*) and domestic sheep do not suffer ill effects because of their contact with bighorn sheep. Other diseases that may be transmitted between bighorn sheep and domestic sheep include scabies, chronic frontal sinusitis, parasites, pneumophilic bacteria, footrot, parainfluenza-III, blue-tongue, soremouth, paratuberculosis, and pink-eye. Because of the disease transmission between domestic sheep and bighorn sheep, they should not share the same rangelands. Recommendations to minimize the problems created when bighorns and domestic sheep are in proximity call for the avoidance of contact between the 2 species by ≥ 13.5 km.

Key words: bighorn sheep, disease, domestic sheep, *Ovis canadensis*, translocation, western United States.

Humans and bighorn sheep (*Ovis canadensis*) have coexisted in North America for 30,000 years (Hopkins 1967). Bighorn sheep constituted a source of meat protein for aboriginal humans in Asia, and early humans in North America. Seton (1929) estimated there were 1.5–2.0 million bighorn sheep in the contiguous United States before the arrival of European humans and another 2 million in Canada and Alaska combined. Seton's (1929) estimate of 4 million sheep in North America is cited often. However, Valdez (1988) doubted that sheep numbers ever exceeded even half a million for all of North America. Bighorn sheep have highly selective habitat preferences and are not distributed uniformly in the mountainous terrain of western North America. In Alaska, where most wild sheep populations (i.e., Dall's [*O. dalli dalli*] and Stone's [*O. d. stonei*]) still occupy vast regions of undisturbed (by humans) habitat, numbers do not exceed 50,000 (Nichols 1975). Buechner (1960) reviewed historical sheep distributions by state and estimated there were 15,000–20,000 wild sheep in the contiguous United States in 1960. In a recent survey by the U.S. Fish and Wildlife Service (unpubl. data) bighorn sheep biologists that represent each state in 1990 estimated there were 47,750 bighorn sheep in the contiguous United States. Throughout their range there are >188,000 bighorn sheep in North America. Dall's and Stone's sheep populations seem to have maintained their historical distributions and numbers. However, bighorn sheep populations of southwestern Canada, the western U.S., and northern Mexico have declined because of humans. These sheep have been reduced from relative abundance to among the rarest ungulates in North America. Unlike their ancestors in the Old World, humans in the New World never domesticated wild bighorn sheep. However, humans did bring domesticated livestock to the New World.

The major decline of bighorn sheep populations occurred during the latter half of the nineteenth century. It was during this period and the early 1900s that cattle and domestic sheep overgrazed much of the northwestern U.S. and probably southwestern Canada (Honest and Frost 1942, Packard 1946, Jones 1950, Foss 1960, McColm 1963). Heavy grazing of northwestern Mexico and the southwestern U.S. occurred in the early 1800s (Fradkin 1979). Bighorn sheep declined concurrent with peak cattle numbers in Arizona (Gallizioli 1977) and Nevada (McQuivey 1978). Similar trends were reported in Wyoming (McCann 1956). Other contributing factors to bighorn sheep reduction included habitat loss and human disturbances (e.g., dam, canal, fence, and road construction; mining; logging; urban expansion; extensive off-road vehicle use; unregulated hunting during the 1800s and early 1900s; unregulated outdoor recreation; introduction of exotic ungulates; competition with mule deer [*Odocoileus hemionus*] and elk [*Cervus elaphus*]; mineral, oil, and gas exploration; and the usurpation of water resources for growing agricultural and domestic demands).

Bighorn sheep clearly face a precarious future. They are an ecologically fragile species, adapted to limited habitats that are increasingly fragmented. My objective is to summarize the relationship of bighorn sheep throughout their range with domestic sheep and review recommendations to enhance the survival of bighorn sheep.

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DOMESTIC SHEEP, DISEASES, AND BIGHORN SHEEP

Bighorn sheep are potentially susceptible to many of the diseases of cattle and domestic sheep. Diseases of cattle that adversely influence bighorn sheep have not been documented, but diseases from domestic sheep have played an important role in bighorn sheep mortality. Throughout the western U.S., die-offs of bighorn sheep and population declines have occurred following the introduction of domestic sheep. Mortality was the result of competition for forage, space, and shared diseases (Goodson 1982). According to Goodson (1982:287)

"Co-use of ranges by domestic and bighorn sheep has been consistently linked with declines, dieoffs, and extinctions of bighorn populations from historical to recent times. While much of the evidence for competition between domestic sheep and bighorn is circumstantial, it is sufficiently strong to have prompted management decisions against co-use of ranges by bighorn and domestic sheep by federal land management agencies and state wildlife departments."

The Technical Staff of the Desert Bighorn Council (1990) reviewed 24 interactions between bighorn sheep and domestic sheep where bighorn sheep died as a result of the

interactions (Table 1). Recent experimental studies confirmed field observations; when bighorn sheep are exposed to domestic sheep, bighorn sheep die from *Pasteurella haemolytica* (Foreyt 1989, 1990, 1992; Silflow et al. 1993; Foreyt et al. 1994).

The actual mechanisms that kill bighorn sheep after they come in contact with domestic sheep are poorly documented (Jessup 1985) but 2 trends seem clear (Tech. Staff Desert Bighorn Council 1990): (1) a large proportion of the bighorn sheep population dies, and (2) domestic sheep do not suffer ill effects because of their contact with bighorn sheep. Bighorn sheep are clearly more susceptible than domestic sheep to diseases they both share. The most likely reason for this is that bighorn sheep have not evolved with the complement of diseases they are now exposed to in the presence of domestic stock. As a result they have not developed effective immunity against these diseases. Silflow et al. (1991) examined lung metabolism between domestic and bighorn sheep and concluded that they had different control mechanisms for lung metabolism and differences in the metabolites released led to different regulation of lung defense mechanisms.

Biologists are not aware of all the factors creating negative interactions between domestic stock and bighorn sheep but scabies, chronic frontal sinusitis, nematode parasites, pneumophilic bacteria, footrot, parainfluenza-III, blue-

Table 1. Bighorn sheep declines and die-offs resulting from contacts with domestic sheep.

Location	Cause of die-off	Results	Year(s)	Source
Sun River, Mont.		>70 died	1910-1935	Goodson (1982)
Upper Rock Creek, Mont.		All died	1965-1970s	Goodson (1982)
Thompson Falls, Mont.		All died	1940-1960	Goodson (1982)
Kootenay National Park, B.C., Can.	Pneumonia	Unspecified mortality (UM)	1939	Goodson (1982)
Bull River, B.C., Can.	Pneumonia	96% died	1965	Bandy (1968) in Goodson (1982) ^a
MacQuire Creek, B.C., Can.	Pneumonia	UM	1981-1982	Davidson in Goodson (1982) ^a
Lava Beds National Monument, Calif. ^b	Pneumonia	All died	1980	Blaisdell (1982)
Mormon Mountains, Nev.	Pneumonia	50% died	1980	Jessup (1981)
Dinosaur National Monument, Colo.		All died	1950	Barmore (1962) in Goodson (1982)
Rock Creek, Mont.		8 remained	1900-1920	Goodson (1982)
Rocky Mountains National Park, Colo.	Pneumonia	All died	1917-1930	Packard (1939a,b) ^a
Methow Game Range, Wash. ^b	Pneumonia	13 of 14 died	1979-1981, 1982	Foreyt and Jessup
Warner Mountains, Calif.	Pneumonia	All died	1988	Weaver (1988)
Oregon	Scabies	UM	1936	Lange (1980)
California	Scabies	UM	1870-1879, 1898	Jones (1950)
Grey Bull River, Wyo.			1881	Honess and Frost (1942)
Wyo., Mont.			1885	Hornaday (1901)
Colo.	Scabies	UM	1859-1931	Packard (1946)
Rocky Mountains National Park, Colo.	Scabies	UM	1878-1903	Lange (1980)
Latir Parks, N.M.	Pneumonia	All died	1978-1982	Sandoval (1988)
Utah State Univ., Logan ^c	Pneumonia	All died	1970s	Spillet in Goodson (1982) ^a
Univ. British Columbia, Can. ^c	Pneumonia	All died	1970s	Hebert in Goodson (1982) ^a
Colorado State Univ., Ft. Collins ^c	Pneumonia	All died	1970s	Hibler in Goodson (1982)
Utah State Univ., Logan ^c	Pneumonia	4 of 5 died	1988	T. D. Bunch ^a
Washington State Univ., Pullman ^c	Pneumonia	All died	1987	Foreyt (1989)
Washington State Univ., Pullman ^c	Pneumonia	All died	1987	Foreyt (1990)

^a Unpublished report or pers. commun.

^b Large pen or paddock.

^c University-controlled conditions.

tongue, soremouth, paratuberculosis, and pink-eye are documented decimating factors. Each of these was summarized by Jessup (1985).

Scabies

Scabies is a condition caused by mite (*Psoroptes* spp.) infestation and was unobserved in bighorn sheep before the introduction of domestic sheep (Buechner 1960). However, with the introduction of domestic livestock onto bighorn sheep ranges in the late 1800s and early 1900s, widespread declines of bighorn sheep were attributed to scabies (Hones and Frost 1942, Couey 1959, Bear and Jones 1973, Lange 1980, Jessup and Boyce 1993). This pattern was common throughout the West (Packard 1946, Couey 1959, Buechner 1960, Dean 1977). Scabies has been greatly reduced in domestic livestock, but remains in bighorn sheep populations.

A recent outbreak occurred in 1978 in San Andres National Wildlife Refuge, New Mexico. When scabies was discovered in 1978 there were 150 bighorn sheep on the refuge. The population declined to <30 by 1982 and has not recovered (Hoban 1990). Scabies was present in all animals during the epizootic but the actual cause of mortality for many individuals was not definitely determined. In addition, attempts to understand mite-host relationships have been inconclusive (Kinzer et al. 1983, Jessup and Boyce 1992), which further compounds our understanding of the relationship mites have with bighorn sheep.

Chronic Frontal Sinusitis

Chronic frontal sinusitis is an important cause of mortality in bighorn sheep, especially desert races. The disease is initiated primarily from bacterial decomposition of necrotic nasal bot fly larvae (*Oestrus ovis*) that die from entrapment in the paranasal sinuses (Bunch et al. 1978a,b, 1985; Paul and Bunch 1978; Allen and Bunch 1982). Progressive debilitation often results in weight loss (50%), draining lesions on the forehead, and blindness. Little is known about the effects of bot flies in bighorn sheep. Nasal bots are considered minor annoyances of domestic sheep but the sinusitis and subsequent osteonecrosis in desert races of bighorn sheep seem to be a major mortality factor that may have led to the demise of some populations and restricted population increases in others (Bunch et al. 1978a,b).

Nematode Parasites

Abomasal worms (*Hemonchus*, *Ostertagia*, *Trichostrongylus*), small intestinal worms (*Nematodirus*, *Cooperia*, *Strongyloides*, *Bunostomum*), and large intestinal worms (*Oesophagostomum*, *Chabertia*, *Trichuris*) are just a few of the internal parasites shared by domestic sheep and bighorn sheep (Jessup 1985). Their influence on bighorn sheep is usually with younger age classes causing direct blood loss and by contributing to malnutrition (Jensen 1974). These problems are especially magnified when bighorn and domestic sheep graze the same pastures.

Lungworms (*Protostrongylus stelesi*), especially during periods of stress, have been a principal cause of death for Rocky Mountain bighorn sheep (Wishart 1978). This nematode parasite seems to be unique to bighorn sheep (Jessup 1985) whereas the less common and less pathogenic *P. rushei* is common to bighorn and domestic sheep.

Pneumonic Bacteria

When bighorn sheep are held in captivity near domestic sheep the latter apparently transmit pneumonic bacteria (*Pasteurella multocida*, [Jessup 1981, Foreyt and Jessup 1982], and *P. haemolytica*, [Foreyt 1989, 1990; Silflow et al. 1993; Foreyt et al. 1994]) to bighorn sheep resulting in mortality. In cases where nose-to-nose contact was made with domestic sheep, bighorn sheep died within weeks. This phenomenon has been reported in California (Foreyt and Jessup 1982), Utah, Colorado, Wyoming, and Canada (Jessup 1985) and clinically demonstrated in Washington (Foreyt 1989, 1990; Silflow et al. 1993; Foreyt et al. 1994). Pneumonic bacteria (*P. hemolytica*) can cause fatal pneumonia in domestic sheep and cattle and can be a serious source of mortality in wild bighorn sheep.

Viral Diseases

Parainfluenza-III (PI-3), bluetongue, and sore-mouth are only 3 viral diseases that can lead to mortality in bighorn sheep. All 3 are also related to domestic stock; PI-3 is associated with shipping fever and feedlot pneumonias of cattle and is stress related. Bluetongue is a cosmopolitan virus that has been isolated from domestic sheep, goats, cattle, deer, elk, pronghorn (*Antilocapra americana*), and bighorn sheep (Jessup 1985). Bluetongue is transmitted by gnats (*Culicoides* spp.) that breed near water sources. Soremouth also is related to stress and can be transmitted from domestic sheep to bighorn sheep. This virus is not as deadly as others but may stunt growth of wild lambs.

Other diseases (e.g., Paratuberculosis or Johne's disease, pink-eye, and a *Chylamydia* sp.) also have caused mortalities in bighorn sheep (Jessup 1985). Bighorn sheep did not evolve with these and other diseases of European livestock and they are not "natural" to bighorn sheep. Jessup (1985:33) stated that bighorn sheep "... are possibly the most exquisitely sensitive North American wild ungulate to common livestock diseases and parasites." Because resource managers are unfamiliar with all of the mechanisms involved in disease transmission and treatment, Jessup (1985:33) further stated that the "best management strategy is to maintain bighorn herds at optimal nutritional planes, at or below carrying capacity and as widely separated as possible from domestic livestock." Bighorn sheep and domestic sheep do not coexist well together.

RECOMMENDATIONS TO MINIMIZE MORTALITY OF BIGHORN SHEEP ON RANGELANDS SHARED WITH DOMESTIC SHEEP

Because of disease transmission (Jessup 1985), most researchers agree that domestic sheep should not be grazed in bighorn sheep habitat. Jessup and Boyce (1992:559) state that "... the best management strategy involves the maintenance of wild sheep herds at optimal nutrition planes, at or below carrying capacity, and as widely separated as possible from domestic stock."

Lauer and Peek (1976) proposed a 2-fold approach for livestock in general: modify the livestock grazing system to minimize competition with bighorn sheep and improve the range condition of critical habitats. This supports Jessup's (1985) recommendation to keep livestock and bighorn sheep apart and maintain nutritional quality in the diet of the latter.

Goodson (1982:308) stated "On ranges where bighorn sheep are considered an important resource, domestic sheep should not be introduced. Where domestic sheep are currently grazed on bighorn ranges, reduction or elimination of such use is recommended if enhancement of bighorn status is a management goal."

The Technical Staff of the Desert Bighorn Council (1990:33) recently evaluated problems that arise when there is contact between healthy bighorn sheep and domestic sheep and concluded (from 25 cases [Table 1]) that (1) "There is a preponderance of evidence strongly linking the presence of domestic sheep with subsequent loss of part or all of the affected bighorn population," and (2) "The effects have all been 1 way—bighorns have died, whereas domestic sheep never have suffered ill effects because of coming into contact with bighorn." To minimize mortality of bighorn sheep caused by contact with domestic sheep, the Technical Staff of the Desert Bighorn Council (1990) made 5 recommendations.

1. Domestic sheep in the vicinity of desert races of bighorn sheep habitat should be managed so that bighorn sheep never come in contact with domestic sheep or the disease organisms that the latter carry.
2. Unless topographic features or other barriers prevent interaction between domestic and bighorn sheep, domestic sheep should be excluded from a buffer strip 13.5 km wide that surrounds bighorn sheep habitat.
3. Domestic sheep that are trailed or grazed outside the 13.5-km buffer strip but in the vicinity of bighorn sheep range should be closely supervised by competent, capable, and informed herders.
4. Domestic sheep should be trucked to ranges instead of trailed when the latter would bring them closer than 13.5 km to bighorn sheep range. When domestic females are in estrus, trailing should never occur.

5. Reintroductions of bighorn sheep should be avoided in areas where grazing has occurred by domestic sheep within 4 years. "The Technical Staff does not advocate the co-use of bighorn habitat by both bighorn and domestic sheep."

The effective management of bighorn sheep will have to be cooperative, especially on rangelands also used by domestic sheep. Clearly, domestic and wild sheep cannot coexist. However, there are pressures to allow domestic stock in the habitat of bighorn sheep. This can be a problem when different agencies are responsible for the management of sheep habitat and domestic sheep allotments. This is the situation in the Tri-State area (i.e., public lands on the Arizona Strip, Las Vegas, Nevada and Cedar City, Utah districts of the Bur. Land Manage.). The Bureau of Land Management in Arizona, Nevada, and Utah; Nevada Department of Wildlife; Utah Division of Wildlife Resources; and Arizona Game and Fish Department are developing an agreement to "... provide the basis for cooperative efforts to coordinate and facilitate management activities to benefit bighorn sheep (*Ovis canadensis nelsoni* on public lands ...)" in the Tri-State area (R. M. Lee, Arizona Game and Fish Dep., unpubl. agreement). The objectives of the agreement are to:

- Develop and implement ideas designed to enhance and protect bighorn sheep and their habitat in the Tri-State area.
- Identify the important characteristics of bighorn sheep habitat in the Tri-State area.
- Develop baseline bighorn sheep population demographic information and monitor their trends.
- Investigate factors affecting the health and vigor of the bighorn populations.
- Acquire and coordinate information necessary to facilitate multiple-use resource allocations and decisions.

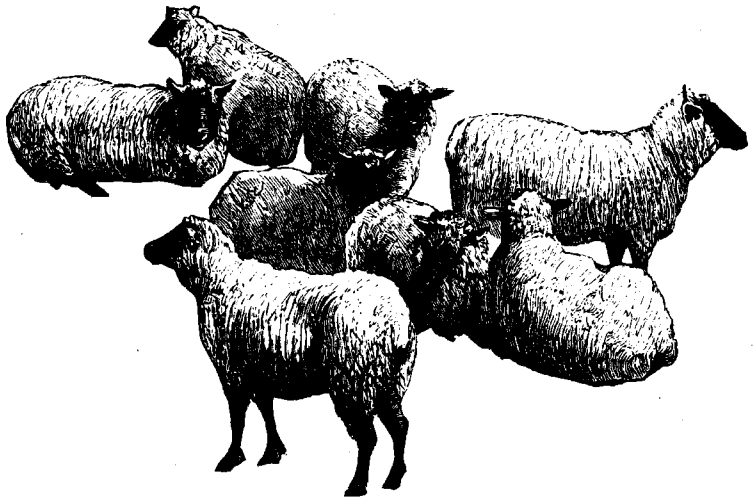
The last 2 objectives are critical to keeping domestic sheep and wild bighorn sheep separated in time and space. Only when this is obtained will bighorn sheep be free of the threats posed by domestic sheep.

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IMPROVING BIOLOGICAL CONTROL OF YELLOW STARHISTLE WITH GEOGRAPHIC INFORMATION SYSTEMS

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Abstract: Yellow starthistle (*Centaurea solstitialis*) is a noxious weed that infests >4,000 km² of rangeland in Oregon, and threatens thousands more. A 1992 state survey showed 269 townships in 26 counties infested with yellow starthistle, a 7-fold increase since a 1982 survey. Biological control has been implemented where traditional methods of weed control were ineffective or too costly. Since 1985, 5 capitula-feeding insect species from Europe have been introduced as biological control agents against yellow starthistle. All became established and 3 have been redistributed. Records were kept of each bioagent release and entered into a database. We used a raster-based geographic information system (GIS) that interacts with databases to measure the distance from infested townships to the nearest biocontrol release. The distance measures were coded, mapped, and prioritized in order to optimize the redistribution of biocontrol agents. Our goal is to reduce the mean distance measure of infested townships to < 1.5 townships from a biocontrol release.

Key words: biological control, *Centaurea solstitialis*, geographic information system, GIS, Oregon, weeds, yellow starthistle.

Yellow starthistle (*Centaurea solstitialis*) is an aggressive introduced plant that has become a noxious weed on Oregon rangelands. Originating from the Mediterranean area, it arrived in the Pacific Northwest in the late 1800s (Roche and Roche 1988). Yellow starthistle is a member of the knapweed genus, a group that contains several other noxious weeds. Yellow starthistle is not palatable to livestock once the flowerhead spines have formed. It is toxic to horses, and when consumed in sufficient quantities, will cause nigropallidal encephalomalacia, a neurological disorder called "chewing disease" (Cordy 1978). Yellow starthistle is a hardy plant that thrives in areas with hot, dry summers and well-drained soils, especially where vegetation has been disturbed (e.g., by fire, construction, overgrazing, etc.).

Without natural enemies to keep it in check, yellow starthistle flourished and spread. Estimates of yellow starthistle in the northwest include 3.2 million ha in California (Maddox and Mayfield 1985), 81,000 ha in Idaho (Callihan et al. 1989), 54,000 ha in Washington (Roche and Roche 1988), and 400,000 ha in Oregon. Conventional methods of weed control on yellow starthistle often have been ineffective because of lack of competitive vegetation, grazing practices, size of infestations, high cost, and difficulty of treatment. Infestations of yellow starthistle often become monocultures that displace important forage species and native flora.

Yellow starthistle is rated as a Class B noxious weed in Oregon. Control is generally at the discretion of the landowner or manager, and sometimes enforced by county weed control programs. Eradication and detection programs exist in counties where the distribution of yellow starthistle is limited and where it does not yet occur.

Integrated vegetation management uses combinations of chemical, cultural, physical, biological, and preventative control methods. The costs of conventional weed control practices against yellow starthistle often exceed the value or return on productivity of the lands to be treated. Chemical control has been the treatment of choice for large infestations. Many large projects have failed because of the lack of long-term commitment. Cultural practices such as grazing and competitive plantings can be effective in reducing the density of yellow starthistle. Experiments using combinations of herbicides, fertilizers, and competitive plants have shown partial success in Oregon (Larson and McInnis 1989). Prevention is an effective way to reduce the spread of yellow starthistle, especially by using seed certified as "noxious weed free" for reseeding projects. Despite the integrated practices employed against yellow starthistle, it has spread rapidly throughout the Pacific Northwest.

In 1985, the Oregon Department of Agriculture (ODA) in cooperation with U.S. Department of Agriculture Agricultural Research Service (ARS), began a yellow starthistle biological control program (Coombs et al. 1994). Biological control is a method in which selected natural enemies of yellow starthistle are reunited with the plant in order to reduce its abundance. To ensure that the natural enemies would not become pests, they were carefully tested under a strict scientific protocol for host specificity and environmental safety before they were released (Klingman and Coulson 1983). Five insects that attack seed heads have been introduced from Greece as biological control agents against yellow starthistle (Turner et al. 1994a). All new biocontrol agents were quarantined at the ARS Biological Control of Weeds Laboratory in Albany, California. Only agents found free of parasites and disease were shipped to Oregon for field release.

Our goals for the biological control of yellow starthistle were to import approved biocontrol agents, establish a nursery site in each infested county, and achieve a mean distance measure of 1.5 townships from release sites. We experimented with the use of a geographic information system (GIS) to increase the accuracy and speed of implementing biocontrol against yellow starthistle.

Portions of this project were funded through contracts with the U.S. Bureau of Land Management, the U.S. Forest Service, and the Bonneville Power Administration. We gratefully acknowledge the assistance of personnel from both agencies and the county weed control supervisors. We also gratefully acknowledge the efforts and assistance of C. E. Turner, ARS.

METHODS AND MATERIALS

Biological control agents were first released to establish nursery sites, from which surplus agents were harvested for redistribution to other counties (Coombs 1992). Data were recorded on ODA biological control agent release forms for each release. Information from the forms was entered into a database on a DOS-based microcomputer. The hard copies were stored in files by year, host, agent, and county. Nursery sites were monitored to determine establishment, spread, and impact of biocontrol agents.

In order to increase efficiency in the redistribution process, we used IDRISI (Eastman 1990), a raster-based GIS, using individual townships as management units (Isaacson et al. 1994). A matrix of Oregon by township was created, which required 50 rows and 67 columns. The Oregon noxious weed database and biological control agent release database records include a geographic reference number, which corresponds to a particular row and column in the township template. IDRISI interacts with each database to generate data layers for combination and analysis. Each layer can be overlaid as a separate template over the Oregon template. The totals for each cell in each corresponding template depicted the status of each township (i.e., 0 = non-Oregon, 1 = a township in Oregon, 2 = township infested with yellow starthistle, 3 = release site of a biocontrol agent). The distribution data for each biocontrol agent was placed in a separate file. Vector files also were created in order to plot general county border outlines for visual reference.

The distance module in IDRISI was used to generate a new layer from the biocontrol agent layer that showed the distance (in townships) from the nearest release. The distance layer was integrated with the yellow starthistle layer to remove uninfested townships. The resulting layer was integrated with the Oregon noxious weed database. The new database provided a real number for each infested township that represented the distance to the nearest release of a selected biocontrol agent.

The distance measures for each infested township were coded, mapped, and prioritized to reduce duplication and maximize redistribution of biocontrol agents. Infested townships closest to a release site were given the lowest priority.

By using a mouse, the row and column indicator was used to find positions on the map template. The row and column numbers corresponded to a township in a reference table (e.g., r8 c29 = T1N R14E). The mean distances from release areas were calculated in IDRISI by year and cumulative totals to show project status. A distribution ratio (total releases/total releases in new townships) was calculated.

Biological control agents were collected and shipped to cooperators, usually county weed control supervisors, throughout the state. Along with the shipments of biocontrol agents, a table of prioritized townships for release consideration was provided. Each cooperator was asked to decide which townships were suitable for biocontrol. We received feedback on which townships were unsuitable for biocontrol, errors in the database, and the release forms.

The collection of most biological control agents was done with an insect net. Adults were swept from plants during their early breeding period. Releases generally consisted of 100–500 adults. The seed head flies also were harvested by collecting the seed heads in the fall or spring while larvae or pupae were dormant. The infested plant material was placed at new sites, so adults could emerge naturally in the field environment. Proper handling of the biocontrol agents is critical during the collection and transportation process. Five insect species were introduced as biological control agents for yellow starthistle.

The gall fly (*Urophora sirunaseva*), Diptera: Tephritidae, a seed head fly, was introduced in 1985 and is established in California, Oregon, and Washington, and has been released in Idaho (Turner et al. 1994b). It has 2 generations/year and overwinters as larvae and pupae in galls. The larvae cause woody galls to form that act as nutrient sinks, reducing the number of viable seeds produced (Turner 1994). Infestation rates of the gall fly are 10–40%. Once established they spread rapidly. Adults can be collected during the bud stage.

The bud weevil (*Bangasternus orientalis*), Coleoptera: Curculionidae, was introduced in 1985 and is well established in California, Idaho, Oregon, and Washington (Coombs et al. 1994, Turner et al. 1994a). It has 1 generation/year and overwinters as an adult. Larvae can reduce seed production 50–60% (Maddox et al. 1991). Adults can be collected during the bud stage.

The peacock fly (*Chaetorellia australis*), Diptera: Tephritidae is a seed head fly introduced in 1989 and re-released several times. Establishment has only been confirmed in Oregon and Washington (Coombs et al. 1994, Turner et al. 1994a). It has 2–3 generations/year and overwinters as a pupa. First generation adults generally require bachelor button (*Centaurea cyanus*) as an early spring host when yellow starthistle buds are not available (Maddox et al. 1990). Larvae burrow throughout the seed head, damaging many of the seeds. Adults can be collected during the bud and flowering stage.

The hairy weevil (*Eustenopus villosus*), Coleoptera: Curculionidae, a seed head weevil, was introduced in 1990 and is well established in California, Idaho, Oregon, and Washington (Coombs et al. 1994, Turner et al. 1994a). The

weevil has 1 generation/year and overwinters as an adult. Adults feed on the developing closed buds, causing extensive damage. Larvae destroy most of the seeds in the seed head. This agent has a good potential to significantly reduce the density of yellow starthistle (Fornasari and Sobhian 1993). Adults can be collected during the late bud to early flowering stage.

The flower weevil (*Larinus curtus*), Coleoptera: Curculionidae, was released in 1992 and is established in California, Oregon, and Washington (Coombs et al. 1994, Turner et al. 1994a). It has 1 generation/year and overwinters as an adult. Females lay eggs in open flowers and larvae feed on the developing seeds (Fornasari and Turner 1994). Adults can be collected during mid-bloom.

RESULTS

In 1982 the ODA conducted a statewide survey that identified 38 townships in 10 counties infested with yellowstarthistle. The 1982 and 1992 ODA yellow starthistle survey data were entered and analyzed with the GIS software. In 1992, 269 townships in 26 counties were reported infested, a 7-fold increase in 10 years (Fig. 1). We estimate that this weed has achieved about 10–20% of its ecological potential in Oregon. Major infestations of yellow starthistle occur in Jackson, Josephine, Umatilla, Wasco, and Baker counties. Yellow starthistle is one of the fastest spreading noxious weeds in Oregon. It has a great potential to cause extensive reductions of livestock and wildlife forage, displace native flora, interfere with recreation, and impact threatened and endangered plants. The most susceptible habitats in Oregon include annual grasslands, south-facing slopes in sagebrush steppe, Columbia River Basin loess deposits, overgrazed pastures, and roadsides.

We began using GIS to assist us in our redistribution efforts in 1992. In 1993, we started using distance measures to identify target townships for new releases of bioagents. We attempted to ensure that most releases were made in townships where the specific biocontrol agent did not occur. Most releases occurred after 1989 (Table 1). A distribution ratio of 0.5 indicates that 50% of the releases of an agent were made in new townships. By using GIS, we hope to maintain a high distribution ratio during the first 5–10 years for each biocontrol agent.

If an insect becomes available for mass collection, then its availability allows for multiple releases in the same township. This is particularly true when treating several infested drainages and land ownerships that occur in the same township. We found that it was difficult to establish the gall fly in eastern Oregon. We made numerous releases at the same site for several years, thereby decreasing the initial distribution ratio (Table 1). Since 1985, there have been >300 biocontrol releases against yellow starthistle in Oregon.

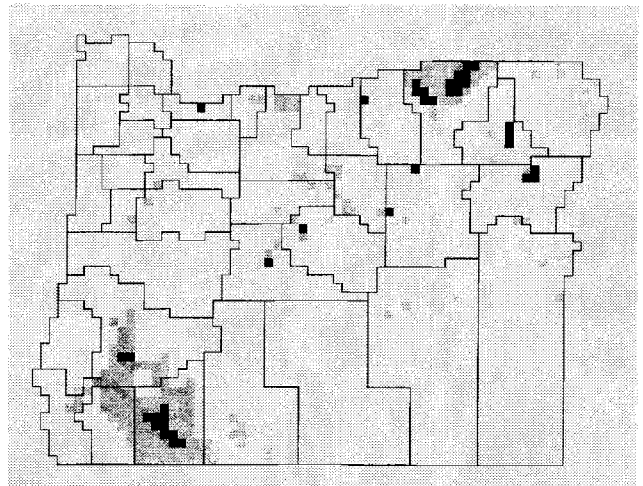


Fig 1. The distribution of yellow starthistle-infested townships in Oregon based on a 1982 (black) and 1992 surveys (gray).

The mean distance measures decrease each year if biocontrol agents are released in new townships and if the range of the target weed is not expanding (Table 2). Our work with the hairy weevil was enhanced by using GIS, as we were able to reduce the mean distance measure to 2.2 townships in 2 years. Our detection survey data was added to the noxious weed database annually. As yellow starthistle expanded its range, the distance measures from biocontrol agent release sites increased. That required our program to step up efforts to increase the number of releases and identify new release sites. With GIS analysis, the distribution ratios increased and mean distance measures decreased during the past 2 years (Table 2).

The gall fly has been released in 15 counties and is established in 5 (Fig. 2). GIS analysis allowed us to increase the cumulative distribution of the gall fly. A list of GIS-prioritized townships proposed for biological control releases of this gall fly for Wasco County were developed (Table 3). Similar lists for this and other biocontrol agents were sent with releases to other county cooperators throughout the state. The fly has become widespread throughout the Rogue Valley.

The bud weevil has been released in 12 counties (Fig. 3) and is established in 8. The bud weevil has established at most sites and seems to be spreading, but infestation rates have been low. At several sites, >95% of the seed heads had weevil eggs on them, but only 5% produced adults. Our distribution efforts were redirected to other more promising agents in 1994.

The peacock fly has been released in 3 counties (Fig. 4) but is only established in Josephine County, near Merlin. Initial redistribution has been limited to areas where bachelor button and yellow starthistle occur together, primarily Josephine and Jackson counties. The distribution ratio on this agent is high (Table 1) as a result of very limited redistribution. We did not do distance measures on this insect,

Table 1. Releases/year (No. rel.), cumulative total townships with releases (TR), and distribution ratio of biocontrol agents in Oregon against yellow starthistle.

Year	Gall fly		Bud weevil		Hairy weevil		Peacock fly		Flower weevil	
	No. rel.	TR	No. rel.	TR	No. rel.	TR	No. rel.	TR	No. rel.	TR
1985	1	1	1	1	—	—	—	—	—	—
1986	0	1	0	1	—	—	—	—	—	—
1987	0	1	1	2	—	—	—	—	—	—
1988	0	1	2	3	—	—	—	—	—	—
1989	5	6	1	3	—	—	1	1	—	—
1990	11	12	4	4	1	1	0	1	—	—
1991	9	19	10	9	1	2	1	2	—	—
1992	25	36	39	31	0	2	0	2	2	2
1993	27	47	17	45	34	26	1	2	1	3
1994	69	84	3	48	32	53	9	11	0	3
Total	147		78		68		12		3	
Distribution ratio	0.57		0.62		0.78		0.92		1.00	

Table 2. Mean (\pm SD) distance measures of biological control agent releases in Oregon by year and comparison year of weed database (DBYR).

Year	DBYR	Gall fly	Bud weevil	Hairy weevil
1989	1991	5.5 (3.9)	—	—
1990	1991	4.7 (3.8)	9.1 (7.0)	—
1991	1991	4.2 (3.9)	7.3 (7.3)	—
1992	1992	2.5 (1.8)	2.9 (2.2)	—
1993	1993	2.4 (1.8)	2.3 (1.6)	3.4 (3.0)
1994	1993	1.9 (1.4)	2.2 (1.7)	2.2 (1.5)

The hairy weevil has been released in 14 counties (Fig. 5) and is established in 6. The distribution ratio, 0.78, is high for this insect because we used GIS to minimize duplicate releases within a township. Adult weevils at the Myrtle Creek nursery site, in Douglas County, inflicted heavy damage on developing buds within 3 years of release. This insect seems to be the most effective biocontrol agent against yellow starthistle in Oregon.

The flower weevil has been released and established in 3 counties (Fig. 6). Redistribution of this insect may begin in 1995 or 1996. This insect will attack later flowering plants missed by the other biocontrol agents.

because we have not created a database for bachelor button, the secondary host. The seed head infestation rate near Merlin was about 30%, with most seeds destroyed (C.E. Turner, U.S. Dep. Agric, Agric. Res. Serv., pers. commun., 1994).

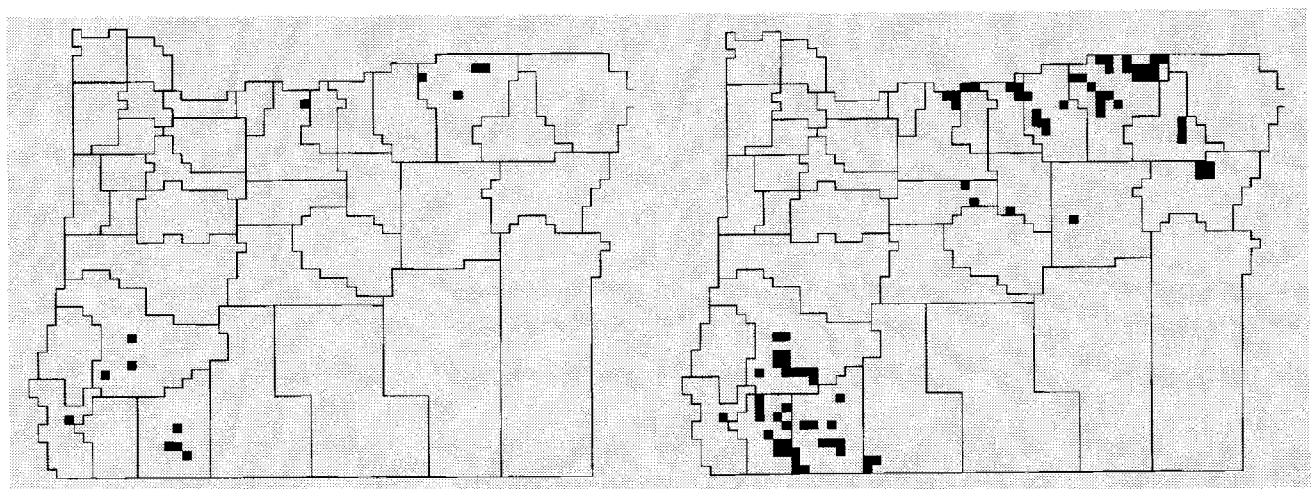


Fig. 2. Distribution of gall fly releases in Oregon by townships on yellow starthistle during 1985–90 (left), before implementation of GIS, and 1985–94 cumulative releases (right) using GIS.

Table 3. Priority classes determined by GIS distance measures (in townships) of yellow starthistle-infested townships from the nearest releases of gall flies in Wasco County, Oregon, for the 1994 field season. One is the highest priority class.

Township and Range	Distance from nearest release township	Priority class
08S 11E	9.26	1
08S 15E	7.37	1
07S 15E	7.28	1
07S 16E	7.27	1
08S 16E	6.56	1
05S 13E	5.58	1
04S 12E	5.16	1
01N 13E	1.45	3
01N 14E	1.01	4
02N 13E	1.01	4

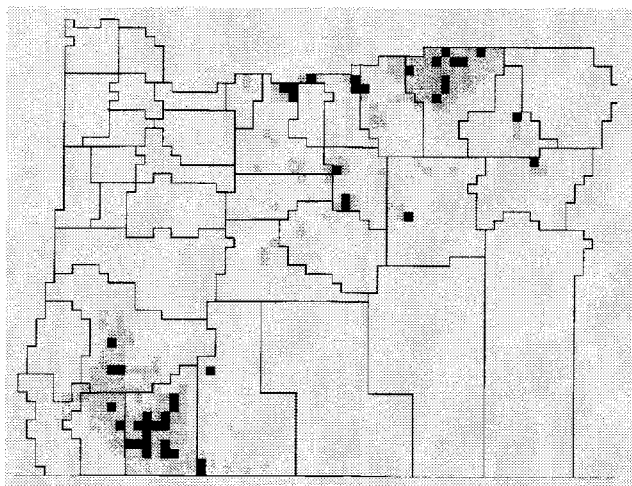


Fig. 3. Distribution of bud weevil releases (black) in relation to yellow starthistle-infested townships (gray) in Oregon.

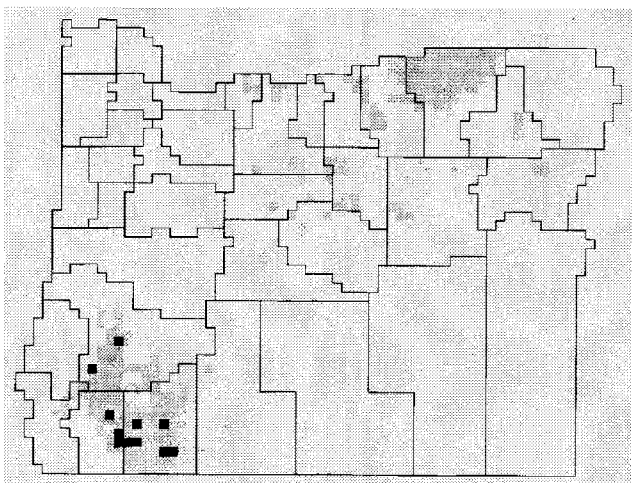


Fig. 4. Distribution of peacock fly releases (black) in relation to yellow starthistle-infested townships (gray) in Oregon.

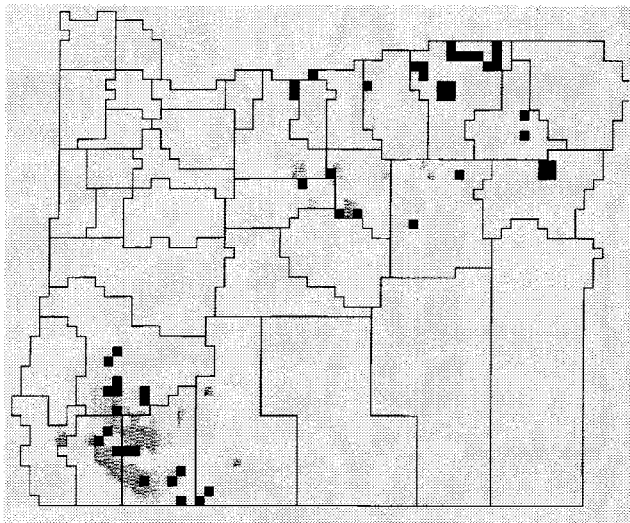


Fig. 5. Distribution of hairy weevil releases (black) in relation to yellow starthistle-infested townships (gray) in Oregon.

DISCUSSION

Our goal is to quickly establish each species of biological control agent in every yellow starthistle-infested township in Oregon. In time, the insects will naturally disperse and fill in the infested areas between releases. The technique of using GIS for biocontrol agent redistribution was also used by ODA against Scotch broom (*Cytisus scoparius*). We are attempting to incorporate the use of GIS to improve the redistribution and monitoring process of all biological control projects in Oregon. The databases developed for GIS analysis also can be used by other state and federal agencies.

The importation, establishment, and redistribution of natural enemies of yellow starthistle are important parts of the integrated vegetation management process. The use of GIS for implementing biological control will become a very important tool. As a result of decreasing funds and increasing numbers of biological control projects, we must become

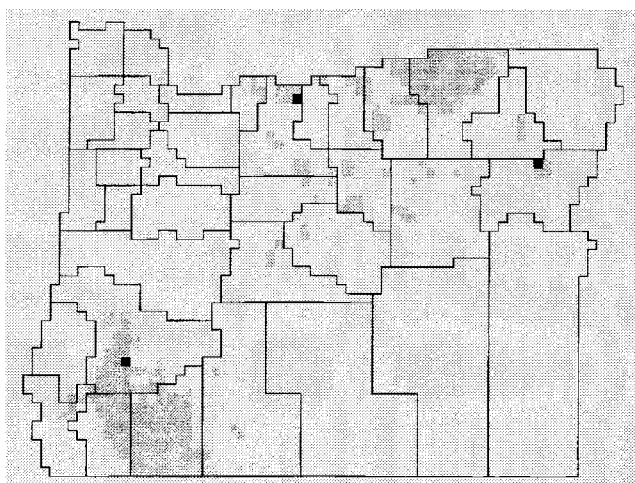


Fig. 6. Release locations of the flower weevil (black) in relation to yellow starthistle-infested townships (gray) in Oregon.

more efficient in the implementation process. Redistribution of biological control agents can be enhanced by modeling the relative rate of spread of an agent with GIS. Then the optimum distance between releases can be determined and release locations prioritized. Common sense must be used when relating GIS data to the field. It is likely that many areas classified as high priority by the computer are in reality areas under intensive control, where biological control is unwarranted. Those areas can be reclassified to reduce the number of target sites.

This integrated pest management approach will require a long-term commitment on the part of range managers and must be based on sound ecological principles. The statewide implementation of biological control against yellow starthistle, coupled with improved cultural practices in managing grazing and competitive vegetation, should improve infested rangelands.

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CHANGING SOCIAL AND ECONOMIC VALUES

RANGE, RANCH, REAL ESTATE: THE CONSTRUCTION OF A SUSTAINABLE LANDSCAPE

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Abstract: Sustaining rangeland ecosystems is a social process as much as an ecological one. It requires application of many of the same principles as those used in planning for wildlife reserves, but the tenets of conservation biology need to be applied to conserve social as well as ecological structural elements and processes. In some landscapes, a crucial element in a sustainable, culturally meaningful, and ecologically rich rangeland landscape is ranching, which is at once a collection of ecological processes and interactions, and an expression of human community. Results of several surveys and case studies are used to highlight the "culture clashes" that occur at the ecological and social edges of landscape elements. Unfortunately, differing expectations of what conserved areas should be like has hindered the alliances between environmentalists and ranchers that might prove effective in preventing the degradation of the landscape by uncontrolled residential and urban development. The successful planning and alliance building that led to the conservation of the ranchlands and parklands of western Marin County, California, is described and analyzed. In this case, zoning, conservation easements, political and financial support for the livestock industry, community leadership, and recognition of the heritage value of rural lifeways all played a part. To conserve many of the most productive and biodiverse rangeland landscapes, ranching must not just be tolerated as a means to an environmental end, but valued and planned for, ecologically, socially, and economically.

Key words: California, conservation easements, culture, demographic change, development, land-use planning, Marin County, ranching, urbanization.

Defining, building, and maintaining a landscape that includes sustainable rangeland ecosystems requires application of many of the same principles as those used in planning for wildlife reserves, but the tenets of conservation biology need to be applied to conserving social as well as ecological structural elements and processes. Implementing these principles also calls for the participation and cooperation of the diverse social groups that make up a rich, balanced, future landscape. We argue that one of the most crucial elements in a sustainable, culturally meaningful, and ecologically rich rangeland landscape is ranching, which is at once a bundle of ecological processes and interactions, and an expression of human community. Uncontrolled development fragments ranchlands, creating social and ecological edges that eventually diminish the rangeland ecosystem. Unfortunately, differing expectations of what conserved areas should be like has hindered the alliances between environmentalists and ranchers that might prove effective in preventing the degradation of the landscape by

uncontrolled residential and urban development. In this paper we explain why ranching is a key patch in the quilt of tomorrow's sustainable rangeland landscape, and we address 2 major aspects to planning for such a landscape: (1) why planning is needed to minimize edge, maximize connectivity, and protect core areas in both ecological and social dimensions; and (2) how differing landscape ideologies can hinder alliances that can support, develop, and implement planning.

We conclude by describing a successful land use planning effort to conserve the grazing and dairylands of western Marin County, California, and the alliance-building between ranchers, planners, and environmentalists that made it work.

CALIFORNIA AS CASE STUDY

California provides a case study in the influence of socio-economic forces on the status of rangeland ecosystems. Often dismissed as an irrelevant outlier, we believe California

is in some ways at least a harbinger of changes to come in other parts of the West. In fact, California has contributed vast numbers of citizens to surrounding states in recent years (Starrs 1995) but even without this direct infusion the trends are familiar: rapid population growth, expanding urban areas, proliferating ranchettes, and suburban sprawl.

CALIFORNIA RANGELANDS INCREASINGLY FRAGMENTED

About half of California's 41 million ha is public land, the rest is privately owned. Of the 25 million ha of land generally defined as rangeland and desert in the state, 7.5 million ha are owned by ranchers (Forero et al. 1992). Not only are private rangelands the most productive for livestock grazing, they support the highest densities and diversities of wildlife species in the state. Producing >10 times the forage grown on the state's public rangelands, California's ranchlands are predominantly made up of annual grasslands, oak woodlands, and chaparral shrublands. Of these, annual grasslands and oak woodlands provide the vast majority of the forage for livestock grazing.

Compared to the state's other major vegetation types, forest and desert, the woodlands and grasslands of the state are overwhelmingly in private ownership. As an example, of the 3 million ha of oak woodland, <20% is in public ownership, compared to 76% of the state's forests and 80% of its deserts (Ewing et al. 1988). Shortly after the turn of the century, when California's agricultural development began in earnest, millions of acres of woodlands and grasslands were converted to crop production. Today California's ranchlands are mostly in the foothills and coast ranges, where steep topography, poor soils, and limited water made crop production infeasible. In this wooded refuge California range livestock production has continued relatively undisturbed until the last decade or 2. Recent demographic and technological developments are now changing this landscape.

California's population continues to grow, estimated to reach 36 million by the turn of the century. Formerly confined to major transportation centers like the San Francisco Bay, the Sacramento River, and the Los Angeles Basin, the urban population of the state is making rapid inroads into the foothills and coast ranges in search of less costly housing, expansive mansions, or the ranchette lifestyle. Once sleepy, retired, gold rush communities, some central Sierran foothill towns are now the most rapidly growing in the State. Expanding out from the San Francisco Bay, the hills of Contra Costa, Alameda, San Mateo, Solano, Marin, and Sonoma counties are increasingly fragmented by subdivisions and ranchette developments.

All this has had tremendous and not yet fully appreciated effects on our woodlands and grasslands. A statewide survey of oak woodland owners in 1985 and 1992 showed that most ranches are now <5 miles from a subdivision, and that the average size of rangeland properties is shrinking (L. Huntsinger, unpubl. ms.; Huntsinger and Fortmann 1990).

The 1992 survey also revealed that more than a third of the woodlands had changed hands in 7 years, and approximately 5% were known to have been subdivided for intense residential development during that period (L. Huntsinger, unpubl. ms.). The pattern of urban expansion seems to be that the more level lands are developed first, with croplands close to town centers the first to be converted for housing on a large scale. As pressure intensifies, however, and as the amenity values of oak woodlands become increasingly popular, housing expands into the woodlands (Forero et al. 1992). A compilation of data from sources estimating oak woodland extent over the years since 1932 shows what seems to be an increasing rate of decline (Fig. 1.)

RANGLANDS AS BUFFER

When we talk about sustaining the rangeland ecosystems of California, we are to a large extent talking about ecosystems that are owned and managed by ranchers for livestock production: ranchlands. The economic imperatives for

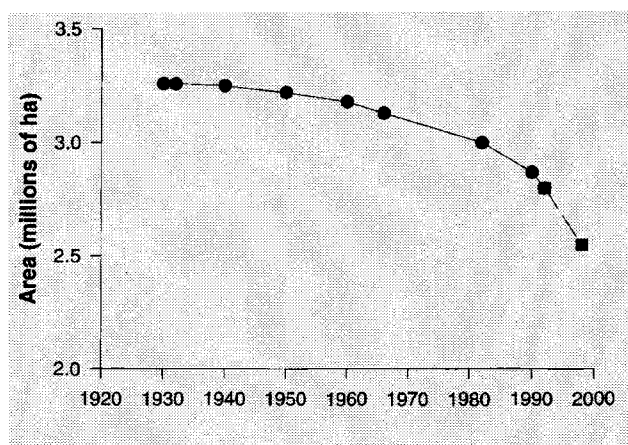


Fig. 1. Extent of California oak woodlands, 1932-92 (from L. Huntsinger, unpubl. ms.; Bolsinger 1988; Ewing et al. 1988:63).

preserving rangeland livestock production in an urban state are controversial; it is the conservation imperatives that are most clearly beyond debate. Land used for ranching acts as a buffer between urban areas and wildlands, offers high-quality wildlife habitat, watershed, and open space, and provides a spectrum of public goods. The problems caused by not having a buffer zone of intermediate use around national and state parks are well documented and increasing (Huntsinger et al. 1995).

Environmental interests and public agencies simply do not have the money to buy extensive areas of private ranch land for open space and wildlife habitat, especially when they are competing with development dollars. A ranching economy provides a tax base, and the land is cared for by people who are off the government payroll. Basic credos of conservation biology tell us that we need larger core areas of habitat, and connected areas of habitat, to protect larger wild-

life species and species with special needs, and to permit adequate gene flow. Extensive land uses like ranching supply such expanses of habitat.

RANCHLAND AS CULTURAL AND ECOLOGICAL RESERVE

Concepts of connectivity and core areas for protecting reserve ecosystems also apply to ranching communities: unless a "critical mass" of ranchers remains in an area, ranching communities find themselves whittled down by incremental development to the point where the community is no longer economically viable, even for determined holdouts (Daniels 1991). Ranchers rely on other ranchers and the rural community for social as well as economic reasons, for outside jobs, informal labor pools, and support services (Smith and Martin 1972). In addition, as with any preserve, minimizing the amount of edge between ranchland areas and different land uses such as subdivision and ranchette development is important.

THE ISSUE OF EDGE

This expanding land conversion has direct effect on California ranchers. Whereas in eastern Oregon the types of clashes we discuss often have more to do with visitors from urban centers, the root causes and many of the results are the same: population growth and accompanying value shifts are bringing people with very different ways of looking at the landscape into more frequent contact. The lives of urban and rural dwellers are becoming increasingly intertwined, and unfortunately often tangled. The physical expression of this entanglement can be found at the urban-wildland interface.

As urban development advances into rangeland, the business and cultural practices of ranching are hampered. When ranches and suburbia meet, the resulting "clash of cultures" or lifestyles makes running a livestock operation more difficult and less profitable, increasing the likelihood that the rancher will decide to sell his or her land for further development.

Ranching at the urban-rangeland interface becomes more difficult (Hart 1991:90, Forero et al. 1992, Hargrave 1993:49) as a result of factors such as:

1. marauding dogs;
2. introduction of exotic plants;
3. vandalism, trespass, carelessness with gates and fences;
4. restrictions on traditional management activities, such as prescribed burning, or predator, weed, and pest control;
5. the "impermanence syndrome:" anticipating seemingly inevitable development, ranchers postpone ranch improvements, perhaps do not take as good care of their land (Heimlich and Anderson 1987, Daniels 1991, Hart 1991:54); or

6. increased liability costs because of greater number of cars, stray livestock, and trespassers.

New suburban neighbors too may find that their home adjoining ranch land is not as idyllic as they had hoped because of:

1. stray livestock causing property damage, fence damage, and automobile accidents (Ellickson 1991:35);
2. slow ranch vehicles or livestock blocking commuter traffic;
3. unaccustomed smells, noises, and other side effects of ranching;
4. the possible threat of pesticide or fertilizer residues in soil, air, and water;
5. water pollution from contaminated run-off; or
6. the unexpected demise of a (stray) family pet(s).

Pervasive, however, in the relations between ranchers and those suburbanites who live adjacent or near to ranch properties is "culture clash." Many of those moving to rural areas from cities simply do not understand the ethics or traditions of rural life, and even if they did, often do not have the resources to comply. For example, views of how to resolve disputes or work with institutions are fundamentally different. In a recent survey of ranchers in Tehama County, most of those surveyed said that if stray stock wandered onto their property, they would either round up the animals and return them or call the owner and discuss the procedure for rounding them up and returning them, rather than call any of the agencies or legal entities responsible for animal or livestock control (L. Huntsinger et al., unpubl. ms.). The suburbanite is used to relying on institutions and officialdom when concerned about a legal infraction such as trespassing stock. New ex-urban residents may not even be able to tell whose stock is involved when the animals wander onto the driveway or into the back yard. Yet they also do not understand the rancher's disgust when the police or animal services are contacted. Ellickson's (1991) work in Shasta County, *Order Without Law*, documents the tendency among ranchers to resolve disputes within their own groups through peer pressure and avoidance of outside intervention.

Despite conflicts and misunderstandings, these new neighbors share some values: both ranchers and urbanites on the edge generally share a fondness for natural landscapes. Suburbanites often have paid a premium to be at the edge. Ranchers have in many cases sacrificed opportunities for easier or more lucrative careers to stay in the country and work in the open air.

Suburban dwellers often appreciate having a rancher keep a eye on the open space, to prevent vandalism and other uncontrolled activities. In much of California, grazing is valued for fire control, a great concern to those at the wildland interface. These kinds of commonalities can help people overcome differences. In one notorious California case, af-

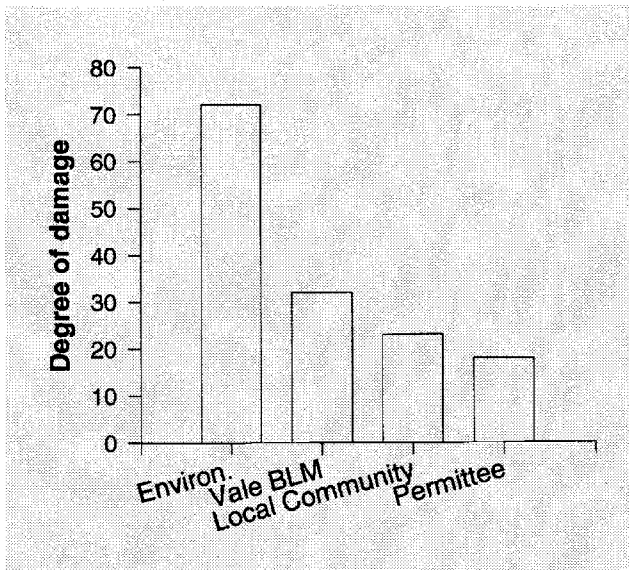


Fig. 2. Perceived degree of environmental damage on Malheur County rangelands, by environmentalists, Bureau of Land Management, local community and permittee, 1987 (Huntsinger and Heady 1988).

fluent suburbanites living next to a state park sued when a decision was made to remove grazing because they were concerned about fire hazard (Huntsinger et al. 1995). Anticipatory planning that provided a ranchland buffer around the park would have improved the park's ecological potential and prevented a long and alienating battle between the park and local residents.

Land-use planning is needed to prevent the urbanization of ranchland buffer zones. Unfortunately, ranchers are often uncomfortable with the concept of land-use planning. It is associated with what they perceive as an accelerating erosion of property rights. About half of the ranchers in a recent survey of ranchers in Tehama County stated that local and statewide land-use planning was a serious threat to ranching (L. Huntsinger et al., unpubl. ms.). On the other hand, the overwhelming majority of ranchers expressed a desire to see their ranchlands remain in private ownership and used for livestock production in perpetuity, and universally objected to the prospect of residential development on their land when and if sold (L. Huntsinger et al., unpubl. ms.). Yet very few wanted to see their land designated as "open space," owned by a nonprofit organization, or in the hands of a public agency. The rancher generally has a fundamental affection for the ranching lifestyle and believes that land should be used **productively** (L. Huntsinger et al., unpubl. ms.). In general the rancher also dislikes the involvement of outsiders, particularly agencies and bureaucracy, in land management.

Finally, land value often is a significant part of a rancher's financial portfolio. One study in the central Sierra showed that ranchers in the last decade had a higher return from land appreciation than livestock production (Hargrave 1993). But this return remains unrealized until the property is sold, and it follows that the rancher is threatened by land use restric-

tions and regulations that might impinge on the ultimate sale value of the land—whether or not the rancher plans to sell the land in the near future. Ranchers, especially those close to retirement, are often nervous about losing the right to develop their land (Gobster and Dickhut 1988). The ranch's development value, not revenue from ranching, may be their sole major investment. In the Tehama County survey, about a fifth of the ranchers indicated that they considered land appreciation an important motivation to retain their land and keep ranching. Just as many, however, indicated that an important motivation was to encourage their children to continue ranching, and about two-thirds had their land in the California Land Conservation (Williamson) Act. The Williamson Act provides tax relief to landowners who agree to keep their land in agricultural production through annually renewable 10-year contracts (Forero et al. 1992). At the same time, two-thirds of Tehama County ranchers claimed that overregulation was a reason they might throw in the towel (L. Huntsinger et al., unpubl. ms.).

THE NEED FOR COALITION

Alliances are needed to create a sustainable ranchland landscape. The best intended land-use planning and zoning often give way to the financial might of the development industry. Bringing diverse groups in line to support a General Plan or zoning decision is necessary to create a stable land-use pattern that will limit land speculation and its unfortunate consequences. This includes urban-based environmentalists who can bring considerable financial and political support to efforts to fund conservation easements and development rights swaps, as well as the ranchers who own and manage the land.

A PROBLEM OF PERCEPTION? ENVIRONMENTALISTS AND RANCHERS

In general, ranchers and environmentalists are not overjoyed with one another. Almost 90% of ranchers in Tehama County, for example, felt that "environmentalism" was a serious threat to ranching. In a 1987 survey of ranchers and environmentalists in Malheur County, Oregon, the 2 groups were diametrically opposed on the issues of grazing and "wilderness designation." Environmentalists thought that there was simply too much grazing going on in the county, whereas ranchers thought too much valuable rangeland was being set aside as wilderness (Huntsinger and Heady 1988). On the other hand, the great majority of ranchers in Tehama County stated that "feeling close to the earth" was an important reason they kept on ranching. In the statewide surveys of oak woodland landowners, most ranchers reported that being "near natural beauty" was an important reason why they chose to live and work in the woodlands (Huntsinger and Fortmann 1990).

Ranchers and environmentalists share a common joy in rangelands and nature. Why then are they so alienated from one another? We argue that the alienation arises from different expectations of nature, and that in fact, the differences between these groups arise not so much in what they want, but in what they see and in how they think about the past.

In the Malheur County study, there were great differences in how ranchers, environmentalists, local community members, and Bureau of Land Management (BLM) employees viewed conditions on the same rangelands (Fig. 2)(Huntsinger and Heady 1988). Ranchers tended to see grazed rangelands as being in good shape, no doubt because for them, a rangeland that looks well-used is one that looks good. The environmentalist, on the other hand, expects a natural area to look pristine or untouched. This expectation is unattainable on land used for livestock production. Because of this fundamental value difference, environmentalists have long dismissed the environmental values of grazed rangelands.

A typical woodland stockpond provides another example of the difference in how the 2 groups interpret the landscape. The environmentalist sees the stockpond as valuable wildlife habitat, a refugia being trampled and polluted by cattle. The rancher sees a structure built 30 years ago by a forbearer for the express purpose of watering cows. It can be argued that both groups are influenced by nostalgia for an imaginary past. For the rancher, the past was a time when being a rancher meant unrestricted freedom to do as one pleased, a time when the best in American cultural values were represented by the independent, self-sufficient, and honest cowboy. The cow is a symbol of the productive use of a harsh land.

The environmentalist, on the other hand, often sees the cow as a symbol of the rapacious defilement of a glorious pristine natural wonderland, the human influence having been nothing but negative since European settlers arrived in the West. In our view, both are nostalgic about imaginary past landscapes. Nonetheless, this nostalgia pervades their interpretation of natural ecosystems.

Ranchers feel threatened by the public interest in their lands. Rangeland ranching, with its open, undeveloped character, appears "public" to urban visitors and suburban residents, and that is because it is a rich source of public goods. In recent decades, the public interest in extensive private properties is typified by the increasing popularity and use of the term "open space." Open space is a term designed for private lands that provide public goods, and it has become ubiquitous. The rancher clings to the idea that private property ownership means the right to do as one chooses with one's land, instead of use rights designated through social contract. How can ranchers, environmentalists, and suburbanites, each with widely divergent views of what the "right" landscape is, and how to attain that landscape, be brought to the table?

CASE STUDY IN COLLABORATION: PRESERVATION OF RANGELAND IN MARIN COUNTY

In Marin County, California, ranchers, open-space advocates, environmentalists, and planners successfully forged an alliance based on compromise and their mutual interest in preserving rangeland ecosystems, open space, and the ranching way of life. This success is described in John Hart's (1991) book, *Farming on the Edge*.

Immediately north of San Francisco, Marin County comprises a highly-developed urban corridor to the east and a western agricultural zone of rangeland dairies, and beef cattle and sheep ranching. In the late 1960s, the county's General Plan described a vision of massive conurbation linked by freeways infiltrating the whole county. At the time, urbanization of western Marin seemed the logical outcome of Marin's proximity to San Francisco and the apparently inevitable demise of its faltering historical dairy industry. A substantial portion of the coastline area had been preserved in 1962 with the creation of the Point Reyes National Seashore and later the Golden Gate Recreational Area, and the dairies within the Seashore were allowed to lease back land and continue operating. As for the rest of western Marin's ranches, the General Plan assumed they would be quickly sold and subdivided, bringing suburbia right up to the borders of the Seashore. But in the early 1970s, conservation-minded county planners and environmentalists from urban Marin, concerned at the loss of open space and the rural character of the agricultural zone, pushed through a zoning ordinance requiring all lots in the zone to be ≥ 60 acres. It was hoped that this regulation would counter the pressure of rapidly escalating land prices by creating lots large enough to discourage development, but not so large as to result in "takings" challenges.

Zoning and Tax Assessment as Land Preservation Strategies

Zoning can offer significant protection to agricultural land. Although vulnerable to changes in political climate, to the siren call of property taxes from large projects, and to legal challenges of taking, zoning can reduce development pressure while a more permanent land preservation solution is being devised (Atash 1987, Daniels 1991, Hart 1991:53). In addition, because it is not contingent on landowner consent, zoning can protect large, contiguous areas of agricultural land (Daniels 1991). In areas experiencing only low-level development pressures, zoning, especially if part of a region-wide plan, may serve as a powerful and inexpensive method of long-term agricultural land preservation (Daniels 1991).

A less effective tool, primarily intended for promoting agricultural production but with land preservation potential, is tax relief. Marin was the first county in California to sign a contract with a rancher under the Williamson Act (Hart 1991:33). Unfortunately, use-value tax assessment has proved largely ineffective at the urban-rangeland boundary, although counties with firm zoning regulations backed by comprehensive planning have had success with the Williamson Act (McClaran et al. 1985). Most ranchers at the boundary choose not to participate because development opportunities are so enticing (Atash 1987, Daniels 1991, Forero et al. 1992). However, Hargrave (1993:52) argues that, at least in El Dorado County, California, by reducing the cost of ranching, the Williamson Act "more than any other factor makes ranching . . . viable and is responsible for keeping the county's rangeland in agriculture." The act thus indirectly protects rangeland ecosystems, open space, and ranching culture.

Alliances Form in Marin

In 1972, nearly all Marin's ranchers adamantly opposed the new zoning ordinance as a gross violation of property rights. An important exception was the president of the local Farm Bureau who foresaw that if ranching was to have a future in Marin, protection of its land base from development was imperative. His advocacy of the zoning and his subsequent role in alliance-building with urban environmentalists was instrumental in persuading a critical mass in the ranching community that conservation-based planning was in their best interest. Rancher opposition notwithstanding, urbanites imposed their will, and the zoning ordinance stood as the first line of defense against urban encroachment into Marin's rangelands.

In this case, however, zoning proved only a temporary shield. By the mid-1970s, it was apparent that a more lasting solution was needed for 3 primary reasons. There were ample numbers of wealthy buyers willing to purchase 60-acre parcels for nonagricultural purposes. The zoning ordinance was ever vulnerable to political changes on the County Board of Supervisors. In addition, if Marin's dairy industry were to fail, alternative profitable uses of the land would be difficult under the zoning regulation, making it likely that takings challenges would ensue. It was then that urban environmentalists realized that without ranching, open space would surely dwindle and that their first task, if Marin was to retain its rangeland, was to help sustain the dairy industry. Support took very tangible forms, such as large subsidies for water delivery during the drought and for state-mandated runoff control ponds as well as political championing in battles with regulatory agencies. With this clear show of support, environmentalists, ranchers, and county planners began to put their differences aside and form an alliance directed towards the goal of long-term preservation of the agricultural zone. Working together, they developed a strategy for a permanent solution to urban encroachment, the pur-

chase of ranch conservation easements by a local land trust, the Marin Agricultural Land Trust (MALT), using state and private foundation grants and funds from a statewide conservation bond.

PROPERTY CONCEPTS AND CONSERVATION EASEMENTS

This solution required ranchers to modify some strongly-held beliefs about property rights. Most people conceive of their property as the actual land they own, the ground on which they walk. Thus, they believe that if they sell their property, they have sold the land itself. In legal terms, however, property is not the physical land but the various rights to the land (see Macpherson 1978 for a classic treatment of this topic). Each of these rights, e.g., the mineral rights, the timber rights, the right to sell, the right to develop, may be treated and disposed of separately (Atash 1987, Daniels 1991, Wright 1993). Selling or donating a conservation easement precludes development into perpetuity but leaves the other rights intact. The rancher still owns the land and can sell it for certain agricultural uses or continue the livestock operation as before. Conservation easements address rancher concerns about their financial stake in the land by providing estate tax deductions for donation of an easement or a potentially large percentage of the fee simple price for sale of an easement (Daniels 1991, Wright 1993). Money from a sale can be put towards new equipment or stock, ranch improvements, or retiring debt, and estate tax deductions can make it easier for a rancher to pass the ranch along to offspring (Daniels 1991). In addition, after the disposal of the development rights, property tax is calculated based on the agricultural value of the land, not the much higher development value (Ferguson and Rivasplata 1990:7, Wright 1993). The survey of Tehama County ranchers revealed that approximately 5% had their land in conservation easements (L. Huntsinger et al., unpubl. ms.).

Although ranchers would receive substantially more money by selling their land for urban development, there is evidence to suggest that some may be willing to forego the full development value of their land in exchange for partial compensation and the opportunity to preserve the range and continue their way of life. Smith and Martin (1972:217) found that ranchers in Arizona resisted selling ranches at market prices far exceeding their value as livestock operations for reasons that included "love of the land" and "love of rural values." More recently, Hargrave (1993:60) suggested that ranchers in El Dorado County, California, continue to ranch in the face of economic hardships and development pressure because they enjoy the tradition and the way of life and want their offspring to be able to ranch as well. It is perhaps as important to appeal to the cultural concerns of ranchers as it is to address their financial concerns.

MARIN'S SUCCESS STORY

Despite some serious misgivings, many Marin ranchers have agreed to sell or donate conservation easements to MALT. Most of the ranching community have come to realize that protection from development is in their own interest and in the interest of the industry as a whole (see also Daniels 1991). Now that widespread development in the agricultural zone is stymied, the critical mass necessary for continuation of the dairy industry seems to be ensured. Land prices are once again within the budget of ranchers wishing to expand or ranchers' kids wishing to enter the business. With this more secure future, ranchers are inclined to invest in long-postponed ranch improvements, and from a cultural perspective, the land and the life they love will endure.

Urban environmentalists in Marin also have had to discard some of their cherished beliefs about the deleterious effects of ranching and agriculture on rangeland ecosystems and the value of collaborating with ranchers. Initially, their support for agriculture in western Marin was merely a means to the end of preserving open space in the county. However, with exposure to ranchers and their way of life, many Marin environmentalists now support ranching, at least on the family-farm scale, as a productive and worthy activity in itself and as generally compatible with environmental and open-space goals. Hart (1991:120) suggests that environmentalists have, furthermore, come to value ranching culture as an important part of Marin's social character. This admiration is not universal though. At least one national environmental group active in Marin continues to view ranching and conservation as incompatible, despite the protection that ranches afford open space and rangeland ecosystems.

Why was Marin Successful?

Marin County has succeeded in preserving its rangeland ecosystems and open space because:

1. Restrictive zoning imposed by urban environmentalists on unwilling ranchers halted development, giving alliances time to form and start working. Without this initial show of urban force, subsequent collaboration would have had little rangeland left to preserve.
2. Urban environmentalists and county planners were willing to jettison ideas about the incompatibility of ranching and open space and rangeland ecosystems and make the first moves towards alliance with ranchers, and, very importantly, were willing to support the industry politically and financially.
3. Leaders of the local Farm Bureau and other rancher groups were willing to collaborate with environmentalists and county planners. It was through such organizations that a sufficient number of ranchers, the critical mass necessary for both social and ecological success, came to accept that for their way of life and their land to survive, zoning, conservation easements, and alliance with environmentalists were required. Local groups like

the Farm Bureau and Cattlemen's Association can be essential for disseminating information and persuading landowners of the value of conservation-based planning.

4. Marin's dairy industry remained viable.
5. Sources of funding for the purchase of conservation easements were available.

It is important to emphasize that zoning, conservation easements, and other rangeland preservation methods must be developed within the context of a comprehensive, conservation-based regional plan (Atash 1987; Daniels 1990, 1991; Ferguson and Rivasplata 1990:7; Fulton 1993). Haphazard checkerboarding of developed land next to protected land is of minor benefit to ecosystem function and wildlife habitats, and conservation easements, being voluntary, can result in checkerboard landscapes if clumsily planned (Daniels 1991). Restrictive zoning to prevent interim development and a regional (at least county-wide) plan to direct purchase and donation efforts should prevent such a fiasco.

EXTENDING THE MARIN MODEL

The Rocky Mountain West also has seen rancher-environmentalist collaboration and notable use of the conservation easement (Miller and Wright 1991). Ranchers have donated and sold to local land trusts conservation easements on many thousands of acres of rangeland in Montana and Colorado, protecting the agricultural resource, key range and riparian habitat, and open space (Miller and Wright 1991). In these 2 states, conservation easements seem to have succeeded where regulatory systems of land use control have proved ineffective. Miller and Wright (1991) suggest that this is precisely because of the voluntary nature of easements that necessitates collaboration between ranchers, environmentalists, and planners.

Will the Marin model work elsewhere in California and in Oregon? Hart (1991:135-136) points out that Marin is unique in some respects: although Marin is close to a large urban area, its topography prevented urban incursion until the late 1960s, by which time zoning ordinances were politically feasible; a large area of the county was already protected within the National Seashore; there were substantial numbers of urban environmentalists close by who were willing to use their political and financial clout to preserve open space; MALT had access to funds from the Marin-only Buck Trust and received money from a state bond that might not have passed in the current era of taxpayer parsimony. Nonetheless, the planning tools, zoning, use-value tax assessment, and conservation easements should be widely applicable, depending on local circumstances. Most importantly, the collaboration between ranchers, environmentalists, and planners was perhaps the essence of Marin's success and should be readily transferable. It is when these groups work together rather than fight each other, when the sharp edges of conflict are minimized or softened by compromise, that ranchlands and rangelands have the best chance of long-term preservation.

In sum, to conserve many of the most productive and biodiverse rangeland landscapes of California, environmentalists will need to give a bit on their expectations of conserved areas, whereas ranchers may have to reconfigure slightly their concepts of what it means to own property. The ranching and environmentalist communities should not let their polarization over land management prevent steps to protect rangelands from poorly planned development: the solution to debates over the ecological impacts of grazing on rangelands should not be resolved by replacing grass with cement and riparian areas with culverts. As Michael Farrow, Program Director of the Department of Natural Resources of the Confederated Tribes of the Umatilla Indian Reservation said in this session: "something has to be done about this urban sprawl. It is wasteful. It's a mistake our children will be paying for, and their children after that, and so on for generations."

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ALTERNATIVE PRODUCTS ON PUBLIC RANGELANDS

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Abstract: Nontimber special forest products such as wild edible mushrooms and floral greens have become an important industry in the Pacific Northwest. At the same time, the direct and indirect ecological effects of harvesting these products on public lands are generally unknown. This study examined the levels of special forest (or "alternative") product harvesting east of the Cascade and Sierra Nevada mountains. The types and amounts of products harvested on public lands and the demographic characteristics of harvesters are described. Implications for managing the sustainability of alternative products on public rangelands as an economically viable and socially desirable industry are suggested.

Key words: juniper boughs, landscape rock, lichens, native grasses, native shrubs, obsidian, revegetation, special forest products, wild mushrooms.

Ranching, mining, and recreation are the most studied industries on rangelands. This study describes a lesser known but increasingly important rangeland industry, that of commercial collection of alternative products, and particularly those east of the Cascade and Sierra Nevada mountains. Alternative products on rangelands are the arid equivalents of what land managers commonly refer to as "special forest products." The Bureau of Land Management (BLM) defines special forest products as "those forest and rangeland vegetative products being removed from the public lands that are not measured in either board feet or animal unit months" and so considers them to not only originate from forests but also from rangelands (BLM 1993). This definition essentially limits special or alternative products to those plant resources that are not timber or livestock forage. In contrast, the U.S. Forest Service (USFS) defines special forest products as those resources "sold, gathered or collected from the National Forest System. There are four lists: Plants, Animals, Minerals, and Aquatic Resources" (Unpubl. rep. USFS Natl. Spec. For. Prod. Task Force 1993). In contrast to the BLM, the Forest Service defines special or alternative products more broadly as not only plant but also animal, mineral, and even aquatic resources. This broad definition includes such diverse alternative products as ladybugs, quartz crystals, and spring water.

Some of the richest alternative product lands are those of the Pacific Northwest where floral greens, wild mushrooms, and medicinal herbs have become multimillion dollar specialized industries (Schlosser et al. 1992). The variety of alternative products is reflected in the diversity of harvesters. For example, many wild mushroom collectors are not only rural timber community residents but Southeast Asian immigrants from Laos and Cambodia. A study of the Klamath bioregion of southern Oregon and northern California indicated that almost half of all wild mushroom harvesters were Southeast Asian immigrants (R. T. Richards and M. Creasy, unpubl. ms.). Native American tribal members also gather special products as part of their cultural traditions (R. T. Richards and M. Creasy, unpubl. ms.). Thus, the uses of special products vary from the commercial to the sacred.

East of the Cascades and Sierra Nevada, public lands shift from the coastal fir forests to the Rocky Mountain forests and the Columbia-Snake River Plateau, Great Basin, and Colorado Plateau rangelands. The shifts in plant communities are accompanied by changes in the types of alternative products collected and in the ethnic and regional groups who harvest and use them.

One example of a well-known rangeland plant that has alternative product value is creosote bush (*Larrea divaricata*, synonymous with *Larrea tridentata*). Known in the medicinal trade as chaparral, this common rangeland shrub of the Colorado Plateau is collected for health food stores that sell it in leaflets and twigs for tea (Unpubl. Memo, Am. Herbal Prod. Assoc., 1992). Chaparral tea was used as a remedy by the Paiute and Shoshone tribes and more recently has been used as an unapproved cancer treatment (Willard 1991). It is estimated that >200 tons of chaparral have been sold during the past 20 years. However, in 1992, the FDA cautioned consumers not to consume chaparral because of 4 reported cases of liver toxicity symptoms (Unpubl. Memo Am. Herbal Prod. Assoc., 1992).

Another common alternative product from rangeland is velvet mesquite (*Prosopis velutina*). Velvet mesquite occurs from central Arizona into Mexico, particularly in floodplains, and has been a significant plant for native people since prehistoric times. Velvet mesquite pods and seeds were a major source of food for both people and livestock. High quality honey, fuelwood, and charcoal are also produced from velvet mesquite. It is unknown how much velvet mesquite is harvested from U.S. and Mexican rangelands, but woodcutting, agriculture, and groundwater pumping have severely impacted the mesquite forests of the Southwest's riparian floodplains (Johnson 1993).

As chaparral and velvet mesquite illustrate, alternative products on rangelands are important natural resources for human use. Unlike the special products of westside forests, however, the alternative products collected east of the Cascades and Sierra Nevada have not been systematically inventoried or their collection documented. The objectives of this study were to determine what alternative products are commonly collected on the eastside and where, in what

amounts, and by which sociocultural groups they are harvested. In addition, the study aimed to examine how eastside alternative products are managed and what the implications of harvesting alternative products are for sustaining eastside rangelands. The assistance of L. Frazier, S. Costillo, J. Reponen, R. Elam, J. Francis, J. Weir, M. Rassbach, E. Ballard, S. Monsen, K. Urban, and J. Haynes in providing data for this study is greatly appreciated.

METHODS

Telephone interviews with eastside land managers of the BLM and the USFS were conducted in the spring and summer of 1994. Interviews also were conducted with state officials in the California Department of Transportation. In addition to interviews, permit and other secondary data sources were obtained from state and federal agencies. From interviews and secondary data sources, at least 5 alternative products were identified as major resources currently collected from eastside rangelands. These included the plant resources of juniper (*Juniperus* spp.) boughs, wild mushrooms, and native rangeland shrub and grass seed. A fourth alternative product identified was the mineral resource, obsidian. A fifth product, lichen basalt "flat" rock, consisted of both mineral and plant resources.

RESULTS

Juniper Boughs

Juniper boughs, especially those with berries, are harvested from eastside rangelands for use in Christmas wreaths and other floral greenery decoratives. On all of eastern Oregon's BLM districts permits are issued for juniper boughs. The juniper season begins at the end of August and continues until early December. Most boughs are cut in September. Typically, juniper tips ≤ 18 inches long are harvested. Contractors or "cutters" locate desirable collection areas for which they seek BLM permission. If permission is granted, the cutters then buy a permit and bring in crews to clip the boughs. Boughs are tied in 40-pound bundles, loaded onto pickups, and taken to cold storage units or directly to refrigerated semitrucks for transport to urban areas.

BLM data for the last 3 years indicate that most juniper boughs are harvested from the Prineville District followed by the Burns, Lakeview, and Malheur Districts (Fig. 1). In addition to its extensive juniper woodlands, Prineville is closest to the urban centers where the boughs are wholesaled or processed and retailed. Currently, the Prineville District sells juniper bough permits for \$0.05/pound for a maximum of 20,000 pounds, whereas Burns sells boughs for \$30/ton. On the Prineville District, the maximum duration for a permit is 3 days/ton and the average number of permits sold is 40.

On the Prineville District, 51 cutters, all of whom listed business addresses in Oregon or Washington, bought juniper bough permits in 1992. The amount of boughs harvested

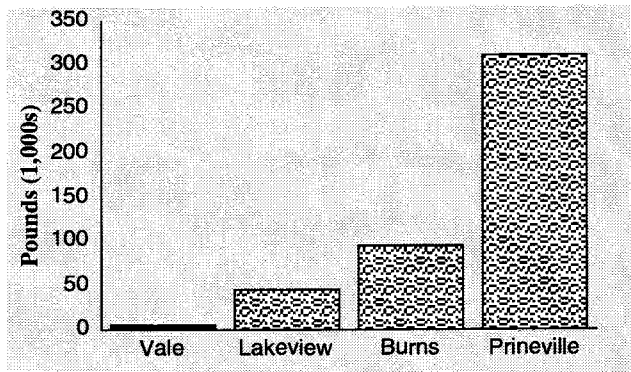


Fig. 1. Pounds of boughs harvested on BLM eastern Oregon districts, 1991-93.

by each individual cutter is unknown but amounts per cutter vary greatly. One cutter on the Burns District collected 150,000 pounds or about half of the boughs permitted in 1993. Cutters reportedly earn \$0.25-0.30/pound on boughs. Data on how much crews earn were unavailable. Crews are frequently Hispanic because the juniper season is the off-season for farm harvest jobs or USFS reforestation or thinning projects. On the Burns District, crews tend to average 6 workers. Typically, crews camp while they are cutting and are not monitored by the BLM for safety, wages, or immigration status. Juniper bough harvesting is not without problems. BLM personnel are concerned about illegal cutting, stripping trees, cutting on private land, reusing bough tags, taking more boughs than permitted, incurring off-road damage, and leaving trash.

Wild Mushrooms

Another eastside alternative product is wild mushrooms, particularly matsutake and morels that are harvested in the higher elevation eastside forests. Matsutake (*Tricholoma magnivelare*) are harvested commercially for sale to Japan from the lodgepole pine (*Pinus contorta*) and red fir (*Abies magnifica*) forests. A survey of mushroom processors indicated that in 1992 >800,000 pounds of matsutake were harvested from Idaho, Oregon, and Washington and almost \$8 million was paid to harvesters (Schlosser and Blatner 1995). Morels (*Morchella* spp.) are harvested in even greater numbers from a variety of eastside forest habitat types. The same study found that in 1992, >1.3 million pounds of morels were harvested from the 3 states and over \$5 million was paid to harvesters (Schlosser and Blatner 1995).

It is estimated that about 48% of all wild mushrooms, or 1.9 million pounds, were harvested in 1992 from eastern Washington, eastern Oregon, and Idaho (Schlosser and Blatner 1994). Of those wild mushrooms harvested from eastern Oregon national forests, USFS permits indicate that about three-quarters were collected from the Winema and Deschutes forests alone (Fig. 2). Of these Winema and Deschutes mushroom permits, almost all were for matsutake. In contrast, permits were issued primarily on the Umatilla and Wallowa-Whitman forests for morels. Morel "flushes"

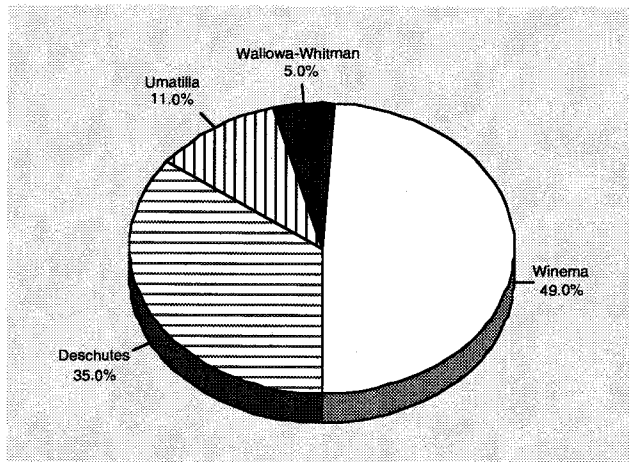


Fig. 2. Number of mushroom permits issued in 1993 on eastern Oregon national forests excluding the Ochoco National Forest (20) and the Malheur National Forest (40) ($n = 13,714$).

or concentrations have been particularly abundant in recent years on the southern ranger districts of the Umatilla Forest where spruce budworm damage has opened the forest canopy and created heavy needle litter.

Unlike juniper boughs, which are permitted as a BLM contract to a cutter who then hires a crew, USFS mushroom permits are issued directly to the individual mushroom picker. In contrast to Hispanic bough cutters, many mushroom pickers are Southeast Asian immigrants. In southern Oregon and northern California, at least half of commercial mushroom pickers are Southeast Asian in origin, primarily Lao and Mien, and to a lesser extent, Cambodian. These mushroom pickers typically are from urban California cities and earn less than \$500 during the mushroom season (R. T. Richards and M. Creasy, unpubl. ms.). Similarly, on the Umatilla Forest, it is estimated that about half of the pickers are Southeast Asian immigrants, and most of these are thought to be Cambodian. Many of the management problems associated with juniper bough cutting also accompany the wild mushroom harvest, including concerns about trash, dispersed camping and fire, picking out of designated areas, conflicts over mushroom "plots", damaging the mycellium mat by raking, and general ecological impacts on biodiversity.

Native Grass and Shrub Seed

A third alternative product on eastside rangelands consists of native grass and shrub seed, which is collected for federal, state, and private revegetation and land restoration projects. Because federal policy has increasingly mandated the use of native species in revegetation efforts, seed from naturally occurring grass and shrub ecotypes is in great demand. These include native perennial grass species such as Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Agropyron spicatum*), and others. In addition to perennial grasses, shrubs and forbs are also required on many projects. These will vary by area but may include rabbitbrush

(*Chrysothamnus nauseosus*), shadscale (*Atriplex confertifolia*), big sagebrush (*Artemisia tridentata*), and other common eastside rangeland plants.

Highway revegetation illustrates the diversity and amount of native plant seed used in eastside rangeland projects. Thousands of miles of highway exist east of the Cascades and Sierra Nevada and highway improvement projects increasingly use native seed for revegetation. California Department of Transportation projects may require a wide variety and large amounts of native seed. This is illustrated in a recent highway revegetation project in Mono County, which required >0.75 ton of 8 types of native seed (Fig. 3).

Whereas much native seed is now produced by commercial nurseries, large amounts are still collected from public lands. A good example is bitterbrush (*Purshia tridentata*). A common rangeland browse species, bitterbrush contributes to wildlife habitat as well as soil stability. Bitterbrush seed primarily is gathered from the wild on either public or private land. One eastside bitterbrush ecotype, "Lassen", has been particularly valued for rangeland restoration because of its seedling vigor, productivity, upright growth, forage availability, and other characteristics. Lassen bitterbrush grows in a 50-mile strip east of the Sierra Nevada Mountains near Susanville where private dealers and state agencies collected >10,000 pounds of seed between 1954 and 1986 (U.S. Dep. Agric. Soil Conserv. Serv. 1986). The total amounts of all bitterbrush seed gathered in a single year are unknown but it is estimated that thousands of pounds are gathered every year and collectors receive around \$8/pound. Collectors are reported to be schoolteachers, miners, and sheepherders. Much of bitterbrush seed, including the Lassen ecotype, is collected in areas where native populations are in severe decline from fire, grazing, or urban development (Monsen and Shaw 1994). Currently, few if any permits are issued for native seed collection. As with many rangeland species, the extent to which native wildland seed is taken and the implications for natural regeneration are of concern to resource managers.

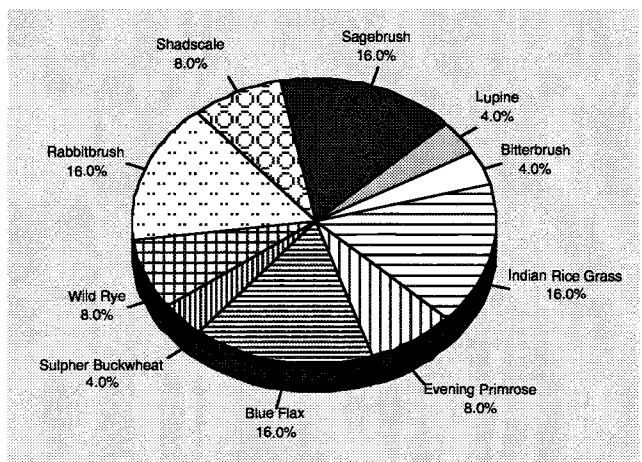


Fig. 3. Native seed for required 1994 California Department of Transportation Mono County project (1,680 lb, 84 acres).

Obsidian

In contrast to plants, which are renewable alternative products, several of the eastside rangeland resources collected from public lands are nonrenewable. One of these is obsidian, which is used for jewelry, landscaping, and other ornamental purposes. Obsidian is collected on the Modoc National Forest where both free use and commercial permits are issued for designated sites on the Warner Mountain Ranger District. One commercial collector uses obsidian "needles" to make wind chimes for a company that specializes in natural products. Other commercial collectors use obsidian for polished spheres and other decorative uses.

Commercial permits are sold for \$12/ton with a 2-ton limit and commercial permits average between 4–6 each year. In addition, free use permits for ≤500 pounds are issued to individual rockhounds (Fig. 4). In 1993, 567 free-use permits were issued for collecting obsidian on the district. Almost all the permits represented an individual collector so the estimated 283,500 pounds of recreational use obsidian collected from the district in 1993 was considerable.

In addition, wide regional variation existed in the recreational use of the obsidian resource with >90% of the permittees having nonlocal addresses. Whereas rockhounds are stereotypically retirees with motor homes, little information is available as to the typical obsidian collector. Management concerns about obsidian are primarily focused on the limited information regarding the extent of the obsidian deposits, particularly the needles, and the sustainability of collecting.

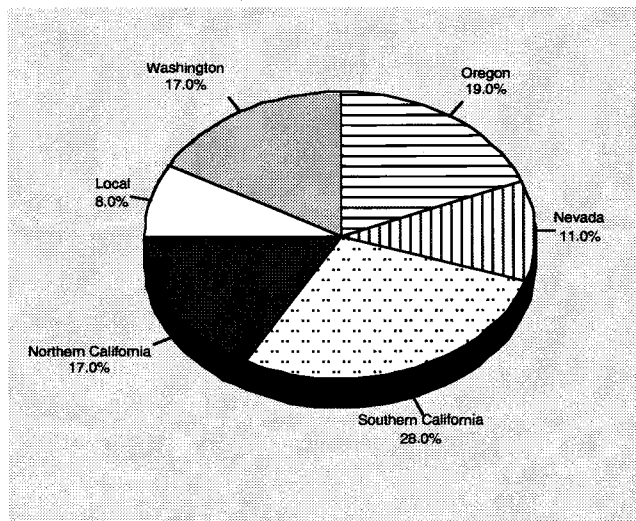


Fig. 4. Regional distribution of 1993 noncommercial obsidian permittees for Warner Mountain Ranger District, Modoc National Forest, California ($n = 567$).

Lichen Basalt ("Flat") Rock

Another nonrenewable alternative rangeland product that is both a mineral and plant resource is basalt flat rock covered with lichens. Seven operators presently collect flat rock with BLM commercial permits from the Alturas Resource Area. One operator has been collecting flat rock on the area for >40 years. All the commercial operators are from San Francisco, Santa Rosa, and other California Bay Area cities. Each operator works alone or with 1–2 labor-

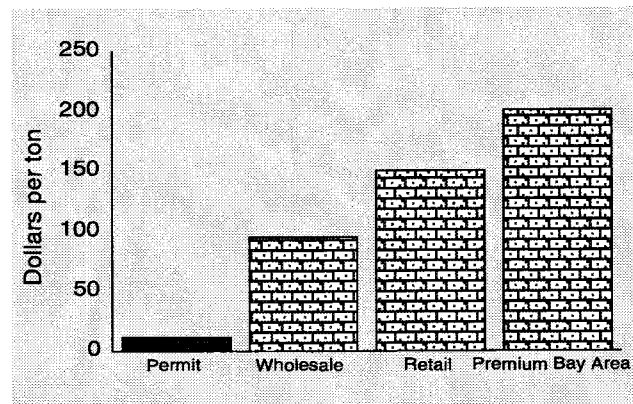


Fig. 5. 1993 price structure of flat rock collected from the Alturas BLM Resource Area, Susanville District, California.

ers. Many of the operators are related to one another through family ties, and many had fathers or grandfathers who were also in the rock or quarry business.

Resource area permits are sold for \$12/ton of flat rock, which is eventually resold for up to 20 times as much in urban markets (Fig. 5). Permit information was unavailable, but BLM personnel report that thousands of pounds of flat rock are collected from the resource area every year. Management problems include trash, site and road damage, and some local versus nonlocal conflict over access and use. A serious concern throughout the district is the degree to which the top layers of lichen covered flat rock have already been removed from some areas and the extent to which the lichen resource is impacted by collection.

DISCUSSION

Alternative rangeland product collection may be a useful rural development tool for some rangeland communities seeking alternative economic opportunities (Schlosser and Blatner 1994). However, alternative rangeland product collection also is associated with numerous management issues and concerns. Currently, both the BLM and the USFS issue permits for commercial or free use of eastside products from public lands. Permits may vary from contracts for an operator and crew, as in the case of juniper boughs and flat rock, to permits to the individual collector, as in the case of wild mushrooms and obsidian. Stipulations regarding the conditions of the permits are the main agency enforcement tool

for resource protection. Thus, managers report that individual permits can be monitored more effectively than contract permits. One exception may be long-term contract leasing or "stewardship" contracts (R. T. Richards and M. Creasy, unpubl. ms.).

The diversity of users also complicates management of alternative rangeland resources. Industry niches exist in which Hispanics dominate juniper bough harvesting, South-east Asians have captured wild mushroom harvesting, and traditional quarry families still collect flat rock. The resulting linguistic and cultural barriers make it difficult for land management personnel to educate a diverse group of users about the sustainability of various alternative products. In addition, conflicts between extralocal and local users are not uncommon and in some areas, conflicts between Native American traditional use or protection of sacred sites and commercial use and resource access also have arisen (R. T. Richards and M. Creasy, unpubl. ms.).

MANAGEMENT IMPLICATIONS

In addition to the direct contributions of alternative products such as wild mushrooms and lichens to ecosystem functioning, indirect ecological impacts such as soil erosion from vehicle traffic may also result from alternative rangeland product use. Social impacts such as increased conflict between commercial and traditional or local and nonlocal user groups may also result. Much is unknown about what products are being collected from eastside rangelands and how much is being harvested. These management questions can only be addressed by increasing efforts to inventory the alternative products being collected and monitor sites for how much is being removed.

Similarly, little is known about who is collecting alternative products from rangelands and how the benefits from alternative product use are distributed among users. For example, do crews benefit relative to operators? Are the externalities of trash and other indirect effects created by alternative product collection proportional to the benefits? Such information will be difficult to obtain but systematic tracking and demographic analysis of permits, contracts, and citations and surveys of user groups would provide initial data for such cost-benefit analyses.

As compliance with the National Environmental Protection Act or NEPA becomes a greater issue for alternative product management, public education and proactive management programs will correspondingly become more important (BLM 1993). Education and proactive management will undoubtedly move beyond brochures and videos to public participation and involvement. Perhaps following the westside "adopt-a-watershed" movement, eastside communities may choose to adopt a flat rock quarry or a juniper woodland. Through such public involvement efforts, inventorying and monitoring alternative products could be expanded and data on use collected. Local land managers will have increasing opportunities to address alternative rangeland uses as our population continues to grow and the accompanying demands for natural resources expand in coming years.

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GEOGRAPHIC INFORMATION SYSTEMS AS A TOOL FOR LAND AND MINERAL MANAGEMENT

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Abstract: People and their activities are part of the ecosystem in which they live and work. Mining is an integral part of social and economic systems of modern society. Therefore, land and mineral managers must have a thorough understanding of the effects of mining on the ecosystem. The mining industry, from the small miner to the large corporation, is challenged to show that it can function in a manner consistent with modern science and technology while meshing with changing social and economic values. Geographic information systems (GISs) are tools available to managers and users of rangeland resources. Maps showing the distribution of ecosystem components are necessary for managing any landscape. A GIS provides a means to maintain, update, manipulate, and display these maps. For example, a GIS can provide a visual display of the effects of mining on the social, economic, and physical aspects of rural communities and rangeland resources. Using GIS-based maps also allows testing and visualizing alternative land management designs.

Key words: ecosystem management, geographic information systems, grazing, landscape, mining.

The purpose of this paper is to acquaint the reader with the geographic information system (GIS) as a computer tool to capture, display, and analyze natural resource, socio-economic, mineral development, and other spatial data, in order to aid in making land and mineral management decisions. I hope that potential users and land managers will see GIS as a practical tool to apply to case-specific areas that will be affected by a mineral development scenario.

GIS is a term that most of us have heard of, but few could explain or describe its use. Fewer still have used or could manipulate a GIS to make better land, mineral, economic, or sociological decisions affecting our natural resources. GIS will, however, in the not too distant future, be as common to land, mineral, and natural resource managers as the word processor.

This paper and presentation are the sum total of the generosity and time given to me by many individuals in private industry and various federal and state agencies involved with the subject matter. Special thanks to Chris Hamilton, Judy Briney, Gary Raines, Carl Almquist, and Dean Crandall for sharing their knowledge and experience on the subject matter. It would be difficult and cumbersome to acknowledge all of the other contributors individually. Therefore, I am using this means to say thank you collectively.

DATA SOURCES

Socio-economic Data

The U.S. Census Bureau has developed a database tagged as TIGER (Topologically Integrated Geographic Encoding and Referencing). It is a nationwide digital map database of socio-economic data required to support censuses and surveys. These data form a digital atlas of where people are and what they do, and were developed as a by-

product of the 1990 Census. Any extensive economic or sociological case study of mining effects on a given area would benefit from application of the TIGER files.

Other Data Sources

There are many sources of digital map data and the number of sources is rapidly expanding. Topographic and geologic digital data are available from the U.S. Geological Survey (USGS). Digital soils maps are available from the U.S. Natural Resources Conservation Service. The Bureau of Land Management (BLM) and U.S. Forest Service (USFS) are assembling >100 digital maps for the Columbia River Basin (Eastside Ecosystem Management Project [EEMP]) that will be publicly available. EEMP digital maps contain >75 topical themes (Table 1). Applications of these data are as diverse as selecting optimal locations for a new McDonald's to real-time landslide warning systems.

MECHANICS OF GEOGRAPHIC INFORMATION SYSTEMS

A GIS begins with the gathering of data at the field level. If we were to look at the effect of mineral exploration or ultimately mineral development on rangelands, baseline data, such as plant or animal population counts and hydrological information, would be gathered in the field. The data could be gathered in the form of a point, line, or area depending on the form of data and spatial relationships to be analyzed. Data comprised of x-y coordinate representations of locations on the earth can take the form of single points, strings of points (lines), or closed lines (polygons). Such data is described as vector data with a vector taking the form of a list or list of joint coordinates (Fig. 1). Another form of showing information is the raster format in which data are assigned attributes within grid cells or pixels (Fig. 1). Such

Table 1. Example of some of the topical themes covered in the Eastside Ecosystem Management Project.

Theme Group	Theme Name	Scale
Boundary	Landscape Characterization Boundary	7500k
Fisheries	Migration Barriers	
Management	Mineral Commodity Sites	100k
Management	Mineral Development Interest Area (Mdia)	100k
Biophysical	Mineral Terranes	100k
Management	Mining Districts	100k
Biophysical	Natural Heritage Data	
Biophysical	Omernik's Ecoregions	7,500k
Base	Ownership	100k
Biophysical	Pollutant Sources—Air	
Management	Recreation Opportunity Spectrum	500k?
Fisheries	Refugia & Fish Productivity "Hot" Spots	100k
Subsample	Riparian—Current Subsample	24k
Biophysical	Riparian Condition—Current	100k
Biophysical	Riparian Condition—Future (Scenerio)	100k
Biophysical	Riparian Condition—Historic	100k
Base	Roads	100
Base	Roads (Cff/usgs)—Subsample	24k
Biophysical	Scarce Environment	100k
Management	Sensitivity to Disturbance—Current	100k/250k
Management	Sensitivity to Disturbance —Future (Scenario)	100k/250k
Biophysical	Species Ranges	2000k
Biophysical	Statsco Soils	250k
Biophysical	Stream Channel Conditions	100k
Biophysical	Streams	100k
Base Data	Streams (Cff/usgs)	24k
Political	Subcounty Census Block Group	100k
Biophysical	Subsection	500k?
Management	Tribal Ceded Land	?
Management	Tribal Court of Claims Boundaries	
Management	Tribal Usual & Accustomed Places	
Biophysical	Vegetation—Current	1km
Subsample	Vegetation—Current Sub Sample	24k
Biophysical	Vegetation—Future (Scenario)	1km
Biophysical	Vegetation—Future Subsample	24k
Biophysical	Vegetation—Historic	1km
Subsample	Vegetation—Historic Subsample	24k
Biophysical	Water Quality	100k
Management	Water Withdrawals	
Biophysical	Watersheds	100k
Biophysical	Watersheds—Classification	100k/250k
Biophysical	Watersheds Huc	250k
Biophysical	Weather Station Location	

raster cell data is arranged in a regular grid pattern in which each unit or cell in the grid is assigned an identifying value based on its characteristics. The resolution obtained with raster formats are dependent on the grid cell or pixel size (Fig. 2). Vector and raster formats have both advantages and disadvantages (Table 2). As an example of either the vector or raster method of data definition, owl populations could take the form of a point or cell for a single nest or as a polygon defined by vector lines or grid cells if looking at the areal or spatial habitat of an owl pair.

Data are digitized and then linked to geographic locations (Fig. 3) through a software system to produce thematic maps. A thematic map is related to a topic, theme, or subject of discourse such as vegetation, geology, landownership, spotted owls, minerals, etc. A theme is the overall topic of a map in which the spatial variation of a single phenomenon is illustrated, such as the boundary relationships among grazing allotments. An example is the Lakeview, Oregon, grazing allotment database (Table 3) that associates grazing management attributes with allotments (polygons). The grazing attributes of each allotment can be used to display a the-

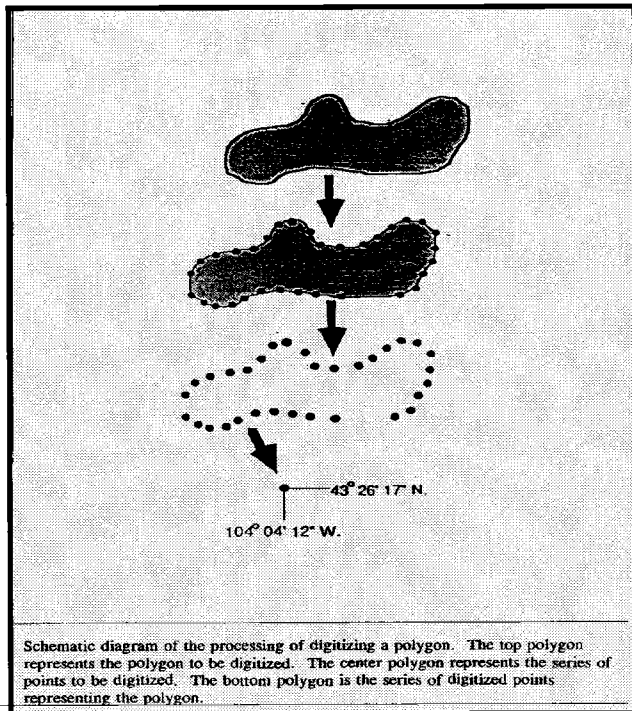


Fig. 1. The storing of digital spatial data in vector and raster form.

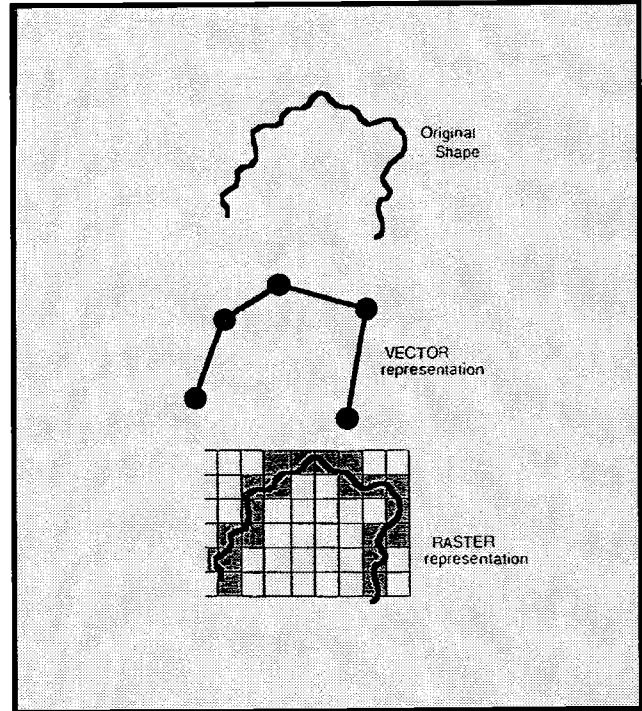


Fig. 2. The effect of raster cell size.

Table 2. Advantages and disadvantages of raster and vector data representations.

Representation	Advantages	Disadvantages
Raster	simple inexpensive analysis easy	large data volumes information loss network analysis
Vector	good graphics compact structure	complex structure and analysis expensive

matic map showing the grazing management for all allotments (continuous, rest-rotation, deferred, or high-intensity, short-duration grazing).

Practical Applications

GIS tools can be used in determining the effects of mining on rangeland resources and rural communities including the social and economic impacts of mineral development on a given community. GIS can be used to analyze data to locate mineral deposits and resources, assist planning by assessing environmental risk, and conduct hydrogeological studies in order to inventory the water supply in a given area. Use of GIS can assist government agencies, working with the private sector, in identifying mineral deposits, planning exploration of the deposits, and monitoring subsequent mineral extraction consistent with sound ecological management. Data are recorded digitally with cartographic coordinates, and then integrated into an appropriate system in

order to obtain a coherent picture of the resource. GIS will play a critical role in standardizing and improving the data collection process.

The surface features of the earth are just some of the pieces of the puzzle making up the physical realm we occupy. Before reaching a decision about the nature of the sub-surface geology, a 2- or 3-dimensional picture may give us a better understanding of what is happening at any given place. If geochemical, geophysical, and other geological evidence is gathered, digitized, linked to topical themes, and then displayed as a GIS product, a manager will have a broader picture of the resource and consequently be in a position to make better informed decisions.

DEPARTMENT OF INTERIOR PROGRAMS

The U.S. Department of the Interior (USDI) is committed to an Integrated Modernization Project including the broad picture of spatial data technologies. Spatial data technology consists of collecting geographically referenced data (data to which geographic coordinates and physical characteristics have been assigned) converting it to digital (computer readable) form, and storing and processing it on a computer. Data come from on-the-ground surveying or aerial photography and then end up recorded on a map in analog form. The maps are then either digitized or scanned into designed computer information systems. These GISs store, process, and display data in virtually any form the operator desires. Once

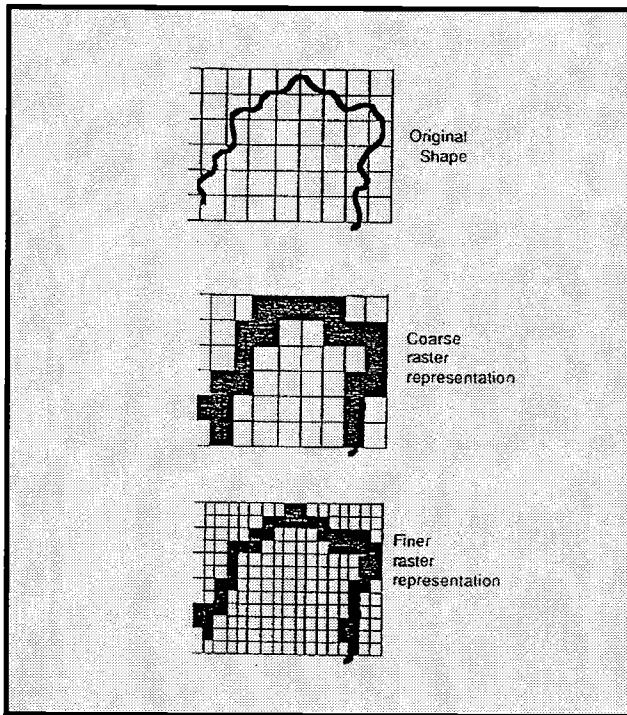


Fig. 3. Schematic diagram of the processing of digitizing a polygon. The top polygon represents the polygon to be digitized. The center polygon represents the series of points to be digitized. The bottom polygon is the series of digitized points representing the polygon.

data are captured and stored electronically, they can be manipulated to create almost unlimited analysis possibilities for a myriad applications.

Among the reasons that this technology continues to gain momentum, even in an austere budget environment, is its virtually unlimited scope of potential applications. Every bureau in the USDI uses spatial data systems in some form to accomplish its mission. Over the past several years, Interior bureaus have invested over \$7.2 billion in spatially referenced data and technology. They will invest another \$2.7 billion during the next 5 years. Development and implementation of a National Spatial Data Infrastructure (NSDI) is one of the elements of the President's National Performance Review objectives. Secretary of the Interior Bruce Babbitt has referred to it on several occasions as being a critical component of effective Interior operations. Thus, spatial data technology will receive increased attention during the next few years.

Spatial data activities are coordinated in the Department by the Interior Geographic Data Committee (IGDC). This senior-level committee is chaired by the USGS and composed of representatives from each bureau and several offices, including the Office of Information Resources Management. Government-wide activities are coordinated by the Federal Geographic Data Committee (FGDC), which was originally chaired by Interior—again, the USGS. But recently Secretary Babbitt has assumed leadership of this criti-

cal committee. The FGDC is composed of 14 federal agencies involved in using this technology to support their missions.

Major activities currently underway in the Department stem from a plan completed by the IGDC in 1992 for mapping and GIS activities. The plan includes creating a Spatial Data Clearinghouse that will allow any user or potential supplier of spatial data to communicate and potentially share data with any other user or supplier of spatial data. This concept is currently being pilot-tested among a number of Interior bureaus. Once fully developed, it can be expanded to locate any user or supplier of spatial data nationwide. This locator capability will allow optimum use of spatial data technologies and eliminate duplicative data collection or processing efforts by enabling users to quickly research data in their geographic area of interest. It will also promote cooperative efforts by allowing users with interests in the same geographic areas to team up in their areas of interest. Other major spatial data initiatives include the BLM's Automated Land and Mineral Records System (ALMRS), the Minerals Management Service's Technical Information Management System (TIMS), and a wide variety of resource-specific applications in the Bureau of Indian Affairs, National Park Service, National Biological Service and U.S. Fish and Wildlife Service. Similar development is under way in the U.S. Department of Agriculture.

Future Prognosis

What is the prognosis for the future? It is a virtual certainty that dynamic growth in the use of spatial data systems and technologies will continue in the Department. Rapid advances in communications, hardware, and software systems capabilities will promote continued innovations in developing spatial data applications. Interior bureaus will increase the level of cooperative ventures in spatial data applications, as will entire government agencies, as the National Spatial Data Infrastructure (NSDI) becomes reality.

Geographic Information System Project

The BLM GIS Project is an Automation, Information Resource Management, and Modernization (AIM) project directed toward providing tools that will facilitate the conversion of the Map Overlay Statistical System (MOSS) family of GIS data, stored on the Prime hardware, to ARC/Info on UNIX RISC 6000 workstations. The project's first priority is to provide a file management system for data translation. Project personnel have analyzed all existing systems used for managing GIS data throughout BLM, and are working toward integrating the various systems into a single, comprehensive system. This system will be used to catalog and inventory spatial data holdings, collect and maintain metadata, and track data transfers. The project's second priority is to provide techniques to ensure complete and accurate translation of data in these formats: Automated Digitizing System (ADS), MOSS, Map Analysis Package System (MAPS), and MOSS GIS plot files.

Table 2. Example of Lakeview, Oregon Grazing Allotment database with field definitions.

	Field number*													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Frf Lynch	1	1	1	1	1	0	0	1	0	0	0	0	0	
Mckee	1	1	1	1	1	0	0	1	0	0	0	0	0	
Frf Laird	1	1	1	1	1	0	0	1	0	0	0	0	0	
Rock Creek Ranch	1	1	1	1	1	0	0	1	0	0	0	0	0	
Cox Butte	1	1	1	0	1	0	0	1	0	0	0	0	0	
Orijana Rin	1	1	1	0	1	0	0	1	0	0	0	0	0	
Northeast Warner	1	1	0	1	1	0	0	1	0	0	0	0	0	
North Bluejoint	1	0	0	0	1	0	0	1	0	0	0	0	0	
Corn Lake	1	1	1	0	1	0	0	0	1	0	0	0	0	
Juniper Mountain	1	1	1	0	1	0	0	0	1	0	0	0	0	
Rabbit Basin	1	0	0	1	1	0	0	1	0	0	0	0	0	
Coyote-colvin	1	1	1	1	1	0	0	0	1	0	0	0	0	
Clover Creek	1	1	1	0	1	0	0	0	1	0	0	0	0	
Fish Creek	1	1	1	0	1	0	0	0	1	0	0	0	0	
Lynch-flynn	1	1	0	0	1	0	0	0	1	0	0	0	0	
Priday Reservoir	1	0	0	0	1	0	0	0	0	1	0	0	0	
Abert Seeding	1	0	0	1	1	0	0	0	1	0	0	1	1	

*Field number	Definition	Field number	Definition
1	Allotment Name	8	Horse/Mule Use
2	Spring Use	9	Continuous Grazing
3	Summer Use	10	Rest Rotation Grazing
4	Fall Use	11	Deferred Grazing
5	Winter Use	12	High Intensity/Short Duration Grazing
6	Cattle/Bison Use	13	Allotment Plan in place?
7	Sheep/Goats Use	14	Meets AMP goals?

Codes for fields: 1 = Yes, 0 = No

The third project priority is to provide tools that enable the GIS community to change existing GIS attributes to BLM standards as the standards are identified. GIS, which has a resources data focus, will be incorporated into the next version of ALMRS.

GIS SOFTWARE SYSTEMS

Digital cartographic data including land, water, mineral resource, and other spatially related topical themes have been going through an ongoing process of being linked through various USDI software for >20 years. These systems are either nonproprietary (public domain) or proprietary type privately developed software. Currently the USDI employs, among others, the latest generation ARC/INFO system. This system is a proprietary vector-based GIS system developed by Environmental Systems Research Institute (ESRI) in Redlands, California, as a replacement for the earlier Polygon Information Overlay System (PIOS) vector-based system. ARC/INFO consists of 4 subsystems for managing, recording, analysing, and displaying information. The system handles topologically structured data, providing automatic topologic structuring, vector overlay, and conversions to and from raster data. The design philosophy has been to

provide a "tool box" of functions for processing and analyzing spatial data. ARC/INFO is presently being used by USGS's National Mapping, Water Resources, and Geologic Divisions, Bureau of Indian Affairs (BIA) on many reservations, and many USDI state cooperators, particularly those involved in water management applications.

Public vs. Proprietary GIS Software

So-called "public domain" computer software is software developed without copyright protection and therefore without private ownership. Most government software is in the public domain, and the MOSS family of systems is no exception. It was developed by the government, is owned by the taxpayers, and is available for use by anyone, without charge. Public domain software is especially beneficial to agencies (like BLM, BIA, and USFS) that have many field offices that are potential GIS technology users.

Although proprietary software such as the ARC/INFO system bears a fee including the cost of licensing and installation, it has an advantage of being continually upgraded as a result of market-driven forces and it is subject to the influences of the needs of large users such as the government. Because of the evolving nature of GIS technology and the

need for field user satisfaction and relevance in the development of new software, it is imperative that a responsive source of software maintenance and enhancement be available.

Public domain software is available to anyone without a licensing charge. However, it does involve a significant and often unrecognized cost. Since the code is freely available, it is also easily modified by users, which can result in many different versions of the software. This makes it more difficult to exchange data between organizations because control is lost. This problem can be minimized by giving one organization responsibility for maintaining and enhancing the common version of the software.

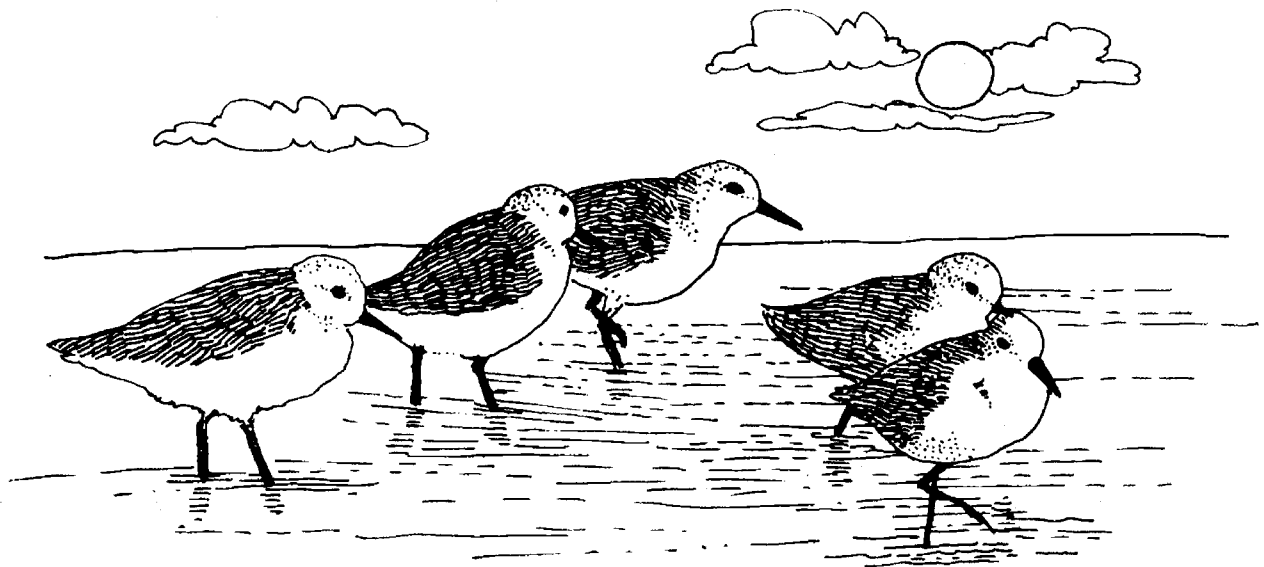
CONCLUSION

Scientific integration of map data can provide alternatives for management when mineral development occurs. Ecological, social, and economic costs can be measured, qualified, quantified, and displayed as a visual product with the GIS. We do not mean to imply that we have all the answers, but only that with modern tools now available, the chances are enhanced that ecologically sound, economically viable, and sociologically acceptable decisions can be made

by land and natural resource managers. I hope from this brief overview of GIS activities that the reader appreciates the magnitude of development. I also hope that some of the applications now are clearer.

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ECOTOURISM AS A RURAL DEVELOPMENT STRATEGY IN OREGON

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Abstract: Rural communities in Oregon are losing employment in resource-based industries. Many rural communities are developing tourism as a source of new jobs and income. "Ecotourism" is a form of tourism development attractive to rural communities with natural amenities. In its purest form, ecotourism attempts to align its practices with principles of sustainability. Examples of 4 recent ecotourism activities in Oregon are profiled and general observations are made. Findings suggest that whereas some individuals are generating supplemental income from ecotourism and are optimistic about its future, to date, few employment opportunities are being created for laid-off workers from extractive industries. Finally, 2 recent models are highlighted that provide a framework for "community-based" ecotourism strategies.

Key words: economic strategy, ecotourism, rural development, tourism.

ECONOMIC TRENDS IN RURAL AMERICA

Changes in the global and national economy have dramatically affected the rural areas of the United States. These are not cyclical changes, but changes in the fundamental structure of our economy. Traditional sources of employment in resource-based industries have experienced dramatic declines over the past 2 decades, and employment in these industries is not expected to return to historical levels (Natl. Governor's Assoc. 1988). The effects of this change on rural residents are made clear to anyone not directly impacted simply by scanning the Contents page of a 1993 U.S. Department of Agriculture (USDA) publication summarizing data from the 1990 Census of Population (USDA 1993):

- "Nonmetro Renaissance Evaporated During the 1980's"
- "Shortage of Young Adults in Nonmetro Areas Greater than Ever"
- "Nonmetro Outmigration Exceeded Inmigration During the 1980's"
- "Fewer Nonmetro Children Live With Both Parents"
- "Nonmetro College Completion Rates Fall Further Behind Metro"
- "Nonmetro Areas Trail in Growth of High Income Occupations"
- "Nonmetro Poverty Rate Inches Back Up"

Despite the overall decline in rural performance nationally, there have been a few pockets of rural counties and towns that had above average annual growth in employment and income during the 1980s. These successful places seem to favor the economic synergy inherent in regional trade centers, and places offering lifestyle amenities to retirees and footloose entrepreneurs. A recent study presented a detailed profile of the characteristics of rural "winners and losers" during the past decade (Drabentstott and Smith In press). Two prominent locational factors were critical to employment and income growth—remoteness and scenic amenities. Counties that were not regional trade centers and that were far

from product markets and metro areas were overwhelmingly losers. Winners were typically associated with retirement destinations, often found in areas with mountains and lakes.

Thus, despite the general outmigration from rural areas, areas with scenic amenities were actually magnets for growth in the 1980s. In Colorado, for example, counties along the scenic Front Range or in the mountains experienced employment growth at 2.3%/year during the 1980s. By contrast, employment growth averaged just 0.5%/year in the state's eastern rural counties located in the plains (Drabentstott and Smith In press).

Scenic amenities were one of the best assets on which to build a rural economy in the 1980s, and this trend is likely to continue in the 1990s. As population increases, the value of natural amenities will also increase. In the introduction to his book *Megatrends*, Naisbitt (1984:xxxii) noted that "trends, like horses, are easier to ride in the direction they are already going." Radically altered trends in the economy have created considerable human misery, but—unlike riding horses—they are very difficult to adjust to.

Adding to the difficulty of this adjustment is the inertia of our basic understanding (or paradigm) of how our local economy works. As Power (1991:397) points out, "One of the last things to change is that shared collective understanding of what drives the local economy. In that sense, the shared conventional wisdom about the local economy is a 'view through the rear-view mirror', a view tied to the past, rather than the present economic reality." In today's economy, development strategies are properly judged in terms of how their potential for creating jobs and income compares against **realistic alternatives** today and in the near future, rather than against historical levels based on traditional industries.

TOURISM AS A STRATEGY FOR RURAL DEVELOPMENT

To understand the potential for ecotourism in rural areas, it is helpful to understand the tourism industry. Tourism is one of the world's largest and fastest growing industrial

sectors (World Tourism Org. 1991). In the U.S., 39 states listed tourism in the top 3 of their largest industries in 1991 (Loyacono 1991). Tourism has emerged as a major focus for new economic activity in rural areas. In Oregon, tourism is estimated to be a \$3 billion/year industry (J. Curtis, State of Oreg. Tourism, Div., pers. commun.). The attractiveness of tourism as a development strategy in rural areas of Oregon is indicated by the number of counties choosing tourism as their industry focus for the state's Regional Strategies program. During the first biennium of the program, 21 of Oregon's 36 counties chose tourism as a focus for development, using over \$15 million in Regional Strategies funds to leverage \$174 million in other funds (Oregon Econ. Develop. Dep. 1989). Seven years into the program 25 counties list tourism as a major focus for development (Oregon Econ. Develop. Dep. 1994). Many factors contribute to the rise of tourism as a rural development strategy. In addition to the immediate attractiveness of hitching on to a rapidly growing industry, tourism is considered clean, easy to establish, and in many places, the only obvious alternative.

A recent review of literature (Frederick 1992:1-2) provides a balanced assessment of the pros and cons of tourism development as a strategy for rural economic development. Included was the following summary of findings:

Tourism can be a mixed blessing. Many new tourism jobs require little training of rural residents because of the menial nature of the jobs, such as food servers, maids and retail clerks. These jobs are often seasonal, with low wages, few benefits, and little chance for advancement. The better paying tourism jobs, such as those in management, could require the costly training of rural residents and, as a result, often go to outsiders.

Though tourism can provide new tax revenues for a rural area, it is also the source of long-term financial commitments from the area, especially in maintenance of roads and other infrastructure. Such commitments tax rural residents who do not always benefit from the tourism development.

Some studies claim that one benefit of tourism is that it places few demands on local public services, like schools and hospitals. But, during the peak tourist season, the resulting congestion, traffic jams, vandalism, and crime can create a demand for more police officers.

Tourism creates a demand for rural land. This demand, along with restoration of unused rural housing, enhances the value of private land and property. While the increased value will raise the tax base and be a benefit to many landowners, the inflated land and housing prices often result in prices above what most local residents can afford.

Tourism is regarded as beneficial to the cultural heritage of rural areas . . . However, tourism development can result in overcrowding that can damage these historic sites. Tourism can lead to the rediscovery or reawakening of regional cultures, but overcrowding can disrupt the patterns of daily life in the destination area. Tourism is also a factor in popularizing local arts and crafts, resulting in an increased demand for these goods. This however, can lead to automation in the production of such crafts, lowering their quality and debasing their original meaning . . .

The rural tourism attraction is often a natural resource, like the beauty of a rural area. In these cases, little physical development is needed to promote the tourism product. However, overdevelopment and overcrowding can degrade, or even destroy, the resource and the environment that first attracted the tourists.

ECOTOURISM'S NICHE IN TOURISM DEVELOPMENT

Ecotourism is a relatively new and rapidly growing form of tourism. The central tenet of ecotourism is the increased appreciation for, and active preservation of, the natural environment. Much of the literature on the subject is based on international experience—primarily in less-developed regions of the world. Nevertheless, this literature is highly relevant for remote rural areas in the western U.S.

"Ecotourism" is a word that has a wide variety of interpretations and an incredible array of associated references. Related terms include adventure tourism, alternative tourism, appropriate tourism, community-based tourism, environmental pilgrimage, environment-friendly tourism, ethical tourism, green tourism, nature tourism, nature-based tourism, nature-oriented tourism, nature travel, responsible tourism, scientific tourism, soft tourism (*tourisme doux*), special-interest tourism, sustainable tourism, and wildlife tourism (Valentine 1993).

Sustainability is a theme inherent to most of these references. In fact, the major difference between ecotourism and most other forms of economic development is the intent (in the more restrictive forms) to develop economic activity in alignment with principles of sustainability. Woodley (1991) identifies 3 major components included in the idea of sustainable ecotourism development: (1) long-term economic sustainability, within a framework of, (2) long-term ecological sustainability, with (3) an equitable distribution of the costs and benefits of development.

Environmental organizations have generally insisted on a restrictive use of the term—that only tourism that is nature-based, sustainably-managed, supportive of conservation, and provides education about the environment should be

described as "ecotourism." Industry and government tend to focus exclusively on the product aspect—often treating ecotourism as synonymous with any nature-based tourism. Most domestic forms of ecotourism fit the less restrictive term.

Even with the best intentions, the sustainability of ecotourism efforts to date has been questionable. Champions of ecotourism, according to Wall (1994), often assume that it is environmentally benign because the party sizes are typically small and the visitors are assumed to be environmentally sensitive. In fact there are good reasons for suggesting that ecotourism has the potential to be ecologically disruptive: (1) ecotourism is usually directed to special places with limited ability to withstand frequent visits; (2) visitation may occur at critical times for local species, such as the mating or breeding seasons; and (3) even if the on-site impact is small, the off-site and enroute impacts may be substantial—especially when the total ecological costs associated with visitors' flying, driving, and other energy intensive practices are calculated.

With regard to economics, the local economic return from ecotourism abroad frequently has been small. Whereas much money is spent by ecotourism participants, relatively little of it is, or can be, spent locally. Also, the structure of the industry (following the economic imperative to grow and achieve economies of scale) works against local control of the industry (Wall 1994). Ironically, if the numbers of visitors are kept small, the local economic impacts will remain small.

Social consequences can include an "invasion" of outsiders (and their culture) into the local area, increased land and housing costs, and the elimination or regulation of traditional uses of the resource by local residents. If ecotourism is to benefit local residents, means must be found to facilitate local participation in the industry. The clear challenge to communities is to balance the ecological, economic, and social goals of ecotourism.

EXAMPLES OF ECOTOURISM IN OREGON

The specific question being asked today in Oregon and the West is can ecotourism replace jobs lost in extractive industries? Can ecotourism provide opportunities for **anyone** to thrive in rural areas? Finally, if ecotourism is emerging as a viable rural development strategy, what will be the social impact on local residents?

Oregon has a long history of nature and adventure-oriented recreation. There are numerous enterprises not mentioned in this paper. The 2 elements relevant to "ecotourism" described in the following examples are that these activities employ nonconsumptive uses of the resource, and they incorporate education about the natural environment. I have selected these examples because they are new ventures as-

sociated with the major resource industries currently in "crisis." Two of the examples relate to the timber industry, 1 primarily concerns the livestock industry, and 1 is tied to the salmon industry.

Coastal Mountain Tours

Coastal Mountain Tours (8505 Pike Road, Tillamook, OR 97141 Ted Arthur, Owner [503] 842-1231), provides educational tours of the Coast Range forests, especially the Tillamook Burn area. Education focuses on the geology and geography of the area, the history of the burn and reforestation efforts, wildlife habitat, current and future logging practices, old-growth remnants, etc. The venture employs 1 program person and an office assistant. Neither were previously employed in the timber industry, although the owner has lived in the area all his life. The business is growing after some early learning experiences. Clientele are almost exclusively from the east coast of the U.S. The economic return to the local economy are the program fee and incidental expenses related to travel. The program "gets people off Highway 101" and into the rural areas of the county. Most clients are unaware of the Tillamook Burn and forestry practices in general. Their feedback indicates a deeper understanding and appreciation of the forest ecology of the region and the local logging culture.

Opal Creek Scientific and Educational Preserve

The Opal Creek Scientific and Educational Preserve (33435 Little North Fork Road, Lyons, OR, Olivia Thomas, Development Director [503] 897-2921) provides educational programs each weekend in good weather. It also has facilities available for scientific research. Examples of recent programs include trips to Jawbone Flats to view the abandoned mining town, old-growth hikes, and custom trips based on visitor interests. Research is conducted on various forestry topics. The Preserve also manages grants for forest restoration projects.

The office and facilities of the Preserve are located in the forest. The Preserve employs 2-3 full time and 6-8 part time. Local residents are currently employed in maintenance and housekeeping jobs. Preserve buildings and vehicles are maintained locally. Some printing of materials is done locally. Visitors and employees eat at local restaurants and buy various personal services locally. The Preserve's business plan specifically seeks to increase returns to the local economy, and to employ more local residents. Plans to grow include a new museum and 2-3 additional employees.

Elderhostel Eco-education Program

The National Elderhostel Network (Barb Gover, Executive Director, Lakeview Chamber of Commerce, Lakeview, OR 97630 [503] 947-6040) is a program of continuing education for people ≥ 60 years old. The program

operates through colleges and outdoor agencies. Thirty to 40 people take part in the Lakeview program each cycle, with about 175 participants/year. Most participants are retired professionals from outside the Pacific Northwest. The Chamber offers educational programs on the ranching and timber industries. Visitors receive education on local ecosystems and cultural history including the Oregon Trail. Some are taken to working ranches where they lasso, brand, and inoculate cattle. A similar program called "From the Hills to the Mills" educates visitors on the local timber industry.

The size and duration of the program results in thousands of dollars spent in the local economy. Many participants in the Elderhostel program return as visitors. No local people are directly employed solely from this program. Ranchers participate voluntarily. Feedback from participants suggests that what they learn adds to their perspective of the role of humans in the environment. Some visitors said they would stop supporting certain environmental groups because of their experience in Lake County.

Columbia River Ecotours (unofficial)

Charter boat captains (Margaret Forbes, Clatsop Econ. Develop. Council, 100 16th Street, Astoria, OR 97103 [503] 325-7870) currently offer 4 tours: an upper river to Cathlamet, Washington, featuring cultural and biological history; a river tour of the City of Astoria, highlighting the historical and cultural aspects of the city; a tour of the mouth of Columbia River from Ilwaco, Washington; and a tour of Willapa Bay, Washington, focusing on the ecology of the estuary.

Lower Columbia River charter boat captains are faced with drastic reductions in fishing charters because of closures on salmon fishing. They are trying to make ends meet by offering ecotours; 8-14 charter boats are offering the tours. Commercial fishermen cannot take paying customers on their boats because of licensing restrictions. Local experts were recorded on tape as they interpreted the original tour. These recordings were transcribed and serve as the educational materials. Despite poor publicity and marketing the first year, the tours are providing limited income to some boats. A few see a real opportunity in ecotourism, others do not. Some peer pressure is felt from other captains not to "encourage" environmentalists.

General Observations from These Examples

Some anecdotal observations can be made from this small sample of ecotourism enterprises. From an economic perspective, it is notable that each example is a private, not public, venture. However, there are currently few full-time jobs drawing a "family wage" in these examples, although most operators feel optimistic about increasing their profits or adding employees in the future. There is a sense of being at the beginning of a growth curve in the ecotourism industry.

Except for the charter boat captains, no resource industry (consumptive) workers crossed over to ecotourism (nonconsumptive) jobs. There is clearly some economic return to the operators and local economy from nonconsumptive uses of the resources, but not much employment at this stage. The major economic returns to local economies are the indirect purchases associated with the personal and business expenses of hosts and tourists.

The observable social impacts also are small, but give a sense of what may develop in time. Most clientele are from outside the region and tend to be affluent professionals. Some operators felt the biggest return to the local economy was the changed perception by these visitors towards resource use in the West. These changed perceptions, they felt, would help "balance" the messages of extreme environmentalists. There was little public criticism by traditional resource users of these operators. A sensitivity toward maintaining a careful balance between local resource users and visitors was expressed by 3 of the 4 operators.

DEVELOPING ECOTOURISM AS A STRATEGY FOR RURAL DEVELOPMENT

If trends are like horses—easier to ride in the direction they are already going—then rural communities would benefit by mounting an effort to guide ecotourism efforts toward desired ends. To develop ecotourism in a manner that sustains the long-term ecology, economy, and social harmony of an area will take hard work. Adversarial (win-lose) forms of development are not sustainable. What is needed are forms of development that identify and support the mutual self-interest of local residents.

Two recent papers on community-based recreation development seem to point in the right direction. Bruns et al. (1994) describe a "partnership approach" that can be used by the major entities charged with planning and managing adventure tourism strategies. Moskowitz and O'Toole (1993) present a specific proposal for a new "community-based institution" to develop, within a framework of sustainability, the recreation potential of Wallowa County, Oregon.

The very nature of adventure travel has significant implications for 3 major sectors of any community: land managers (public and private), the tourism industry, and local governments. Yet each group has traditionally planned and operated independently of each other (Bruns et al. 1994). Natural resource management agencies tend to limit their scope of reference to developing management objectives within their property boundaries. Members of the tourism industry tend to assume the high quality of natural attractions and adequate community infrastructure. Local governments are frequently forced (often because of fiscal constraints) to play a reactive, regulatory role rather than be proactive in developing cooperative management partnerships among the parties. Bruns et al. (1994) argue that a broad-based community approach to planning and managing adventure travel be applied by communities to all of their adventure

tourism efforts, "community" in this context meaning not just rural towns and cities but the "entire rural neighborhood" encompassing all entities affecting the future character of adventure travel (Bruns et al. 1994). Their "partnership framework" is a 7-step process that addresses the partnership organization, community attractions and services, a visioning process, product development (including resource protection, infrastructure protection, and visitor services), marketing and promotion, funding and financing, and implementation and evaluation.

Another community-based approach for fully realizing the recreational potential of Wallowa County, Oregon, is proposed by Moskowitz and O'Toole (1993). They assert that it is possible to develop the county's high recreation potential without destroying the amenities and rural character that make Wallowa County attractive to its residents. The assertion is contingent on the development of "new institutions" that encourage and reward residents for voluntarily protecting the environment, and that give local people an incentive to cooperate rather than fight over their alternative visions and goals. To be effective, these institutions must meet 4 basic goals:

- ◆ They must be **environmentally sensitive**, protecting the scenic beauty, water quality, wildlife, the rural character of the county, and other amenities that residents appreciate.
- ◆ They must be **socially fair**, not leading to enormous benefits for a few at the expense of the many, nor replacing high-paying jobs with low-paying jobs.
- ◆ They must be **unsubsidized** by state or federal agencies, because large subsidies usually come with strings attached that lead to undesirable and unsustainable results.
- ◆ They must **minimize coercion**, allowing county residents to make their own choices to as great an extent as possible.

Moskowitz and O'Toole (1993) admit that meeting these goals will require innovative financing and planning strategies. They outline 5 basic steps to achieve this:

- ◆ Create a "**Wallowa Recreation Company**" that would be largely owned and managed by local residents. All residents would be given one share of common stock (voting) and be invited to purchase more. Initially, people from outside the county would only be allowed to purchase preferred (nonvoting) shares.
- ◆ **Purchase conservation easements**, paid partly with shares in the recreation company, from all or nearly all private landowners in the county. This would allow cooperating landowners to share in the profits from recreation developments so that they will not be pressured to develop their own land.

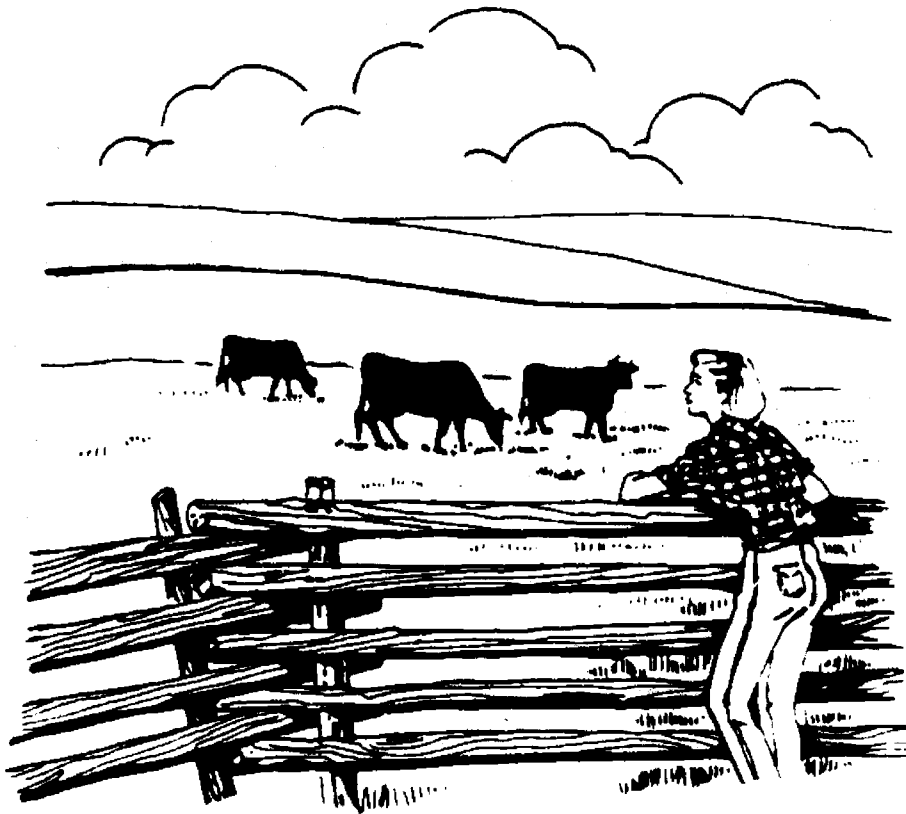
- ◆ Carefully plan and construct **recreation facilities** in selected locations that consider the needs of local uses, as well as the needs of others. The facilities would be designed to supplement, not compete with, existing resorts and motels.
- ◆ Develop an **innovative transportation system** that minimizes congestion and pollution. This would include passenger trains from La Grande to discourage the use of automobiles in the county.
- ◆ Encourage federal land managers to **charge recreation fees** at fair market value so they would not unfairly compete against private recreation programs, and would act to preserve the amenity value of their lands.

The creation of the Wallowa Recreation Company, rather than trying to work through a government agency, is expected to improve the efficiency of planning and management of the recreation developments. Given the typically antigovernment sentiment of many rural areas, and the recent conflicts with federal land management agencies and environmentalists, the idea of a recreation company may be preferable in some cases to the "partnership approach" that depends more on goodwill than on mutual economic self-interest.

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CREATING AWARENESS OF CLEAN WATER ISSUES AMONG PRIVATE LANDOWNERS

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Abstract: Creating awareness among rangeland owners of water quality issues and watershed structure and function has become an objective of the University of California's Cooperative Extension (UCCE) range specialists. In 1989 the Range Management Advisory Committee (RMAC) to California's Board of Forestry realized that protecting water quality had become a major rangeland issue and requested help from agencies including UCCE and U.S. Department of Agriculture Soil Conservation Service (SCS). A program of landowner education was initiated jointly by UCCE and SCS to support RMAC's objectives to develop and implement a statewide rangeland water quality management plan. The education program has resulted in numerous presentations to industry groups, ranch assessment field days, and rancher short courses. In 1994 we supported the public input process for the rangeland water quality management plan and we revised our ranch planning short course so that ranchers can complete a draft ranch plan that addresses rangeland water quality.

Key words: extension education, grazing, ranch management, rangeland, water quality, watersheds.

Rangeland, California's largest land type, covers >40% of the state's 101 million acres, with about half in private ownership. This half, however, represents 90% of the forage base for the state's range livestock. In the late 1980s the livestock industry leadership realized that protecting water quality had become a major rangeland issue for both public and private lands. This resulted in 2 associated activities that have increased awareness of clean water issues among private landowners: (1) development of a statewide rangeland water quality plan, and (2) jointly delivered education and technical assistance by University of California Cooperative Extension (UCCE) and U.S. Department of Agriculture Soil Conservation Service (SCS).

DEVELOPING A RANGELAND WATER QUALITY MANAGEMENT PLAN

In late 1989, California's Range Management Advisory Committee (RMAC) to the State Board of Forestry identified water quality as a priority issue. A few months later it approved a 2-phased program to (1) develop a statewide rangeland water quality management plan, and (2) implement the plan by cooperating agencies, organizations, groups, and individuals at state, regional, and local levels. Leaders in the livestock industry began working with RMAC and the State Water Resources Control Board (SWRCB) to develop a rangeland water quality management plan intended to become an amendment to California's Nonpoint Source Management Plan. Rangeland owner awareness of clean water issues was heightened as they learned the planning process and required content for a state water quality plan.

A technical committee was formed by SCS, UCCE, the California Department of Forestry's Forest and Rangeland Assessment Program, and the SWRCB. In 1991 state and U.S. Environmental Protection Agency (EPA) funds were requested to help strengthen the staff, and in 1993 a private consultant was hired to coordinate a concentrated 2-year effort to complete the plan.

The industry's purpose is to "maintain and improve the quality and beneficial uses of surface water as it passes through and out of California's private rangelands" (Clawson and George 1992:1)—with the initial objective being to "develop and implement a water quality management plan that complies with the Clean Water Act" (Clawson and George 1992:1).

This plan will stress the following elements:

- ◆ voluntary implementation
- ◆ local management decisions
- ◆ public involvement
- ◆ use of existing technology
- ◆ cooperation with landowner assistance agencies
- ◆ strong education and technical assistance support
- ◆ monitoring adoption and performance of management measures and program goals.

Throughout discussion and review of the plan, SCS and UCCE have organized and presented information to support the planning process. Much of this information involved best management practices, watershed and ranch planning processes, and approaches to monitoring. They also helped the industry network with other agencies, especially regulatory agencies.

RANGELAND WATERSHED PROGRAM

Throughout the discussions leading up to the planning process and the plan itself, landowner awareness of clean water issues was furthered by extension education and technical assistance by SCS and UCCE. Concurrent with the planning process the SCS and UCCE have jointly conducted in-service training and landowner education programs. These were first funded through the Renewable Natural Resources Extension Act and now by an EPA grant. Directed toward rangeland watershed management on private lands, with emphasis on ranch and watershed-level water quality management planning, this program involves landowners in the process of identifying real problems and working toward solutions.

The project works with statewide organizations such as the California Association of Resource Conservation Districts, California Cattlemen's Association, California Farm Bureau Federation, and California Woolgrowers' Association, making presentations at committee meetings, conventions, local groups, and field days.

Fact sheets back up presentations and provide short descriptive background information explaining laws, regulations, terms, and the technical aspects and approaches to developing watershed management plans.

Locally delivered ranch planning and grazing management short courses help ranchers to develop ranch plans that address water quality. These short courses assist landowners in goal setting, resource inventory and mapping, record keeping, record analysis, budgeting, grazing management, and monitoring.

Small group "on ranch" field days have been an effective and nonthreatening means of identifying and discussing nonpoint source pollution on the ground. These meetings are kept small and it is understood that problems identified during the field day are not to become the focus of regulation following the field day. Subjects covered include recognition of potential water quality problems, management practices, and monitoring.

As we developed education programs to address landowner questions about watershed and water quality management, 3 questions evolved that tended to summarize rancher questions and concerns:

- What is the problem?
- Who says it is a problem?
- What can I do about it?

Following is a review of the information that we present to landowners to answer these questions.

What is the Problem?

Pollution is defined as "an alteration of the quality of the state's waters by waste to a degree which unreasonably affects their beneficial uses or facilities which serve their beneficial uses." Sewage, sewage sludge, garbage, solid

waste, chemical wastes, biological materials, radioactive materials, heat, soil, and agricultural wastes all can be pollutants of water. In the Clean Water Act, pollution is categorized by its source as **point** or **nonpoint**. **Point source pollution** is an observable, specific, and confined discharge of pollutants into a water body. Examples of this kind of pollution are feedlots, food processing plants, and agricultural processing plants. In contrast, **nonpoint source pollution** consists of diffuse discharges of pollutants throughout the natural environment. It occurs over extensive areas. As water from rainfall, snowmelt, irrigation, or human activities moves over and through the ground, it picks up and carries away natural and manmade pollutants, eventually depositing them into lakes, rivers, wetlands, coastal waters, and underground sources of drinking water. Nonpoint source pollution is usually associated with agricultural, forestry, mining, and urban stormwater runoff.

Nonpoint source pollution from rangelands may be caused by grazing, construction activities, mining, recreational activities, and natural processes. Grazing activity, particularly overgrazing, is considered a potential source of excessive sediment, nutrients, pathogens, and heat. Livestock is attracted to riparian areas for water, high-quality forage, and shade, frequently resulting in concentration of livestock impacts in riparian areas.

Sediment.—Whereas erosion on most rangeland is well below traditionally accepted tolerance levels, the vast area of rangeland and its critical position in the state's water supply system offers an opportunity to improve water quality throughout the state. Erosion is a natural process that is accelerated by human activities. Slopes exceeding the angle of repose naturally erode, especially when vegetation is removed by fire and other disturbances.

Soil erosion and sedimentation are the primary contributors to lowered water quality from rangeland. Pasture and rangeland generally become a source of nonpoint pollution when grazing removes a high percentage of the vegetative cover, exposing the soil surface to erosive action of water and wind. Eroded soil subsequently becomes sediment, creating the potential for water degradation that may lead to impaired uses. Sources of sediment may be divided into upland (sheet and rill), gully, and streambank. The 1984 SCS County Resource Inventory reported that sheet and rill erosion is a problem on one-third of private rangeland in California, with erosion averages of 3.3 tons/acre/year on 19 million acres (U.S. SCS 1994). As expected, this type of erosion is a greater problem in areas of high rainfall and steep slopes.

Streambank erosion is another source of sediment on rangelands. According to the SCS, >9,000 miles of streambanks are eroding and should be treated to reduce erosion (U.S. SCS 1994). Because of steep slopes, highly erodible soils, and intense storm characteristics, the sediment delivery ratio (a measure of the amount of eroded soil delivery to a water body) on most rangeland is relatively high.

Nutrients.—Leaching of nutrients from watersheds is a natural part of nutrient cycling. Nutrients from urine, manure, and decaying vegetation can become pollutants, particularly near streams and lakes during the rainy season or periods of runoff. In these locations, runoff can carry nutrients into water bodies quickly. Nutrient problems are usually most critical where animals congregate for water, food, salt, and shade. Nitrate and phosphate are usually the nutrients of concern. Pasture fertilization can be a source of these and other nutrients. Pesticides may be problems at some locations.

Pathogens.—Localized contamination of surface water, ground water, and the soil itself can result from animals in pastures and rangelands. Research reports show that livestock operations may cause increased coliform bacterial pollution in rangeland streams. Although fecal coliforms themselves are not pathogenic, they indicate that pathogens could exist and possibly flourish. Fecal streptococci also may be a reliable and definitive measure of human or animal pollution. The extent of pathogens depends largely on livestock density, timing of grazing, frequency of grazing, and access to the stream. Fecal coliform levels tend to increase as intensity of livestock use increases. Maintaining the health of livestock is critical, and proper management of the herd, its by-products, and exposed land areas is essential.

Heat.—Thermal pollution is an almost invisible consequence of reductions in stream shade because of heavy or continuous grazing of streamside vegetation. Thermal pollution also occurs when irrigation water heats as it crosses the field and then drains into a stream. Increased water temperature has an adverse affect on fish and other aquatic organisms, especially in cold water fisheries.

Riparian and Streambank Impacts.—Whereas livestock grazing and ranch management practices can influence water quality throughout a watershed, grazing impacts and public attention is focused on riparian areas. Documentation shows that cattle, given the opportunity, will spend a disproportionate amount of time in a riparian area compared to adjacent drier upland areas. This may be 5–30 times higher than expected based on the extent of the riparian area. Features that contribute to higher use levels in riparian areas are (1) higher forage volume and relative palatability in the riparian area compared to the uplands, (2) distance to water, (3) distance upslope to upland grazing sites, and (4) microclimatic features (Skovlin 1984). Although many of the riparian-fisheries-grazing studies have been deficient in design, measurement, or documentation (Platts and Raleigh 1984), a great deal of case history and observational information has been accumulated. Concerning grazing impacts on riparian areas, 4 components were most often studied: (1) fish habitat in the aquatic system; (2) woody vegetation components of the riparian area relating to fish and bird habitat; (3) herbaceous use and grazing levels that can influence

yields of plants, small mammals and invertebrates; and (4) watershed conditions of cover and soil compaction on the floodplain and runoff from upland range (Skovlin 1984).

Platts and Raleigh (1984) summarized direct effects of livestock grazing as follows:

- ◆ Higher stream temperatures from lack of sufficient woody streamside cover.
- ◆ Excessive sediment in the channel from bank and upland erosion.
- ◆ High coliform bacteria counts from upper watershed.
- ◆ Channel widening from hoof-caused bank sloughing and later erosion by water.
- ◆ Change in the form of the water column and the channel in which it flows.
- ◆ Change, reduction, or elimination of vegetation.
- ◆ Elimination of riparian areas by channel degradation and lowering of the water table.
- ◆ Gradual stream channel trenching or braiding depending on soils and substrate composition with concurrent replacement of riparian vegetation with more arid plant species.

Who Says it is a Problem?

Various state and regional assessments report where nonpoint source pollution occurs or could potentially occur. The SWRCB and Regional Water Quality Control Boards (RWQCB) report the beneficial uses of water and the impairments to beneficial uses in periodic state, regional, and river basin reports. Impaired water bodies are listed in the May 1992 State Water Quality Assessment by the SWRCB (SWRCB 1992). The California Department of Forestry and Fire Protection is preparing an assessment of water quality on the state's rangelands. The SCS reports on erosion and sedimentation problems in its county resource inventories. Landowners and managers should review these assessments to determine whether they live in a watershed that drains to an impaired waterbody.

The SWRCB and RWQCBs regulate water quality in California. Riparian and wetland habitats are increasingly regulated by the U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, California Department and Fish and Game, and other agencies. The California Coastal Commission and National Oceanic and Atmospheric Administration (NOAA) have regulatory authority in the coastal zone. The EPA cooperates with and delegates regulatory authority to these agencies. The Clean Water Act, Coastal Zone Management Act, Porter Cologne Act, and other federal and state legislation provide regulatory authority to these agencies.

Federal Water Pollution Control Act (Clean Water Act) (1972).—First enacted in 1972, with the most recent reauthorization in 1987 (due for reauthorization in 1993). The act covers water pollution and water quality from many angles including point and nonpoint source, groundwater, surface water (lakes, rivers, streams, estuaries), wetlands, and water

quality standards. Point sources from urban areas, industry, and confined animal facilities have received the most attention during the past 20 years.

SECTION 208 (1972): Directs the states to develop programs on nonpoint source pollution that include (1) an assessment of nonpoint source pollution, and (2) a program to control nonpoint source pollution. In developing and implementing the nonpoint source pollution programs are the references to Best Management Practices (now called management measures) as a means to control pollution.

SECTION 303: Addresses water quality standards.

SECTION 319 (1987): Reflects the increasing recognition of the importance of nonpoint source pollution and emphasizes the mandate that states implement effective management programs. EPA considers agricultural runoff as the major cause of nonpoint source pollution. EPA also has shifted the emphasis from "direct threat to human health or safety" to a "threat to ecosystems and habitat." Sediment, nutrients, pathogens, and chemicals, in descending order of importance, are considered the "pollutants" from agriculture. All states now have approved (or portions of approved) nonpoint source management programs and currently are receiving grants authorized in this section to assist in implementing approved programs.

SECTION 404 (1987): Includes wetlands of any size and location as "waters of the U.S.," and authorizes EPA and U.S. Army Corps of Engineers to regulate activities that affect wetlands.

California Porter-Cologne Act (1969).—Actually enacted before the Clean Water Act (CWA), it designated the SWRCB as the statewide water quality planning agency, and also gave authority to 9 semi-autonomous RWQCBs that were established 20 years earlier. Beyond establishing the state framework, this act is now revised to comply with the federal CWA.

The State Board is responsible for developing statewide water quality plans (i.e., Inland Surfaces Plan), whereas the Regional Boards are responsible for developing Regional Water Quality Control Plans (usually called River Basin Plans), which in turn are approved by the State Water Quality Control Board and the EPA. Within these plans are water quality objectives, a list of beneficial uses, and implementation mechanisms. These plans, both statewide and basin, include identification of beneficial uses, water quality objectives, and an implementation plan for surface water and groundwater bodies. Regional Boards have the primary responsibility for implementing the provisions in both statewide and basin plans. The state structure implements the federal legislation.

Coastal Zone Management Act (CZMA) (1972).—This was reauthorized with the passage of the Coastal Zone Act Reauthorization Amendments of 1990. The act involves both the EPA and the NOAA.

SECTION 306: Requires states to develop a coastal zone management plan.

SECTION 6217: Entitled "Protecting Coastal Waters," requires states with approved coastal zone management programs to develop and implement Coastal Nonpoint Pollution Control Programs. These programs must comply with sections 208, 303, 319, and 320 of the CWA and the state coastal zone management programs:

- ◆ Provide for the implementation of management measures conforming with the guidelines to protect coastal waters.
- ◆ Provide for additional management measures if needed.
- ◆ Provide for technical and other assistance to local governments and the public to implement management measures.
- ◆ Provide for public participation.
- ◆ Establish mechanisms to improve agency communications and permitting processes.
- ◆ Propose to modify state coastal zone boundaries as necessary to meet NOAA recommendations.

This section also requires NOAA and EPA to develop guidance and implementation documents—i.e., "Proposed Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters" and "Coastal Nonpoint Pollution Control Program—Program Development and Approval Guidance."

California Coastal Act (1976).—Formally authorizes the California Coastal Commission after being established by an initiative in 1972.

Conservation of Aquatic Resources—1970, Fish and Wildlife Protection and Conservation—1976 (Department of Fish and Game).

SECTION 5650. Relates to deleterious materials in water such as silt, nutrients, bacteria, and toxins.

SECTION 1603. Describes streambed alteration process agreements.

SECTION 1607. Provides for fees to cover costs relating to fish and wildlife protection and conservation.

What can I do about it?

Become Informed.—As a landowner you should become informed about assessments and regulations that affect your ranch operation. Talk to the RWQCB and other agencies. Attend Cooperative Extension and SCS education programs. Review the RWQCB Basin Plan that covers your ranch. Participate in local watershed planning and restoration projects.

Develop a Ranch Plan.—If you live in a watershed that contributes to a nonpoint source pollution problem you should develop a ranch plan that (1) assesses water quality problems on your ranch, (2) considers alternative solutions, and (3) selects solutions to be implemented. Cooperative planning of the entire watershed may be necessary to solve

nonpoint source pollution. The RWQCB may require watershed planning in high priority watersheds. Cooperative Extension currently conducts ranch planning and grazing management short courses for ranchers so that they can develop ranch plans.

Change Practices.—Practices that are implemented to reduce nonpoint source pollution are called “best management practices (BMPs)” or “management measures.” The use of BMPs on rangeland to maintain and improve water quality is mandated by the CWA of 1977. The 1991 reauthorization of the Coastal Zone Management Act refers to “management measures” instead of BMPs and recent guidelines define management measures and management practices.

A BMP as defined in the Clean Water Act “is a practice or combination of practices that is determined by a state to be the most effective means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals.” (George et al. 1994) These measures must be technically and economically feasible. The term “best” is subject to interpretation and point of view. In recognition of this, a recent EPA document uses the new terms “management measures and management practices.” Management measures are goals developed during a process of problem assessment. Management practices that address these goals are selected after examination of alternative practices. Legally, a practice must be certified by the SWRCB. The SWRCB may delegate this authority to the RWQCBs.

Monitor.—Whether your ranch is in a targeted watershed or not, you may want to document current management with photographs. If you implement management changes, photograph and document nonpoint pollution sources before implementing new practices. Annually re-photograph these locations to show the success of these new practices.

THE FUTURE

We expect to continue education programs directed at the owners and managers of grazed watersheds. However, we have concerns about our ability to sustain the program in

the long run. Will the funding be available to support these education programs? Will other organizations without a linkage to the research base capture the funding for educational programs? Will federal and state administration in the Land Grant System rejuvenate communication with agencies such as EPA, U.S. Forest Service, SCS and others to cooperate on projects of mutual interest?

Clean water issues have provided an opportunity to conduct rangeland management education programs that not only focus on production but also on environmental quality. This is fertile ground for the Agricultural Experiment Station and the Cooperative Extension Service to conduct education programs and to develop science-based information to improve decision making. Will we seize this opportunity or will the Agricultural Experiment Station and Cooperative Extension Service quietly slip away on the eve of the 21st century?

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WILDLIFE DAMAGE MANAGEMENT TO PROTECT LIVESTOCK: ECOLOGICAL EFFECTIVE OR SOCIO-POLITICAL APPEASEMENT

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Abstract: Wildlife is a publicly owned resource held in trust and managed by state and federal agencies. Society expects government to provide leadership in wildlife damage management to ensure the maintenance of environmental quality while providing acceptable balances between human interests and wildlife needs. Wildlife sometimes cause significant damage to private and public property, including livestock. The U.S. Department of Agriculture, Animal Damage Control (ADC) program provides an alternative approach to wildlife damage control. The ADC program is administered by professional wildlife technicians and biologists through cooperative wildlife management programs with federal, state, and local jurisdictions and private individuals. Wildlife damage management programs implemented by ADC use a variety of methods and techniques. The ADC program considers environmental, social, economic, and legal impacts before control activities.

Key words: animal damage management, livestock, predation, predators, public attitudes, wildlife management.

In the United States, all wildlife is publicly owned and held in trust by state and federal agencies. Wildlife is highly regarded by the public for its aesthetic, recreational, and economic benefits. Governmental agencies are mandated to provide for the welfare and perpetuation of wildlife, and to be responsive to various groups while considering potential socioeconomic conflicts. Society expects these same governmental agencies to provide leadership in wildlife damage management (WDM) to ensure the maintenance of environmental quality while providing acceptable balances between human interests and wildlife needs. Approaches to human-wildlife conflicts are highly variable because of factors such as the wildlife species involved, wildlife population dynamics, and animal behavior. The human-wildlife interface is dynamic, as are the conflicts, and solutions often are not simple or straightforward. WDM is a complex process involving biological, social, economic, and legal considerations. To measure the ecological effectiveness of WDM also requires an understanding of the complex biological, sociological, economic, and political issues, and how they are interrelated.

THE CURRENT ADC PROGRAM IN OREGON

Wildlife Damage Management, commonly known as animal damage control, is the alleviation of damage or other problems caused by or related to the presence of wildlife. WDM is an integral and responsible element of wildlife management (The Wildl. Soc. 1990).

The U.S. Department of Agriculture, Animal Plant and Health Inspection Service (APHIS), Animal Damage Control (ADC) program is authorized by Congress to resolve wildlife damage problems by the Animal Damage Control Act of 1931, and the Rural Development, Agriculture, and Related Agencies Appropriations Act of 1988. In Oregon, WDM is accomplished through cooperative programs and

authorizations from other federal, state, and wildlife regulatory agencies, local agencies, and private entities. WDM efforts are directed towards cooperative cost-shared activities with 24 county governments. Formal cooperative agreements define agency responsibilities and procedures between ADC and the Oregon Departments of Fish and Wildlife and Agriculture, the U.S. Forest Service (USFS), and the Bureau of Land Management (BLM). The ADC program provides leadership in WDM techniques and employs professional wildlife biologists and technicians to conduct, monitor, and supervise WDM programs and projects.

WILDLIFE DAMAGE MANAGEMENT APPROACH

The most effective approach to resolving livestock damage or any other wildlife problem is to integrate the use of several methods simultaneously or sequentially. This approach, sometimes referred to as Integrated Pest Management (IPM) or Integrated Wildlife Damage Management (IWDM), is the combination and application of safe and practical methods for the prevention and control of damage caused by wildlife. ADC program strategy involves analysis of the problem using the informed judgement of trained personnel and a systematic evaluation of results to make ongoing adjustments to the management program. The philosophy of IWDM is to implement effective management techniques while minimizing the potentially harmful affects to humans, target and nontarget species, and the environment in a cost-effective manner. IWDM draws from the largest possible array of options to create a composite of techniques appropriate for the specific circumstances. IWDM may incorporate cultural practices (e.g., animal husbandry), habitat modification, animal behavior (e.g., scaring), local population reduction, or any combination of these, depending on the specific damage situation.

Before selecting management techniques for damage situations, ADC follows specific decision-making steps to consider biological, sociocultural, economic, physical, and other environmental circumstances associated with the wildlife damage problem (Slate et al. 1992). This process, known as the ADC Decision Model, involves:

- ◆ Receiving and responding to requests for assistance.
- ◆ Assessing the problem to (1) determine whether it is within the authority of ADC, (2) confirm wildlife damage, and (3) determine the extent and magnitude of the damage.
- ◆ Evaluating WDM methods for their legality and practicality.
- ◆ Formulating WDM strategies using IWDM principles.
- ◆ Providing assistance, either technical or direct operational management, if warranted.
- ◆ Monitoring and evaluating WDM actions.
- ◆ Terminating project.

Availability of various methods allows ADC greater flexibility and opportunity to formulate an effective management strategy for each wildlife damage situation.

ADC personnel provide technical assistance (information, demonstrations and advice) when the situation warrants. This may include recommendations such as penning livestock at night, shed lambing, herding, the use of guarding dogs, or any combination thereof. Physical exclusion, such as predator-proof and electric fences, are also recommended producer practices when exclusion will stop predation. Other common nonlethal WDM practices incorporated by ADC personnel may include the use of frightening devices, such as electronic guards, propane exploders, and pyrotechnics. Direct operational management (WDM-conducted or supervised by ADC personnel) is usually implemented when it has been determined that the problem cannot be resolved through technical assistance. When appropriate, mechanical methods such as shooting, calling and shooting, leg-hold trapping, aerial hunting, and foot or neck snares are employed. Currently, 2 chemicals are registered for use as predicides by U.S. Environmental Protection Agency and the Oregon Department of Agriculture. These chemicals are sodium cyanide, which is used in the M-44 device, and the gas cartridge, which is used for den fumigation.

Scope of Livestock Losses

The increasing number and kinds of wildlife damage problems are broadening the responsibility of the ADC program and personnel. The public's demand for WDM by ADC to protect all types of agriculture and natural resources is increasing (USDA 1993a). However, livestock protection continues to be the primary responsibility of the Oregon ADC program.

Cattle and calves are most vulnerable to predation at calving and less vulnerable at other times of the year. Sheep, and especially lambs, can experience high predation rates

throughout the year (Henne 1977; Nass 1977, 1980; Tigner and Larson 1977; O'Gara et al. 1983). Studies have shown that coyotes (*Canis latrans*) and other predators can inflict high predation losses on livestock owners. DeLorenzo and Howard (1976) evaluated losses on a New Mexico sheep ranch during 1974–75 and determined that 37% of all losses in 1974 and 50% in 1975 were caused by predators, primarily coyotes. The National Agricultural Statistics Service (NASS) estimated that in the U.S., coyotes killed sheep, lambs, and goats valued at \$16.4 million during 1990 (NASS 1991). In Oregon, NASS (1991) reported that predators killed 5,100 adult sheep valued at \$296,000, 18,800 lambs valued at \$583,000, and 4,500 calves valued at \$1,440,000.

Connolly (1992) calculated that only a fraction of the total predation attributable to coyotes is confirmed by or reported to ADC. He also stated that based on scientific studies and recent livestock loss surveys from NASS, ADC only confirms and reports about 19% of the total adult sheep and 23% of the lambs killed by predators. In 1993, Oregon ADC specialists verified that predators killed 625 calves valued at \$129,645, 608 adult sheep valued at \$36,236 and 1,923 lambs valued at \$103,404 (Manage. Info. System 1993). ADC personnel do not attempt to locate every head of livestock killed by predators, but rather to verify losses to determine that a problem exists that requires some form of WDM.

Though it is impossible to accurately determine the amount of livestock saved from predation by ADC, it can be estimated. Scientific studies reveal that in areas without some level of WDM, losses of adult sheep and lambs to predators can be as high as 8.4 and 29.3%, respectively (Henne 1977, Munoz 1977, O'Gara et al. 1983). Conversely, other studies indicate that sheep and lamb losses are much lower where WDM is applied (Nass 1977, Tigner and Larson 1977, Howard and Shaw 1978, Howard and Booth 1981). An Oregon State University study suggested that about 2% of adult sheep, 4.7% of the lambs, and 0.9% of the calves produced in Oregon typically are killed by coyotes each year in spite of WDM (DeCalesta 1978).

Environmental Monitoring and Analysis of ADC Activities

ADC incorporates mitigation measures to prevent, minimize, or compensate for potential impacts that might otherwise result from ADC WDM. The current ADC program nationwide and in Oregon uses many such mitigation measures as part of the program's Standard Operating Procedures (SOPs). These mitigations are used to provide safeguards that ensure routine program activities are consistent with state and federal laws and regulations.

To ensure that field activities do not adversely impact the environment, the ADC program is planning to develop a monitoring system that will collect, compile, summarize, and analyze information so that decision makers will be able to adjust or refine program activities. This will incorporate information gathered inside and outside ADC, including in-

formation from the public through the National Environmental Policy Act (NEPA) process, research, scientific literature, and reports from various state and federal agencies.

Environmental monitoring currently is being accomplished through standard operating procedures when various methods and techniques are implemented through IWDM. Mitigation measures contained in the U.S. Fish and Wildlife Service's (USFWS) Section 7 consultations provide for additional monitoring of ADC activities. The ADC Management Information System (MIS) currently provides program managers with data specific to each damage situation, thus enabling site-specific monitoring.

Potential environmental impacts from implementation of ADC WDM to protect livestock in the western U.S. were first analyzed by the USFWS in 1979 in an Environmental Impact Statement (EIS)(U.S. Dep. of Inter. [USDI] 1979). This EIS analyzed impacts to target and nontarget species, threatened and endangered (TE) species, rodent and lagomorph populations, and game species (USDI 1979). More recently, ADC released an EIS in March, 1994 assessing the impact of the ADC program (USDA 1994). This programmatic EIS examined 13 alternatives with detailed analyses of 5 alternatives. The analyses focused on wildlife species affected by WDM, losses associated with wildlife damage, social values and attitudes, and impacts on biological, economical, and physical aspects of the human environment. Because this EIS analyzed ADC program impacts on a national scale, it is not intended to determine site-specific impacts of individual project actions. Site-specific project actions are analyzed and evaluated in environmental assessments (EA) in accordance with NEPA. Changes in USDA policies, Memoranda of Understanding with the USFS, and pending revisions of ADC's NEPA implementation regulations have placed more environmental analyses responsibility on the ADC program.

In Oregon, considerable environmental analyses of ADC livestock protection have been conducted. Ecological impacts have been reviewed through the NEPA process, with formal Records of Decisions completed on the Wallowa-Whitman National Forest (NF), and the Vale, Burns, and Lakeview BLM Districts (USDI 1989, 1992a, 1992b). A recent draft EA for the Roseburg ADC District covering the 9 southwestern counties is being prepared by ADC. This EA analyzes the impacts of program activities to protect livestock and wildlife, and human safety threats from black bears (*Ursus americanus*) and mountain lions (*Felis concolor*). A summary of the major issues and concerns common to EAs addressing ADC activities are listed:

- ◆ Impacts on target species.
- ◆ Impacts on nontarget species, to include threatened and endangered species.
- ◆ Activities in wilderness or special management areas.
- ◆ Humaneness of methods used by ADC.
- ◆ The use of toxicants by ADC.
- ◆ ADC threat to human health and safety.

- ◆ Economic impacts to livestock producers.
- ◆ Cost-effectiveness of ADC.

ENVIRONMENTAL IMPACTS OF ADC

Target and Nontarget Wildlife

Since the 1979 EIS released by the USDI, all ADC EAs have analyzed program impacts to target species, primarily coyotes. The USDI (1979:99) concluded that "Based on available evidence, it seems clear that the ADC program, as now carried out, does not significantly reduce coyote numbers for periods in excess of 1 or 2 years on 200,000 square miles of the West." It concluded that "The Service's ADC program is not believed to have a major impact nor a long-term adverse impact on the diverse Western populations of target species" (USDI 1979:114). Target wildlife species commonly linked to livestock predation are coyotes, black bears, mountain lions, bobcats (*Lynx rufus*), red foxes (*Vulpes vulpes*), and domestic or wild dogs (*Canis familiaris*). Analyses of data by the USDI (1979) indicated that approximately 7% of the animals taken by ADC were nontarget. The USDI also concluded that ADC did not significantly impact black bear, bobcat, mountain lion, and fox populations.

The USDA (1994) contains a more detailed biological analysis of impacts to 17 major target species that are removed by the ADC program in relatively high numbers to resolve problem situations. The major issue is whether the ADC take, when added to all other take, would exceed the allowable harvest of a population, resulting in a population decline. Determination of magnitude for ADC take is based on the fraction of total take attributable to ADC activities. Population impacts were rated low across the western U.S. for all target species except the mountain lion, which was rated as moderate (USDA 1994:4-96). Based on these analyses, it was concluded that the ADC program nationwide has no adverse impacts on the abundance of target or nontarget species. These analyses also concluded that the ADC program is not expected to impact populations of target and nontarget species, but may impact populations or individuals on a localized basis (USDA 1994:5-3).

Site-specific EAs for ADC WDM in Oregon on USFS, BLM, state, county, and private lands in the Roseburg ADC District reveal similar impacts, except mountain lion magnitude of impact is low. ADC activities on the Wallowa-Whitman NF during 1987-91 accounted for about 16% of the coyote harvest and approximately 3% of the coyote population (USDA 1993b). Few (1%) nontarget animals were taken as compared to all animals taken. A 1992 EA conducted by the Vale and Burns BLM Districts concluded that the level of ADC coyote take was far below the level needed to have a significant long-term impact on local populations (USDI 1992a). The calculated average for all nontarget animal take in the Vale BLM District (USDI 1992a) for fiscal years 1987-92 was about 4.4%, well below the 7% average identified in USDI (1979).

The Roseburg ADC District draft EA analyzes ADC impacts to target and nontarget species for 1993. An impact analysis for coyotes revealed that the District's impact on the coyote population would not have any long-term effects on the coyote population in Oregon or the District. The ADC take was about 2.5% of the total coyote population in the District. Nontarget impacts also were analyzed in this EA. District ADC specialists took 25 nontarget animals (1.2%) from a total of 2,165 problem animals removed during WDM activities. Professional judgement determined that ADC WDM would have a low impact on nontarget species.

The United States General Accounting Office (GAO) conducted an independent audit of the ADC program to determine if ADC policies and practices were threatening predator populations in 17 western states (GAO 1990). The results of this audit reported several findings: (1) ADC activities, conducted under present policies, are not threatening predator populations; (2) ADC generally takes a small percentage of a total predator population; (3) the number of predators killed by commercial trapping, hunting, and poaching (other take) far exceeds that killed by ADC; and (4) ADC activities occur on only a small percentage of the predators' total available habitat.

Threatened and Endangered Species

Pursuant to the Endangered Species Act (ESA), the ADC program has reviewed its activities nationwide, in the Roseburg ADC District, and on those federal lands where formal EAs have been completed relating to WDM. The USFWS issued a formal Biological Opinion in 1992 that developed reasonable and prudent alternatives where a determination of jeopardy has been made (USDI 1992b). In Oregon, the northern bald eagle (*Haliaeetus leucocephalus*) is the only listed species that may be affected by ADC WDM. Specifically, through informal consultation with the USFWS, it was determined that the leg-hold trap was the only method that may negatively impact the bald eagle. With the inclusion of the reasonable and prudent measures, procedural changes found in the biological opinion and Section 7 consultations, and ADC program SOP, it was determined that the ADC program will have no effect on the bald eagle.

Wilderness and Special Management Areas

The need to conduct WDM in wilderness areas, or on federal or state lands designated for special management purposes (wilderness study areas, natural scenic areas, recreation areas, etc.) is jointly determined by the land managing agency and ADC. Because of specific federal laws and agency policies and regulations, WDM on these lands is highly regulated and controlled. Livestock grazing does occur on these lands, and depredation is responded to on a case-by-case basis, according to each agency's land management plans and guidelines. The ADC program has imple-

mented several mitigating measures for these special use areas that are designed to minimize hazards to humans and wildlife.

Humaneness

During the public involvement process (scoping) of the USDA EIS, some of the sociocultural issues were concerns for animal welfare and the killing of wildlife (USDA 1994). These issues also surfaced during scoping for the site-specific Roseburg ADC District EA. The issue of humaneness, as it relates to the killing or capturing of wildlife, is an important but very complex concept; each person interprets humaneness in a different way. As defined by ADC, humaneness applies only to those actions taken to catch, handle, or kill predators. Animal welfare organizations are concerned about the humaneness of some methods used to manage wildlife damage, such as the capture and detaining of animals in leg-hold traps. Livestock producers and some pet owners perceive humaneness differently. Because humans have removed the natural defense capabilities from most domestic animals through selective breeding, it can be argued that humans have a moral obligation to protect these domestic animals from predators (USDA 1994).

The ADC program understands that the attitudes and perspectives of the public are changing. Because strong human emotions are associated with the ADC program, ADC field personnel are experienced and professional in their use of all methods so that they are as humane as possible. To maximize humaneness, ADC has implemented SOP, mitigation measures in all cooperative program activities, and continue with research and development of more selective and humane management techniques. ADC has improved the selectivity of leg-hold traps with pan tension devices, snares with break-away locks, and the Livestock Protection Collar, which only kills coyotes that attack sheep.

Human Health and Safety

Concern was expressed from some members of the public about the impact of WDM on human safety caused by exposure to management devices and toxicants. To reduce any risk to the public from exposure to management devices or toxicants, SOPs and EPA use restrictions are followed. In addition, the health risks to the public are extremely low because most ADC methods are used in areas where public access is limited (USDA 1994), and warning signs are posted at all entry points where devices are used to warn the public of their presence. A detailed risk assessment in the ADC EIS documents low levels of risk associated with methods used by ADC (USDA 1994).

Economic Impacts

Economic impacts of the ADC program primarily are benefits received from WDM to reduce losses, measured by the difference between the amount of loss without WDM compared to when WDM is implemented. Determining exact economic impacts is unlikely because reliable estimates

of current wildlife-caused damage are difficult to obtain due to the lack of techniques and resources to verify these losses (USDA 1994). The ADC program attempted to evaluate these impacts using available loss data and estimates of livestock loss data in the literature. The economic feasibility of the ADC program to protect livestock from predators is achieved through the application of lethal and nonlethal methods. Selection of these methods depends on individual damage situations.

The USFWS estimated the adverse economic impacts from predation on livestock producers in 16 western states and attempted to answer certain questions (USDI 1979). The questions were (1) are livestock losses to predators lower with the ADC program than they would be without it and (2) how much livestock is "saved" by ADC activities? To answer these questions, a comparison of coyote predation on sheep and without predator control was conducted using livestock inventory and loss data, completed research studies, and by initiating new studies. The USFWS concluded that (1) average losses without control were 3.2% of the ewes and 14.9% of the lambs, (2) average losses with control were 0.3% of the ewes and 4.3% of the lambs, and (3) comparison of predation loss on sheep ranches with and without predator control indicated substantially higher loss on ranches without control (USDI 1979).

The USDA (1994) EIS contains an economic impact assessment similar to the USDI (1979). An assessment of the economic impact of ADC's current program relating to coyote damage management examined the benefits accrued from the program as compared to the costs incurred to achieve these benefits. Benefits or avoided losses, as defined by ADC, are the difference between the value of livestock killed without WDM and the livestock killed with WDM implemented. Based on recent estimates of sheep losses and scientific studies of sheep killed with coyote control, it was calculated that 42,000 sheep and 148,000 lambs were killed by coyotes nationwide during 1988. This represents an average loss rate of 1.2% of sheep and 4.0% of lambs. These rates fall within the normal range of losses with WDM reported in the literature.

Total sheep losses without WDM can be estimated by applying average loss rates from studies in areas where no WDM was conducted. Using data from 4 studies where WDM was absent, the average predation rates from coyotes on sheep and lambs were 4.5% and 17%, respectively (USDA 1994, Table 4-34). In the USDA (1994) EIS, these rates were applied to the inventory of sheep and lambs protected, resulting in a hypothetical loss of 185,000 sheep and 674,000 lambs in 16 western states. The difference between losses with WDM (42,000 for ewes and 148,000 for lambs) and without control (185,000 ewes and 674,000) provides a better estimate of the expected losses.

To better describe the benefits and "worth" of the ADC program, a cost-benefit comparison was undertaken. The efficacy of the current ADC program was determined by

comparing the above calculated benefits to the costs incurred to achieve the benefits. From FY 1990, ADC program costs for livestock protection for 16 western states were determined. Livestock saved or benefited from the ADC program was \$26.3 million. These figures represent a cost:benefit ratio of 2.4:1 and represent the returns expected for every dollar spent by ADC to protect sheep and lambs only.

THE SOCIO-POLITICS OF WILDLIFE DAMAGE MANAGEMENT

Based on the livestock losses from predation in Oregon and the U.S., the need for the federal government (ADC) to provide WDM is a reality to most livestock producers. In contrast, some members of the American public believe that WDM is just another subsidy to the livestock industry and a waste of taxpayers' money (Deeble and Stadler 1993, O'Toole 1994). Is federally sponsored WDM (ADC) an ecologically effective program or is it just another federal expenditure of dollars aimed at satisfying the current socio-political climate?

American attitudes toward predator control have changed dramatically since 1931 when the Animal Damage Control Act (Act) was passed. The attitude in Congress at the time of passage of the Act was a reasonably accurate reflection of American citizens' moods concerning animal pests. The debate over the passage of the Act, however, addressed issues of growing concern today: these are animal welfare and environmental impacts (USDI 1978). Despite this, Congress and most federal and state wildlife agencies support the ADC program. This support stems from the growing need of a federal presence in WDM and the growing support for ADC from other agricultural and natural resource interests, land and homeowners, and many other segments of the public who believe the federal government has a responsibility to minimize wildlife damage. Along with environmental protection, animal welfare, and endangered species, Congress has established legislative responsibilities to several agencies that directly affect WDM (Berryman 1992). To say that ADC is the sole agency responsible for WDM is incorrect. State and federal wildlife management and regulatory agencies along with private, state, and federal land managers also share responsibility to minimize wildlife damage. The current ADC program, through cooperative agreements, MOUs, and implementing IWDM, assists in meeting the goal of adequately protecting livestock.

As with many other government programs funded through various local, county, state and federal legislative levels, socio-politics play a major role. The very nature of "field level" ADC cooperative programs promotes local involvement and empowers citizens with a certain amount of oversight in the program. The ADC program is a "customer-driven" government program, because a great deal of program funding and support is derived from its "clients" or cooperators. Most of the cooperative funds come from state legislatures, county and city governments, elected boards,

and the U.S. Congress. The ADC program is responsive to these political entities, since these elected bodies of government are directed by the needs of their constituents.

Government officials and agencies strive to please those who are interested and respond to the agency. The ADC program, like many other state and federal government programs, desires to be responsive to its clients and the public. Determining client satisfaction is one method to assess program effectiveness (Osborne and Gaebler 1993). In 1993, ADC initiated a multi-phased national client-satisfaction survey. The objectives of the survey were (1) to determine if ADC clients are satisfied with direct WDM services, (2) what resources does ADC expend to achieve this level of satisfaction, (3) does the general public and groups familiar with ADC believe that wildlife and wildlife damage should be managed, and (4) what are the current public attitudes that affect ADC? The survey covered issues dealing with ADC personnel and the program's effectiveness. The results of the survey revealed a very high level of client satisfaction with the current ADC program. A summary of the overall level of satisfaction indicated that about 43% of ADC's clients were highly satisfied and about 42% satisfied. Results were also obtained for client satisfaction for ADC personnel and program delivery and indicated that (1) >97% of ADC clients believed that the services ADC provided were useful, and (2) >94% believed that the level of loss, damage, hazard, or nuisance would increase without ADC services. The results of this survey indicate that ADC is effectively satisfying clients.

The second objective of the survey was not accomplished. Current record keeping does not furnish the cost of each WDM action and therefore no estimate of resources expended could be made on each site-specific direct control project.

To accomplish objective 3, 42 individuals familiar with the ADC program were invited to attend 6 separate "focus group" meetings; 36 of those invited attended the meetings. These individuals were wildlife management advocates, animal rights-welfare activists, and ADC client representatives. Most participants valued wildlife, but for very different reasons. When asked, "Should wildlife be managed to reduce damage to agriculture, natural resources, and property, and to reduce risks to human safety?" many animal rights-welfare activists stated they supported WDM depending on the approaches and methods used. Most of the groups' participants agreed that the responsibility and funding for WDM should be shared. Some agreed that public agencies' roles should include education, technical assistance, direct control, and research. The findings of this "focus group" are inconclusive, but indicate that the current direction ADC is taking is in harmony with the group's findings (USDA 1993c).

To achieve objective 4, 2 major studies concerning public attitudes about WDM were reviewed by this group. This review revealed several relevant findings about public attitudes that affect ADC:

- ◆ Most people are unaware of wildlife issues except those concerning animals that have appeal to the public (i.e., wolves, bears, whales, etc.)
- ◆ Humaneness is the predominant determinant of acceptability of WDM methods.
- ◆ The public opposes nonspecific, inhumane methods.
- ◆ The public opposes indiscriminate killing and prefers nonlethal methods.
- ◆ The public believes compensation to farmers for losses to wildlife is not a viable alternative.
- ◆ The public believes farmers have the right to kill offending animals, but not as a preventive measure.
- ◆ As wildlife damage increases, lethal control becomes more acceptable.

The current program is committed to the sociocultural issues identified through the public involvement process. The primary social issues identified in the USDA (1994) EIS relative to managing wildlife damage are humaneness, effectiveness, and ecological soundness. The ADC program is responsive to public attitudes and concerns, and is taking the lead in the NEPA process on all lands to better monitor environmental impacts. The ADC program's current direction is futuristic in that field specialists and managers understand public attitudes and are striving to be better trained, educated, and professional in their work (USDA 1989). ADC is moving in the direction of preventing wildlife damage and promoting ways people can live with wildlife.

The mission of ADC has changed since being transferred to USDA in 1986. It is true that the protection of livestock remains an important aspect of the program's mission, but ADC's mission is becoming increasingly complex as field personnel respond to the increasing number and kinds of wildlife damage problems. IWDM, as implemented by ADC, is consistent with the needs of its clients and the desires of today's society. The USDA, APHIS, ADC program is an ecologically sound and effective means to handle human-wildlife conflicts that balances the concerns of the public.

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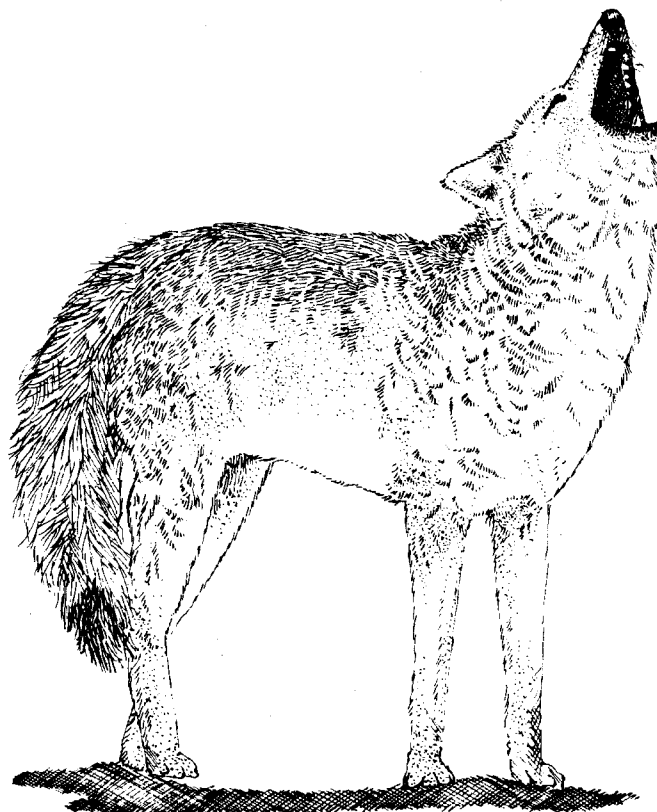
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PREDATOR CONTROL ON RANGELANDS: SOCIO-POLITICAL APPEASEMENT

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Abstract: For 63 years, the federal Animal Damage Control (ADC) program has conducted predator control on public and private lands in the West in an effort to reduce predation on sheep and cattle. During Fiscal Year 1992, ADC's predator control work, for livestock protection, in the 11 western states accounted for >80% (or \$8,242,487) of its expenditures in those states, and >44% of ADC's total field operations nationwide. During that same year, ADC killed 917,953 coyotes (*Canis latrans*), 10,598 foxes (*Vulpes* spp.), 1,243 bobcats (*Lynx rufus*), 1,022 badgers (*Taxidea taxus*), 306 mountain lions (*Felis concolor*), and 230 black bears (*Ursus americanus*) almost exclusively in an effort to reduce predation on sheep and cattle in the West. Yet, livestock losses remain at record highs in the West. I will present research that shows coyote exploitation does not reduce coyote populations, and statistical data that shows livestock losses are independent of numbers of predators killed. Instead, I will show that the western livestock industry's political clout is driving the federal ADC program in a direction contrary to public interest, resulting in a program that requires neither economic or management prerequisites of ADC's beneficiaries—the rancher.

Key words: animal damage control, livestock protection, predation, predator control.



PUBLIC LANDS GRAZING—THE COWBOY PERSPECTIVE

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Abstract: I present a general overview of past and present range management techniques, and ecological changes in our forests, streams, and ranges as witnessed by a life-long rancher and public lands grazer on the Joseph Creek drainage of Wallowa County, Oregon. I provide comments regarding range reform, the grazing fee issue, the Endangered Species Act, and other political decisions that affect the rancher and his ability to be a good steward of the land. I outline the economic realities of grazing public lands to the user, the community, the consumer, and the nation.

Key words: Endangered Species Act, grazing, grazing fees, public lands, rangelands.

We need to review history to understand the current circumstances and to properly assess the consequences of various proposals relating to grazing, not grazing, and the destruction of rural communities and our western culture. Perhaps we should start by looking at recent history (the last 2,000 years). Many people believe the grasslands of the West did not develop with large herds of ungulates. Large herds of ungulates grazed in the Pacific Northwest 1,500–2,000 years ago. Indian populations were at least twice what they were when the Europeans arrived. Thus, the native population had exceeded the carrying capacity of the land given the technology, lifestyle, and native plant and animal production capabilities. By the time the Europeans arrived in the Pacific Northwest, the big herds of ungulates were virtually gone; lack of food and associated diseases were decimating the Native Americans. As a result the ecosystem was already in trouble and was starting to collapse. Most winters some Native Americans died from malnutrition or associated diseases; these were the circumstances encountered by early trappers and explorers.

When the Europeans came they settled on the best lands. These were usually in the river bottoms and along creeks where the best soil and water were available. By the late 1890s most of the best lands and some of the marginal lands were homesteaded. Practically all riparian areas at the lower elevations were being intensively farmed or grazed and in many cases both. Each homesteader needed milk cows, pigs, chickens, and both draft and saddle horses. These animals were kept in close vicinity to the homestead. Pigs turned the meadows upside down; grazing was close and often year-long.

The uplands were carrying large numbers of cattle, sheep, and owned and feral horses and mules. To try and provide adequate forage these people burned some acreage yearly. Whenever ranchers found large areas of windfalls or other fuels, it was burned either early in the spring or late in the fall. Homesteaders had learned that burning at these times was the least detrimental to perennial grasses and kept the forest open and productive. The U.S. Forest Service (USFS) stopped this burning by the late 1950s.

When the USFS was formed in 1906, ranchers welcomed the opportunity to control uses on public lands and the assignments of certain areas for each rancher to graze. Through the cooperative efforts of ranchers and the USFS, large re-

mote areas were developed for the benefit of society. These areas were fenced, water was developed, roads and trails were constructed, and recreationists began to have access. Remember these were the lands left after the homesteaders had chosen the lands they felt were possible to develop and make a living on. They included steep canyons, dry deserts, high elevation areas with short growing seasons and extremely limited access.

Water development is the key to proper distribution of cattle and good range management. Developments should be made in under-used areas, not in areas that are already used. Proper placement of ponds is a very useful tool in range management. We've been involved in hundreds of pond and spring developments.

Fences were constructed to control drift. We found it necessary to fence allotment boundaries and fence spring, summer, and fall pastures, ensuring that cattle stayed in these units where the forage was ready for grazing and water was available. To progress through these pastures as the seasons progress, riparian pastures, corridor fencing, and deferred rotation and grazing systems are in place today to better control livestock use.

Today the rules of the game are changing—as responsible land stewards we are trying to adapt to these changes. Let's talk about some of these changes.

- ◆ Increased fencing, riding, and water development because of endangered salmon. Also loss to grazing of the easy productive areas along the creeks.
- ◆ Increased pressure from the USFS to adhere strictly to annual operating plans, allotment management plans, and Forest Plan standards and guidelines. That is not easy.
- ◆ Monitoring—permittees are required to monitor all pastures twice, during use.
- ◆ Increased use of allotments by the public.
- ◆ More government regulations—PacFish—Babbitt—fee increases.
- ◆ Lawsuits and political pressure—we have to react with time and money—both could be used in a more productive way on the land. If a sense of cooperation could prevail today in the areas of public lands management instead of an era of legal attacks, certainly the resource that I am trying to protect and enhance would benefit.

Probably any discussion of public lands grazing would be incomplete without addressing the grazing fee question. In my opinion the current grazing fee formula is fair. It has withstood the criticisms and scrutiny of Congress and the public since 1966. Every review and study by expert economists, college, and range management specialists has come up with the same conclusion. It is fair. Common sense tells me that if the fees were too low, equity would have flowed toward public land ranches. Just the reverse has happened. Public lands ranches are losing value every day whereas private land ranches are appreciating in value.

The true public-land-dependent ranches, those that graze 50–100% of their animals on government lands, enjoy very little prosperity. If you doubt this, take a little tour through the canyons and deserts of Oregon, Washington, or Nevada. The further you get from the deeded land valleys the more you will notice older buildings, older machinery, and other signs of marginal operations. Remember the homesteaders took up the most valuable productive ground, the ground that had good water and good farm land and was close to towns or railheads. The land that was left the government could not give away. Those are the public lands we graze today. Why would anyone think it should rent for the same fee as the private, more productive land?

What do we contribute, as public land grazers, to our communities and our country?

- ◆ Wildlife numbers have increased dramatically; from 1960 to 1988, antelope (*Antilocarpa americana*) have increased 112%, bighorn sheep (*Ovis canadensis*) 435%, deer (*Odocoileus* spp.) 30%, elk (*Cervus elaphus*) 782%, moose (*Alces alces*) 476%. That takes good habitat and feed to accomplish this and also is a direct result of more water developments that enlarged the usable part of the resource. It also takes tolerance for game damage.
- ◆ We are the caretakers—we are first on hand for fire prevention and the last link for communication for hunters and other recreationists. We share our experience with land management agencies in a cooperative manner.
- ◆ Certainly our most precious contribution is our children to our communities as school teachers, ranchers, or whatever profession they may choose. Children who learned to work, accept responsibility, and develop the character qualities that are produced by working with the family to achieve our ranching and personal goals. Ranch kids like ours will lend strength and stability to a faltering society.

- ◆ Economically we contribute 50% of the marketable lambs and 20% of the calves that go to the feedlots. In addition, western states produce nearly 52% of the wool, most of it from ranchers that use public forage. Of course, many cull cows and bulls are marketed each year, contributing to hamburger and other meat supplies. Grazing fees make substantial contributions to the Federal Treasury.

In 1990, Bureau of Land Management Director Cy Jamison, estimated that the grazing program actually cost \$17.5 million—\$1.5 million less than the grazing receipts. That seems to me to show quite clearly that the grazing program is not subsidized. By contrast the recreation budget recovers only 1% of its costs. Could our critics be those who are subsidized?

In summary, please remember that the public rangelands are in better condition now than at any other time in this century. We stand at the crossroads in regard to the future of public land grazing. On one hand you have the enviro-preservationists who live in a dream world of no-use. Under pressure and court actions they are slowly shutting the forest, grazing, and our communities down. Their land management philosophies will cause chaos to the environment and to the western communities dependent on resource production. Under their no-harvest concept of forest management, we are seeing all forest timber sales appealed, all bug-killed salvage sales appealed, resulting in an overstocked, stagnant, dying timberstand waiting for the lightning strike to turn our forest into a catastrophic wildfire that cannot be contained. By eliminating livestock grazing, flash fuels are added to this picture. The wildlife and their habitat will burn so hot that it will take years to heal. The fish will cook in the brook. This has happened and will continue until responsible land managers assert their leadership. Wake up Americans.

Your food supply is in the hands of 2.5% of the population. These people farm and harvest resources, and feed and shelter you. The Endangered Species Act, lawsuits, wetlands, legislation, the Clean Water Act, wilderness designations and a host of others threaten our survival, and ultimately yours. I pray you see the danger. We need responsible land managers in control, not fairy-tale and Alice and Wonderland dreamers. On the other hand you have 28,000 public land permittees committed to doing a better job all the time. Mostly ranch families. The system has worked well, and public lands grazing should continue.

POSSIBLE AND PROBABLE GAINS ARISING FROM CESSATION OF CATTLE GRAZING PUBLIC LANDS

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Abstract: The issue of permitting domestic livestock grazing on public lands has been receiving both local and national attention. The effects of such grazing are apparent when comparisons are made between riverine-riparian systems where grazing has been excluded and areas still subjected to livestock grazing. Comparisons also can be made between the existing condition of public lands and the uses sustained on, the products obtained from, and the cultures supported by those lands before the advent of Europeans and their livestock. Photographic evidence is available documenting the gains that can occur following the cessation of domestic livestock grazing. A listing of the benefits derived from removing domestic livestock from public lands builds a solid foundation for the case against permitting this commercial use of public lands. Those gains, or benefits, constitute vital elements of a healthy ecosystem—an ecosystem characterized by diverse communities of native plants and animals (reptiles, amphibians, insects, and predators of all kinds, as well as both game and nongame fish, birds and mammals), clean, flowing streams, green riparian zones, and stable uplands that safely capture, store, and release the precipitation that falls within a given watershed.

Key words: alien, cattle grazing, cessation, gains, Intermountain West, invasion, native, restoration, riverine-riparian.

Today domestic livestock, primarily cattle, graze the public domain lands. Various federal and state bureaucracies have been mandated to manage these lands under laws and regulations, policies, administrative rules, and executive orders intended to protect the nation's native species and their habitats, restore and maintain clean water and air, stabilize and conserve soils, protect various values, and provide for multiple use (Gen. Accounting Off. [GAO] 1991a)—all in the public interest.

What is to be gained from resting these public lands from the annual demands of cattle grazing?

This paper attempts to answer that question by reviewing what once was and by envisioning and listing some of the possible and probable gains to be made from the cessation of livestock grazing. The focus will primarily be on the inherent resource conflicts between native species and livestock on public lands, principally with respect to riverine-riparian zones. The paper's premise is that cessation of livestock grazing on public lands is the most economically feasible, most ecologically effective solution to the conflict.

An additional premise is that it is neither economically feasible to fence cattle out of all the riverine-riparian zones in the Intermountain West, nor is it ecologically effective or desirable. Given that "riparian zones are the most critical wildlife habitats in managed rangelands," that they are of disproportionate value to a wide variety of "uses" including water, fish and wildlife (Thomas et al. 1979:2-4) and that their status westwide is primarily degraded (GAO 1988), I conclude that the restoration, protection, and maintenance of these areas is of far greater value to the region and to the nation than the short-term lifestyle benefit (Holechek and Hess 1994, Power 1994) derived by the heavily subsidized public land livestock producers who operate in direct competition with all other deeded land livestock producers.

BASIC EFFECTS OF CATTLE GRAZING

Vegetation

I am convinced that in any discussion considering any aspect of livestock grazing it is vital to keep in mind certain basic facts about livestock. First, being ungulates, livestock remove vegetation. This may be selective removal as preferred plants are grazed or browsed first, but if livestock are permitted to remain, the vegetation removal will increase, culminating in total or near total lack of vegetation.

Soil

Second, the "cryptobiotic soil crust, consist[s] of cyanobacteria, mosses, and lichens, an important component of ecosystems in semiarid areas" (Belnap 1992:1). Livestock disturb soils, breaking through and churning up this living skin of the earth's surface, thereby increasing natural erosion from wind, water, and animal movements. This disturbance negatively affects nutrient cycling and the ability of the crust to receive and store precipitation (Belnap 1992, Belnap and Gardner 1993, Belnap et al. 1993).

Water

Third, livestock require substantial amounts of water and tend to congregate around water sources, whether vulnerable natural systems such as streams, lakes, or springs, or artificial systems such as reservoirs, tanks, and troughs. These areas receive a disproportionate share of animal wastes as the livestock remain near the water sources. Vegetation removal, waste deposition, and soil erosion are concentrated in and around those landscape features most valuable to native wildlife and to humans—the riparian areas and their associated aquatic ecosystems.

Cumulative Effects

Finally, the cumulative effects of these activities are expressed in how the affected area handles natural climatic cycles and events (drought, flood, extreme cold), fire, rain, and other precipitation. Healthy watersheds and their dependent native species (plant and animal) coevolved with these events and cycles. Domestic livestock did not (Mack and Thompson 1982, Platts 1990).

This paper does not review the laws and regulations that apply to public-land livestock grazing, nor does it debate the issue of livestock degradation of the land and natural resources. The solution to the conflict is "certainly not to argue whether livestock grazing degrades riverine-riparian zones" (Platts 1990:1-18).

Documented Degradation.—That debate has been addressed extensively in many writings that document livestock grazing degradation of natural resources (Bowers et al. 1979; Thomas et al. 1979; Ferguson and Ferguson 1983; Kauffman and Krueger 1984, Comm. on Gov. Operations 1986; GAO 1988, 1991*b*; Bur. Land Manage. [BLM 1990]; Dimick 1990; Jacobs 1991; Platts 1991; Williams et al. 1991; Marshall et al. 1992; Hanson et al. 1993; Rees 1993; Drew 1994; Horning 1994; Li et al. 1994; U.S. Fish and Wildl. Serv. [USFWS] 1994*b*).

Species Extinction.—The extinction of species is part of the degradation. Whereas extinction is a natural process, the earth is losing species at an accelerated rate. Current trends indicate half the earth's species

will be extinct within the next 100 years. The major cause . . . is large-scale destruction of native habitats, which has increased since European settlement began in the mid-1800's—in Oregon and throughout the New World" (Oreg. Nat. Heritage Prog. [ONHP] 1993:2).

Society is documenting what it is losing or is in danger of losing, in part as a result of continued livestock grazing on public lands (Bond 1974, Williams et al. 1989, Marshall et al. 1992, Hanson 1993, ONHP 1993, Rees 1993, Horning 1994, Niemi et al. 1994, USFWS 1994*b*). It is timely to consider what might be gained by removing livestock from the public lands of the United States. Removal of livestock would restore to the surviving native species more natural ranges, as well as the food, shelter, rearing areas, and communal interactions currently limited or degraded on public lands by domestic animals.

RECOMMENDED READING

The writings of those who have a memory of how the land was before the invasions of Europeans and cows provide valuable histories—the stories of the self-sustaining western lands (Wheat 1967, Morrison 1980, Buan and Lewis 1991). These histories enable today's generations to envision how the degraded public lands might recover.

Before reading the histories of the preinvasion inhabitants of western lands, I found it was helpful to read 2 volumes that address the history of the United States and free speech—free speech and history being intimately entwined.

Nat Hentoff's *Free Speech for Me—But Not for Thee* (1992) is a cold reviving shower of ideas about this basic right. Howard Zinn's *A People's History of the United States* (1980) vividly portrays the power of those who interpret, record, ignore, or gloss over events. Combined with the histories of western lands as remembered by those whose generations on the land number in centuries not decades, these writings enlarge vision and stimulate thoughts and dreams of what was and what could be.

ON-THE-GROUND ILLUSTRATIONS

Reports and on-the-ground examples of recovery help answer pertinent questions: what species are still enduring? Which are missing? How has the land itself, the morphology (or form) changed? What are the apparent effects, the consequences of the land uses introduced to these arid and semi-arid high desert lands? Where has recovery occurred, and how?

Oregon, specifically 2 sites in central and 1 in southeastern Oregon, provide examples of the land's potential for recovery. The fourth site, the Sheldon-Hart Mountain National Antelope Refuge complex, will during the next 15 years provide the opportunity to thoroughly document the changes that can occur with the cessation of domestic livestock grazing on public lands (USFWS 1994*a*).

LIFE BEFORE THE INVADERS: SEASONS AND CYCLES

Before the invasion of the Intermountain West by European immigrants, the people of these lands lived off the native plant and animal species through gathering, fishing, and hunting in accord with the rhythms of climate, seasons, and cycles of scarcity and abundance, increasing and ebbing like the tides, over thousands of acres of land and thousands of years, hundreds of generations.

Drought followed severe cold, flood followed drought. Lakes rose high flooding sheltering caves. Food and fiber were abundant in times of plentiful water. Lakes the size of small seas retreated from their high beaches as dry years, dry decades, followed the wet periods. In southeastern and southcentral Oregon, the high tide marks of those ancient beaches are clearly visible today along the foot of Hart Mountain and in Catlow Valley along Steens Mountain.

Food and Fiber

Through the seasons the people of the land pursued their respective duties. Scattering across the lands in small family groups, women gathered huckleberries (*Vaccinium* spp.), chokecherries (*Prunus virginiana*), and the seeds of woksas (water lily, [*Nuphar polysepalum*]), pigweed (*Chenopodium* sp.), saltbush (*Atriplex* spp.), and other plants. They gathered native rice (*Oryzopsis* sp.) seeds, and other grains; dug and dried roots (Tsuga "Indian potatoes" and bitterroot [*Lewisia rediviva*]), and the bulbs of lilies (camas [*Camassia*

sp.), fritillary [*Fritillaria* sp.], onion [*Allium* sp.], and tulip [*Calochortus* sp.]. They gathered native fibers (willow [*Salix* spp.], alder [*Alnus* spp.], sage [*Artemisia* spp.] and bulrush [*Scirpus* spp.]) from which they built shelters, made clothing, and wove baskets and other household items.

Men fished for salmon and trout (*Oncorhynchus* and *Salvelinus* spp.), suckers (*Catostomus* spp.), chub (*Gila* sp.), and other abundant native fish species; hunted pronghorn (*Antilocapra americana*), deer (*Odocoileus* spp.) and big-horn sheep (*Ovis canadensis*). Men joined the women and children in winter rabbit drives to obtain the thick, warm furs for robes. Women and men alike hunted marmots (*Marmota* spp.). Pine bark from dead trees was used for building sweat houses for purification. Tule (*Scirpus* spp.) and cattails (*Typha* spp.) provided the fibers needed to craft duck decoys and hunting canoes.

A multitude of indigenous plants and animals supported the people of the land. Native species were regularly harvested staples.

"For all, altitude, soil, and water dictated" where food species could be found (Aikens and Couture 1991:21–22). The nature of the land and its climate and weather cycles dictated a flexible, nomadic lifestyle. For the "Wada Tika" (the "Wada Eaters"), now known as the Burns Paiute Tribe of Oregon, "the nomadic way of life was vital to survival . . . to gather food . . . visit . . . trade with other Paiute bands or with the Klamath, Modoc, or Umatilla" (Soucie 1991:71). The people lived lives relatively unrestricted in space, limited in time only by the changing of the seasons and extremes of climactic events and cycles. The invaders from Europe and the eastern United States changed the face of the land—and the people who had been long upon it.

The Invaders.—The European immigrants who invaded these lands and claimed them as trappers, miners, cattlemen, and settlers were apparently blind to the well-developed, self-sustaining cultures of the people of the land. Ignoring the wisdom of these long-time inhabitants, the newcomers worked to adapt the land to their Old Country ways and standards of successful living, changing and diminishing the lives of those who had lived on the land for millennia (Wheat 1967, Kittredge 1987, 1992; Buan and Lewis 1991).

Unsustainable Harvests—the Internment

The trappers came first, clearing the streams of beaver (*Castor canadensis*). Then the settlers. Camas fields were fenced off by cattle barons (Soucie 1991:72). Livestock were pastured on the Truckee River meadowlands, the traditional spring creek-side campgrounds of the Paiute who annually fished the Lahontan cutthroat trout (*O. clarki henshawi*) of Pyramid Lake. Wars for land and dominance were fought. The Paiute were imprisoned on the "1.8 million-acre Malheur Reservation" (Soucie 1991:72) near Burns. The Wada Tika were removed from Burns and interned at Fort Simcoe in Washington state (Kittredge 1992:19–23). With the Paiute at Fort Simcoe, the Malheur Reservation, already reduced

from its 1.8 million acres, was returned to the public domain because "there weren't any Indians living on [it]" (Soucie 1991:71).

Livestock cleared the lush wetland and riparian vegetation—20 pounds of air-dried green vegetation/day/cow, using the average figure associated with the standard "Animal Unit Month" of public land grazing. Marshes were ditched and drained. Rich lake and stream bottoms were plowed or cleared and used for livestock pastures and hay fields. Streams were diverted to water hay fields, and many were channelized. The unravelling of a healthy, richly diverse, self-sustaining high desert ecosystem had begun.

WHAT WE MIGHT EXPECT WITH NO CATTLE GRAZING PUBLIC LANDS

Whereas few areas remain that have not at some time suffered from the grazing of domestic livestock, several small watersheds have been at least partially fenced to exclude cattle and prevent continued depredations, allowing natural recovery to begin.

Willow Creek, Crooked River National Grassland, Oregon

Willow Creek on the Crooked River National Grassland, administered by the Ochoco National Forest, Prineville, Oregon, is one such site. Beginning >20 years ago as a result of the vision of Harold Winegar, a biologist with the Oregon Department of Fish and Wildlife, a segment of the stream was fenced on both sides, protecting the narrow severely degraded riverine-riparian canyon from livestock grazing. Sharing this vision, from family memories, of trout in Willow Creek and desirous of the return of streamflow and fish, area rancher Pete Reed also worked to achieve his dream of restoring Willow Creek and its riparian zone. In the 1980s the state-wide native fish conservation organization, Oregon Trout, Inc., worked with the U.S. Forest Service Grassland staff and others to complete the work of fencing Willow Creek on the grassland. Reed lived to see the redband trout (*O. mykiss*) return with season-long summer flows on the entire 4.8-km stream segment on the public grassland (Oreg. Trout, unpubl. notes 1987–91).

Before being fenced, Willow Creek had gone dry each summer for the past 50 years. The stream profile was wide and very shallow; stream banks were eroding with scarce vegetation and bare soil in many sections. Sage and other xeric plant species had invaded the riparian zone. Few young native shrubs were being recruited; mature plants were "high-lined" ("cowed" or "hedged") from being browsed by cattle. The cowed shrubs also exhibited impaired vigor from bark being rubbed off by cattle.

Ravens (*Corvus corax*), black-billed magpies (*Pica pica*) and American robins (*Turdus migratorius*) constituted the few bird species observed during an October 1988 field trip to an unfenced stream segment below the fenced areas. No fish were seen in those unshaded waters.

Just across the fence in the protected area, riparian vegetation had changed. The effects of cattle browsing and rubbing shrubs were still evident, but young shoots of native shrubs were present. Rushes (*Juncus* spp.) and sedges (*Carex* spp.) edged the stream banks. Seed heads and dried stalks of flowering plants could also be found. Dace (*Rhinichthys* sp.) and sculpin (*Cottus* sp.) fed along the rocky stream bed. Redband trout darted for cover as shadows fell across the small stream. Flycatchers (*Empidonax* spp.), sparrows (*Spizella* spp.), rufous-sided towhees (*Pipilo erythrophthalmus*), quail (*Callipepla californica*), and rock wrens (*Salpinctes obsoletus*) were observed. This degree of recovery occurred within 25 years even though the area had been heavily grazed for decades before being fenced (Oreg. Trout, unpubl. notes, 1988).

Little Whitehorse Creek Enclosures, Southeastern Oregon

The enclosures on Little Whitehorse Creek in the Coyote Lake-Lahontan subbasin of southeastern Oregon are also examples of the potential riparian areas have for recovery if cattle grazing, the introduced causative factor for their degradation, is eliminated. These are high-elevation subbasins, grazed from top to bottom. The mountaintop plateaus are between 2,100 and 2,500 m. The small streams flow out onto the desert at approximately 1,360 m.

The 1972 Little Whitehorse Creek enclosure is located downstream from the extremely degraded Pole Patch area, formerly a beaver marsh. A more recent enclosure, begun in 1991 and located at the main stream road crossing, is immediately below the 1972 enclosure. Both enclosures demonstrate vegetation successional stages following the removal of livestock grazing. Water gaps located in the newest enclosure serve to remind viewers of the effects of concentrated cattle numbers on a small stream and vulnerable riparian zone located in a narrow canyon. When visited during a mid-August 1987 BLM tour, the 1972 enclosure was a green oasis of deep grasses, sedges, rushes, wild rose (*Rosa* sp.), alder, willow, and other native vegetation. The thickly vegetated undercut banks nearly touched over the deep, narrow cold-flowing stream. Some tour members reported seeing the unique Willow-Whitehorse cutthroat trout (*O. clarki* ssp.) (K. Simpson Myron, unpubl. field notes, 1985-94), since recognized and designated members of the Lahontan cutthroat trout complex, a federally listed threatened species.

The 1972 enclosure was trespass-grazed during the summer of 1988, but has since been free of livestock grazing. It stands in verdant contrast to the downcut stream channel and reduced vegetation diversity and abundance of the Pole Patch upstream. Both enclosures have small headcuts (1 m deep) working upstream, even through the dense vegetation in the 1972 enclosure. The Pole Patch has a much larger headcut (1.5 m deep) that has worked its way >1.2 km upstream from its point of origin (M. L. Hanson, Oreg. Dep. of Fish and Wildl., pers. commun., 1988).

Beginning in 1989, portions of the upper elevation Whitehorse Creek subbasin were rested for 3 years from grazing. The new grazing strategy called for the segment of Little Whitehorse Creek that includes Pole Patch to continue to be rested through the first 2 years of a 4-year grazing cycle with grazing to resume in 1994 (BLM 1991b).

The purpose of the [original] three-year rest period [was] to enable non-woody vegetation to form and build streambanks and the woody vegetation to attain sufficient height prior to the beginning of grazing treatments (BLM 1990:7).

Grazing treatments . . . on these mountain riparian pastures will be designed to increase density of the vegetation for watershed cover, to create a more palatable forage condition for livestock/wildlife, and to assure continued improvement of the riparian zone for fish production and improved water quality (BLM 1989a:1).

Although riparian vegetation is obviously improving within the enclosures in this subbasin, low, warm-season stream flows, degraded stream habitat, high water temperatures, and stream siltation continue to challenge and stress the threatened Lahontan cutthroat trout.

Removal of vegetation and increased siltation have caused a decline in the available habitat and have made the streams more susceptible to further damage during storms and floods (BLM 1990:12).

Grazing riparian vegetation and loss of cover leads to increased water temperatures (Li et al. 1994, BLM 1990:13). High stream temperatures also negatively affect invertebrate composition, or "trout prey" (Li et al. 1994) resulting in less palatable species dominating warmwater stream reaches.

Crooked River Tributary

A small spring-fed stream in central Oregon confirms the hope of the Lahontan subbasin enclosures and the example of the Grassland's Willow Creek restoration success. A tributary to the Crooked River above Prineville, this unnamed stream was part of a large ranch operation that failed in the mid-1960s.

The small watershed went ungrazed by all but the native deer, elk, pronghorn, small mammals, insects, and other native grazers until surrounding lands were leased for livestock grazing in 1986. That year the yellow warblers (*Dendroica petechia*), rock wrens, and quail were absent. The thick bunchgrasses were grazed to trampled dusty stubble. Even the cattails that were >1.6 m before the summer grazing were grazed down to 2.5-5.0 cm stubs. The thickets of willow, wild rose, and red-osier dogwood (*Cornus stolonifera*) also had been heavily browsed. The narrow riparian canyon with the cold, clean stream winding down 303

m in 1.67 km had been transformed into a muddied, manured, fly-plagued chute by the intensive grazing and trampling of a herd of <150 cows, calves, bulls and steers.

The owners fenced the property in 1987-88. Small numbers of cattle have briefly trespassed the area in the ensuing years, but damage has been limited. The yellow warblers have not yet come back, but the rock wrens returned in 1994. The native grasses set seed again, though the willows and other shrubs have not recovered their volume, height, or vigor, and the cattails are less abundant.

The riparian zone has withstood several heavy rain and hail storms. Most summers and into the early fall, the cattle graze the steep canyon slopes and the spring areas above the fenced stream segment.

Raptors frequently are seen on or over the property. Long-eared owls (*Asio otus*), northern pygmy-owls (*Glaucidium gnoma*), prairie falcons (*Falco mexicanus*), northern goshawks (*Accipiter gentilis*), and great grey owls (*Strix nebulosa*) hunt the area. Adult golden eagles (*Aquila chrysaetos*) and mature and immature bald eagles (*Haliaeetus leucocephalus*) also have been seen soaring on the thermals above the ridges.

Small mammal mounds dot the hillsides. Western Juniper (*Juniperus occidentalis*) and sage are scattered among the abundant bitterbrush (*Purshia tridentata*) and other native shrubs. Rattlesnakes (*Crotalus viridis*) have been seen near the stream. Sagebrush lizards (*Sceloporus graciosus*) and side-blotched lizards (*Uta stansburiana*) live on the property.

A wide variety of butterflies use the riparian zone and steep slopes for feeding, both as adults, and in the caterpillar stage: mourning cloaks (*Nymphalis antiopa*), blues (*Euphilotes* sp.), sulphurs (*Colias* sp.), juniper hairstreaks (*Mitoura siva*), swallowtails (*Pterourus* sp.), wood nymphs (*Cercyonis sthenele*), and whites (*Pieridae* sp.) among them. Many other insects also make their homes among the diverse vegetation, attracting common nighthawks (*Chordeiles minor*), flycatchers, mountain bluebirds (*Sialia currucoides*), Say's phoebe (*Sayornis saya*), and other insect-eating birds (K. Simpson Myron, unpubl. field notes, 1985-94).

Many of these diverse life-forms are recognized as simply aesthetically pleasing. However, people who value healthy watersheds understand the ecological values of these native plants and animals. They understand that the foraging of insects and small mammals is part of the natural cycling of nutrients and part of the larger food chain. They understand that the burrows of ground squirrels (*Spermophilus* spp.), badgers (*Taxidea taxus*), and myriad insects facilitate the infiltration of water. They understand too, that the roots of bunchgrasses not only hold the soil, helping to limit soil erosion, but also are conduits for moisture to penetrate those soils.

ANTICIPATED GAINS

Ecological

With the cessation of livestock grazing will come a noticeable increase in vegetation as has occurred in the 3 examples and at Hart Mountain. Where this increase is monitored, it will be measurable—a cow can consume 5,455 kg of plants annually (Drew 1994:16).

With an increase in vegetation volume, species diversity, and community health, will come an increase in the native grazers; the insects and small animals for which forage is not currently calculated on public lands. They will be followed by an increase in those who feed on the grazers. On Hart Mountain, 19 wildlife species now breed where 36 species would breed were the livestock-grazed area restored to a "mosaic" of grasses and shrubs at various stages of growth" (Drew 1994:18).

Vegetative restoration will in turn begin to restore the hydrologic functioning of uplands and the cycling of nutrients. As riparian vegetation diversity and volume increases, degraded wetlands, springs, and streams will begin to recover. The soils of eroding stream banks will begin to be held in a more stable state, as woody plants and herbaceous vegetation protect the soil surface and form an intermingled web of roots below the surface. As the riverine-riparian vegetation stabilizes the banks, floods will undercut the protected banks creating the overhanging banks fish need for cover. These undercut banks also will help shade the surface of the water, decreasing the heating effect of the sun's rays in these arid lands.

As the years pass, or decades and centuries depending on the species, native shrubs and trees, no longer rubbed and browsed to death, will return and grow, providing additional stream shading, as well as nutrient cycling in the form of fallen leaves, twigs, branches, and eventually, tree trunks and root wads.

All together, the recovering plant communities will provide habitat for terrestrial and flying insects, some of which will become prey for candidate, threatened, or endangered fish species such as the Snake River chinook salmon (*O. tshawytscha*), bull trout (*Salvelinus confluentus*), and Lahontan cutthroat trout. Riparian vegetation will filterout suspended sediments transported by the streams from naturally paced erosion, in an ebb and flow of bank building and channel alteration. This is opposed to the current situation with livestock grazing in which stream banks are trampled, riparian soils compacted, and undercut banks absent. With the recovery of riparian vegetation will come the recovery of natural stream processes.

When livestock no longer destroy the living skin of the earth, the cryptobiotic crust will recover where soil and climate conditions permit and inoculant sources are present. This recovery will take time, perhaps 4-5 decades in the case of lichens and cyanobacteria, or 2-3 centuries for moss (Belnap 1993).

When livestock no longer remove native vegetation, facilitating the spread of alien plant species, the land will have the opportunity to recover and once again be able to function as wise managers recognize we humans need it to—to safely capture, store, and release the precipitation that falls in any given watershed.

The ecological benefits to humans will include restoration of some intermittent streams to perennial flow and of some ephemeral streams to intermittent, decreased soil erosion and stream sedimentation, moderated flow extremes (decreased flooding) and increased pollution control as riparian ecosystems and their interrelated stream systems recover.

As riverine-riparian areas recover, we can also anticipate a decreased need to list species after species for protection under federal and state endangered species acts. The cash benefits may be incalculable.

Miscellaneous National Benefits.—Other benefits to the nation will result from the restoration of natural checks and balances on public lands. Predator eradication (Animal Damage Control) on public lands will no longer be needed. Native species will no longer need to compete with livestock for forage. Native species will no longer depend on the leavings of spring/summer/fall cattle herds to survive, or risk food runs on ranchers' hay stacks for winter feed.

It is possible that special hunts to remove (kill) marauding native wildlife would become a thing of the past as the public lands once again provide sufficient forage, cover, water, and more adequate range for native wildlife year-round.

As native vegetation, soil health, and hydrologic function recover in an upward spiral, herbicide use may also decrease as native plant communities reestablish and successfully compete with alien plant species. Restoration of native species communities should halt or ease juniper expansion, resulting in decreased human reliance on juniper treatments, sage "conversion" projects, and other native plant eradication actions.

Nutrient cycling can also be expected to respond to plant community improvement and restoration. Alien species, annuals such as cheatgrass (*Bromus tectorum*), quickly invade disturbed sites. As native vegetation is released from the pressures of livestock grazing, nutrients now lost through destruction of the cryptobiotic crust and through range treatment projects (Tiedemann and Klemmedson 1994; A. J. Belsky, Oreg. Nat. Resour. Council., Portland, unpubl. ms.) would remain in those ecosystems.

Public Lands Cattle Operators

Removing cattle from the public lands would do more than benefit the public trust through the probable recovery of native vegetation, hydrologic functioning, nutrient cycling, soils health, and native species. Removal also would benefit those whose cattle currently graze public lands. Those benefits would fall into 2 main categories or opportunities: equal economic opportunity for all livestock producers in the United States and environmental status opportunity.

Equal Economic Opportunity.—No longer would 2% of the nation's livestock producers receive subsidies paid by the 98% of the producers who do not have the opportunity to enjoy the privilege of grazing their livestock on the public lands (Dimick 1990:13, Holechek and Hess 1994:63). Instead, both groups would be able to compete equally.

The western livestock industry will be freed from its dependence on national tax supports, freed from answering to the U.S. Forest Service (USFS) or BLM for annual cattle management, freed from the responsibilities of maintaining range cattle developments: miles of fences, pipelines, hundreds of cattle troughs, tanks, pits, and reservoirs, cattleguards, and spring developments (BLM 1989*b*; 1990; 1991*a,b*; 1992; 1993). Nor would livestock operators have to meet the expenses associated with driving ranch trucks with horse trailers or heavy equipment (cats and backhoes) out on the public lands. Because some ranch hands drive trucks hauling horse trailers out to distant pastures in the morning, then back to the ranch headquarters after dropping off the horses and riders, only to return to pick up the same horses and riders in the evening and haul them back, repeating the same time-consuming drives the following days, not grazing the public lands could save a ranch operator hundreds of miles driven a week, as well as wages and lost labor time.

While public land ranchers could save hours of labor lost in commuting as well as wages and unknown dollar amounts no longer spent maintaining cattle developments, the nation could save millions of dollars in range developments and in administrative costs now spent developing site-by-site planning documents for range developments and grazing schemes. Eleven million dollars were spent on range developments alone in 1983 by the BLM (Comm. on Gov. Operations 1986). In 1992, the BLM spent \$89 million on range management (Holechek and Hess 1994:63). These dollars could be used to meet the longstanding shortfalls in agency budgets for values such as fish and wildlife monitoring, study and research, riparian restoration, Clean Water Act monitoring and compliance, and Endangered Species Act compliance. A BLM study indicated that without livestock grazing, the costs of rangeland management for inventory, monitoring, and resource protection would be about 40% of the current costs of management (GAO 1991*b*:65). Public lands livestock grazing is costing taxpayers millions annually. Net grazing fees provide minimal economic return to local economies and directly to ranchers (GAO 1991*b*:67, Niemi et al. 1994).

Environmental Status Opportunity.—Finally, ranchers whose cattle currently graze the public lands would have the opportunity to assess their operations and make them truly self-sustaining. Public lands livestock operators would have the opportunity to demonstrate the much-voiced belief that cattle ranching can be ecologically sound, economically profitable, and socially responsible.

Unknown amounts of time, labor, and money are currently spent commuting to distant public pastures to move and check on cattle or to maintain fences, pipelines, pumps,

troughs, and all the other developments apparently required to sustain cattle grazing at great ecological cost on arid and semi-arid public lands. Stories of long days, grueling work, and little income to show for the effort abound in working groups meeting to talk about cattle needs and government plans. With the cessation of public lands cattle grazing that time, labor, and money would be available to improve deeded lands and ranch operations.

CONCLUSIONS

The possible and probable benefits that could result from the cessation of cattle grazing on public lands would encompass a wide range of ecological processes and native species. The cessation would likely reduce the need to list everincreasing numbers of native fish, birds, mammals, invertebrates, and plants. This would reduce substantially the cost to the nation in tax dollars required to fund recovery plans and associated legal actions.

Benefits would result for public land cattle operators as well. Those benefits would include direct economic benefits as well as personal self-esteem benefits.

An additional benefit not discussed, but implied in this paper, has to do with the treaty promises that the United States made with the Indian tribes of the western lands. Remove the cattle and I am convinced the native food and fiber species once so abundant for the tribes' use and enjoyment would be among those species that would recover. It would be morally uplifting to know this nation was taking action to keep its century-old promises to the Native American peoples of the West.

With the seemingly chronic agency problems of inadequate budgets and resource staffs to address the needs and condition of native species and their habitats on public lands, halting livestock grazing on those lands could free up personnel and funds to better manage the public trust. This subject would benefit from closer investigation, data accumulation, analysis, and application.

National management agencies have been attempting unsuccessfully to meet the demands of commercial livestock interests for natural resources since early this century. As the nation looks forward to entering the 21st Century, it is time to admit the multiple values of public lands do not benefit from continued livestock grazing. It is time to free both the agencies and the livestock operators from the expensive, hopeless effort of meeting cattle needs and protecting, restoring, and maintaining natural resources on public lands.

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RANGELAND SUSTAINABILITY: WHERE'S THE BEEF?

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Abstract: Questions about the sustainability of public rangelands are partly because of disputes over which reference resource(s) should be assessed, and how. For example, an important traditional view centers on the actual yield of livestock and big game at historical rates, while reform-minded definitions often focus on the chances of short-term persistence by aquatic species. Public rangeland managers seeking the rational middle ground of "sustainability through compatibility" and innovation of locally based management models can improve their own odds of success by explicitly acknowledging multiple definitions, and adjusting their institutional information flow accordingly.

Key words: biodiversity, definitions, grazing, livestock, natural resources, rangeland management, rangelands, sustainability, wildlife.

I do not intend to write about America's favorite fast food, or even livestock grazing in general. My objective is to present sustainability in a much broader economic and political context. The primary goal of this symposium was to update attendees on technical and socio-political issues affecting management of intermountain rangelands. Among other things, it also intended to identify common ground and new ways of managing rangeland ecosystems for sustained production of biodiversity and traditional commodities and amenities.

"Sustainability" is a watchword of natural resource management that is constantly before the general public, specific constituencies, and resource managers. As a result, the conception of sustainability held by each of these groups will have a fundamental influence on the natural resource management environment. I believe that most natural resource managers who were trained in traditional academic disciplines feel very comfortable with the concept of sustainability. For us, "multiple use sustained yield" is practically one word that has been ingrained during thousands of classroom hours and often many years of professional employment. However, I also believe that for the general public and various constituent groups, this relatively simple concept is fraught with peril for reasons that I will be sharing with you. In other words, many of our publics have come to view sustainability as a little like the character played by Glenn Close in the movie *Fatal Attraction*, she seemed so nice at first but quickly became a threat to survival for the film's other main character. I hope to offer a few definitions of sustainability, or at least present the concept of sustainability in several different contexts, in an effort to identify what "sustaining ecosystems" may mean in a broad sociopolitical sense. I make a prediction and recommendation about what these different definitions may portend for the emerging discipline of ecosystem management.

DEFINITIONS

Because I am primarily a wildlife biologist, I always like to include a quote from the master, Aldo Leopold (1933:3), when I write a paper like this: "Game management is the art

of making the land produce **sustained** [emphasis added] annual crops of wild game for recreational use." Of course Leopold had a good many things to say about natural resource sustainability, but this quote from his landmark textbook on wildlife management demonstrates an unadorned concern for maintaining production of wild game through a relatively short period of time (i.e., years).

If we jump ahead 60 years to the present, we find that Fred Samson (1992:308), another wildlife biologist, wrote this comment about sustainability. "**Sustainability** [emphasis added] provides the diversity that is

- ♦ necessary to keep all ecological systems functioning and healthy,
- ♦ required for an acceptable standard of living, and
- ♦ adequate to meet stewardship responsibilities for an aesthetic environment."

Like Leopold, Samson expressed concern for maintaining resource productivity through time but expands the concept in this quote to include healthy, functional ecosystems, and the full range of useful ecosystem resources or products necessary to maintain an acceptable standard of living. This statement is getting pretty close to what I feel are the elements of a complete, conventional definition of sustainability with explicit consideration for the needs of both natural ecosystems and acceptable human economic concerns.

Elsewhere in his article, Samson (1992:318) noted that "biological diversity is not an outcome of wise land and resource management; it is the single most significant influence leading to healthy ecological systems and wise resource management, including the production of goods and services." This is where the beef, as it were, begins to rear its unsightly head, or its slightly head, depending on your personal orientation and community narrative.

The issue, of course, is in the overall weighing of factors related to sustainability; in the following example, Peter Raven (1990:772) is clearly stating that the needs of the environment come first, or a biocentric vision of sustainability. "**Sustainability** [emphasis added] and preservation of biological diversity are two sides of the same

coin." This quote is slightly out of context from the original article but nonetheless illustrates the biocentric view that sustainability and the needs of the environment are the same thing.

If this were not enough to set off major alarms among traditional resource constituents who have long been accustomed to thinking of the environment primarily in terms of how it can be useful to humans, there is one more element of the sustainability issue to consider. Many proponents of sustainability not only place the needs of the environment before the needs of people, they also place the natural resource needs of people yet unborn ahead of, or at least equal to, the needs of people alive today. Herman Daly, an economist, and John Cobb, a theologian, writing about the relationship between economics and sustainability put it very simply (Daly and Cobb 1994:146), "**Sustainability** [emphasis added] is really justice extended to the future." I think they intended that statement to be a sort of shorthand for the formula popularized in the last decade that identifies sustainable development as that which "meets the needs of the present without compromising the ability of future generations to meet their own needs." In effect, this is an effort to create a public trust sort of duty on the part of all resource users and managers to moderate our consumption for the benefit of others besides ourselves and our immediate family or community. Whereas that expression is attractive to many, it provides no guidance as to how we may separate need from luxuries or even impossible desires, and it gives us no clues as to what "the ability of future generations to meet their own needs" may be.

As you might expect, statements about natural resource sustainability that assign a higher priority to nature and generations yet unborn have provided fertile ground for critics of government's role in resource management. For example, Terry Anderson and Don Leal, associates of the conservative Political Economy Research Center, have warned that concerns about sustainability or the lack thereof are largely a scare tactic to promote total control of resource use by governmental institutions (Anderson and Leal 1991:161-162). "Fears of global (environmental problems) are being used to drive **sustainable** [emphasis added] development policies where nearly all resource use will be controlled by government." Anderson and Leal (1991:162) describe sustainable development as "a hold over from the 1960's and 1970's when economists were struggling with steady state and zero-growth economic models." They say that the main difference is that in the 1970's the overarching concern was that energy resources were being exhausted, a problem they feel was solved by deregulation.

Anderson and Leal (1991) say that the primary environmental fear being espoused today is global warming—a fear they concede may be well-founded but for which they foresee a very different remedy than government regulation. Other global problems related to sustainability include desertification, loss of biological diversity, ozone depletion, marine pollution, acid rain, nuclear proliferation and waste disposal, and others. Anderson and Leal advocate anthro-

pocentric solutions to these and other resource concerns based on policies that promote free-markets and private property rights; they believe that the best way to take care of future generations is to provide for economic growth in the present generation. What the future may lack in resources, they contend, we will make up to them in terms of education, technology, institutions, stored wealth, and other advantages of current economic growth.

Before you make up your mind to whether Anderson and Leal's (1991) approach is a smash or trash, however, consider that although it's proponents take a dim view of many so-called environmental regulations, they also object to many other forms of government generosity currently perceived as "rights" by some traditional resource user groups and as unsustainable "welfare for the wealthy" by many environmentalists. These include programs such as below-cost federal grazing fees and timber sales; free recreational access; farm policies such as crop price supports, crop insurance, disaster aid, subsidized irrigation rates; certain trade policies; and many other types of fiscal generosity. According to free-market environmentalists, these are pork-barrel programs that help reelect "fiscal liberals" to Congress but distort market signals and insulate individuals from the economic and environmental consequences of their actions, and thus contribute to a growing legacy of fiscal and environmental problems.

Not all critics of sustainability are as kind and gentle as Anderson and Leal (1991), however; some urge flat out that sustainability is part of a larger, sociopathic conspiracy. Statements such as this one by Tom McDonnell of the American Sheep Industry is typical of many currently being made by members of some traditional resource use organizations (quoted in Wortham 1994:2). "**Sustainable** [emphasis added] use is part of an environmentalist plan to control every aspect of human life through ecosystem management and a vast system of laws and regulations, including population control." Environmental groups may be raising similar objections but I am not aware of specific examples. This is not surprising, however, since environmental groups typically view sustainability arguments as tending to support their desire for greater management focus on ecological processes.

To bring this back to rangelands specifically, I want to provide just a few more examples of sustainability in a rangelands context. The Society for Range Management (SRM) (Soc. Range Manage. 1991:3) adopted a policy statement in 1991, if not earlier, stating that "Rangelands should be managed to provide optimum **sustained** [emphasis added] yield of tangible and intangible products and benefits for human welfare." SRM endorsed the application of sound use of ecological and economic principles to achieve this end and defined "sustained yield" as the "production of a specified resources or commodities at a given rate for a designated unit of time," a definition remarkably close to Leopold's 1933 formulation.

The National Research Council's (1994:4) report on Rangeland Health had much to say about rangeland use and management, but defined rangeland health narrowly as

"Rangeland health is the degree to which the integrity of the soil and ecological processes of rangeland ecosystems are **sustained** [emphasis added]." This academic definition seems most closely related to the biocentric school of sustainability thought.

The primary goal of the proposed federal grazing administration reforms, known as Rangeland Reform '94, falls explicitly into the camp of sustainable development (U.S. Dept. of Inter. 1994:6). "The purpose of rangeland reform is to carry out a rangeland management program that improves ecological conditions, while providing for **sustainable** [emphasis added] development on lands administered by [the Departments of Agriculture and Interior]." Judging from the widely reported rhetoric surrounding opposition to this proposal, it is clear that many of Interior's problems with this proposal flow directly from its central reliance on this concept.

Now, 2 final examples from the emerging world of ecosystem management. Volume 5 of the Eastside Forest Health Ecosystem Health Assessment, also known as the "Everett Report," is titled "A Framework for Sustainable-Ecosystem Management." The document (Bormann et al. 1994) states that sustainability is "the most important concept associated with ecosystem management" and offers this definition of "sustainability for practical ecosystem management" (Bormann et al. 1994:44). "Practical **sustainability** [emphasis added]:

- ◆ contains the idea of a continuing balance, where society obtains a desired yield of goods, services and state from an ecosystem in the present without damaging the ecosystem's capacity to produce goods, services, and states for society;
- ◆ leads to a method for making a quantitative, objective assessment of sustainability for producing very different ecosystem products from very different ecosystems over varying periods; and
- ◆ implies that many ecosystems require remedial management to restore them so that they can sustainably produce ecosystem goods, services, and states for society."

This self-conscious and somewhat legalistic definition has the usual components, a balance between environment and economic concerns and a strong future orientation, but the overall emphasis is unmistakably anthropocentric. Interestingly, the "Framework for Ecosystem Management in the Interior Columbia River Basin" (Sci. Integration Team 1994), which was a guide to scientifically-sound and ecosystem-based management of federal lands found east of the Cascades Range and within the Columbia Basin, scarcely mentions sustainability at all. The Charter creating the Columbia Basin Project simply notes that its major products will include an EIS describing management alternatives that take sustainability into account (Sci. Integration Team 1994:xiii), and a scientific evaluation of those planning alternatives that considers sustainable levels of renewable natu-

ral resources in the context of maintenance and restoration of biological diversity and long-term ecosystem health (Sci. Integration Team 1994:xiv).

CONCLUSION

In conclusion, I believe that there is a significant danger that sustainability is becoming a thought-stopping slogan in natural resource debates. While this happens to much of our professional vocabulary, there is a far greater danger in this case than simply having the term lapse into irrelevancy or becoming part of the standard bureaucratic baffle-gab, that is, hollow jargon that merely produces numbness in the audience.

PREDICTION

My prediction is that if "sustainability" is used in resource discussions without concern for its growing political and economic connotations, the result for some constituent groups may be more like a seismic vibration that is guaranteed to temporarily end any opportunity of defining real problems, much less a range of alternative solutions.

RECOMMENDATION

To me, it probably doesn't matter very much which term we use as we search for a policy that allows society to enjoy the full diversity of resource values without destroying productivity. Sustain, maintain, conserve, reserve, preserve, economize, husband, steward, land ethic, viability, integrity, "saving the goose that lays the golden egg," and other terms may all have their uses in this context. The practical thing that we do need to do, however, has been well described in parts of the Everett Report quoted above, in Charles Wilkerson's instructions on how we may cross the new meridian in his book with the same name (Wilkerson 1992), and no doubt by others as well.

The primary take-home message is that we must always be as explicit and inclusive as possible when we are describing the resource values that we want to sustain, or restore, or conserve. In other words, we need to define exactly what is the natural and cultural legacy that we have received and wish to pass on, and recognize that whatever else that legacy may include, wildlife and individual liberty are both important.

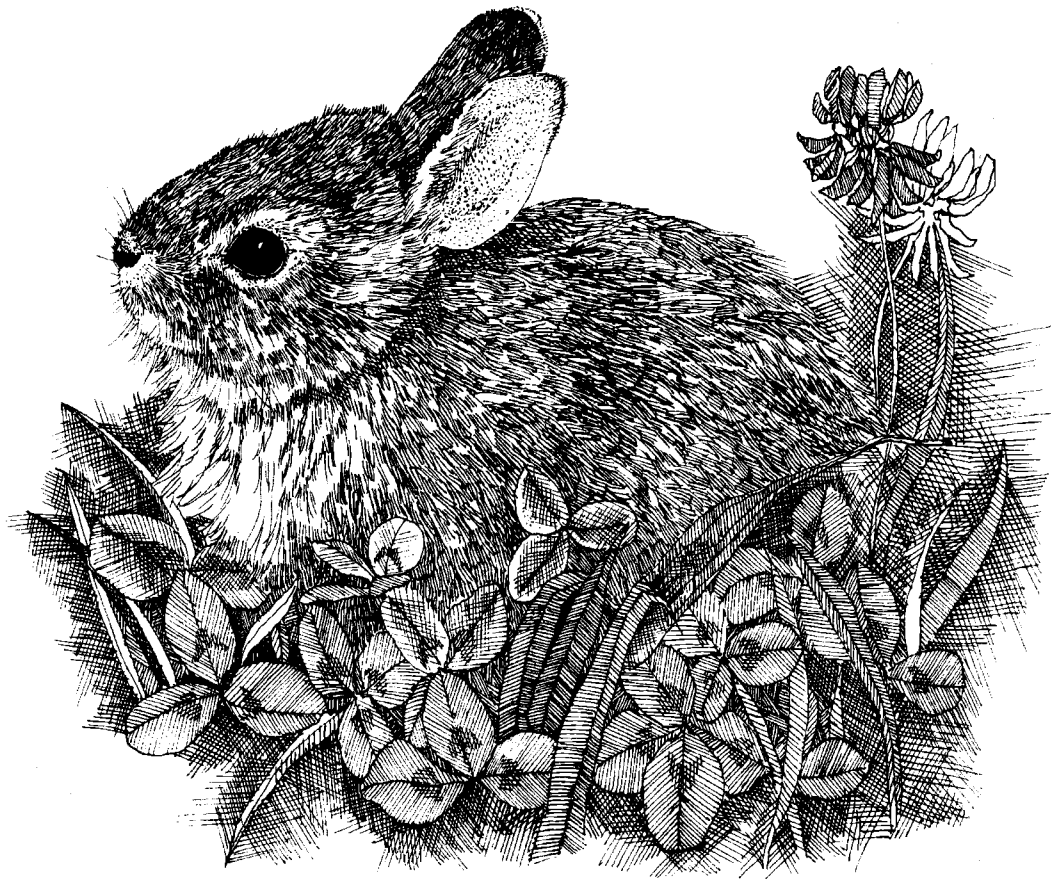
Next, we need to determine the ecosystem configuration necessary to sustain, or restore, or conserve that legacy. Third, and this is the fun part, we need to be as creative as possible in designing an appropriate resource management system with due consideration for the fact that regulations, incentives, education, technical assistance, and planning each must be part of the final package.

Finally, and this is the hard part, we must engage in a broad social debate to set priorities among competing demands as the management system is implemented. Of course,

if the history of National Forest Planning is any indication, all bets may be off at that point, but at least we will have taken important first steps to expand our knowledge and care for the natural and cultural legacy we all seem to want.

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LEGAL LANDSCAPE OF WETLANDS REGULATION

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Abstract: A variety of wetlands regulatory programs exist to conserve the ecological values of these areas. I describe the principal legal requirements of the Clean Water Act Section 404 wetlands permit program. Recent Supreme Court takings cases raise issues regarding inverse condemnation and private property concerns in the Section 404 program. These cases may lead regulatory agencies to more carefully evaluate the justification for permit conditions or denials. Future wetlands regulatory developments are most likely to come from the courts and administrative agencies rather than Congress, except for potential changes enacted as part of reauthorization of the Clean Water Act. The high percentage of wetlands in private ownership also suggests that voluntary conservation measures may play an increasing role in the nation's wetlands protection program.

Key words: Clean Water Act, Fifth Amendment taking, habitat conservation, land-use regulation, riparian areas, Section 404, wetlands.

Wetlands are protected by federal, state, and local regulatory programs because these areas perform important ecosystem functions. For instance, wetlands may act as a nutrient trap for hydrogen and phosphorus and a filter for water pollutants. Wetland areas may control stormwater runoff, and provide surface water sources, groundwater recharge, sedimentation basins, and other hydrologic functions. Wetlands also provide important wildlife habitat, including crucial habitat for many of the threatened and endangered species found in the intermountain region. In the arid West, wetlands have a proportionately greater importance for fish and wildlife habitat, flood control, aquifer recharge, and water quality protection, because of the relative scarcity of these areas in the region (U.S. Dep. Inter. 1994). In light of these important wetlands functions, the Clinton administration has supported an interim goal of no overall net loss of the nation's remaining wetlands and a long-term goal of increasing the quality and quantity of the nation's wetlands resource base (Off. Environ. Policy 1993).

DEFINING AND DELINEATING WETLANDS

Identifying and delineating wetland areas is a key inquiry from the legal perspective because it determines the existence of regulatory jurisdiction for a particular wetland area and also may determine what legal mechanisms are available for its protection. The federal regulatory definition of a wetland is:

those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas (Army Corps Eng. 1993a:484, Environ. Prot. Agency 1993:207).

This definition highlights the 3 key indicators of a wetland area: hydrology, soils, and vegetation. Whereas there is agreement on these basic definitional factors, controversy has developed in the implementation of the federal wetlands program as to how these factors are applied. The federal agencies responsible for implementing the wetlands program (including the U.S. Fish and Wildl. Serv., Environ. Prot. Agency [EPA], Army Corps of Eng. [ACE], and Soil Conserv. Serv.) developed a series of wetlands delineation manuals in 1987, 1989, and 1991. These 3 manuals differ primarily in their application of the wetlands parameters to determine the presence of a jurisdictional wetland (Hanson and Feldman 1992). For instance, the 1987 manual requires ≥ 7 consecutive days of inundation or saturation during the growing season to satisfy the hydric soil criteria. The 1989 and 1991 manuals instead require ≥ 7 days of inundation or ≥ 14 days of saturation during the growing season. The 1987 manual allows a wetland determination when at least 1 positive indicator of each parameter (hydrology, soils, and vegetation) is found, whereas the 1989 manual allowed information on 1 parameter to be used to satisfy another parameter. The 1991 Manual required independent evidence of all 3 parameters simultaneously.

The debate over the 3 manuals was temporarily resolved through an appropriations bill rider in 1991 that compelled the ACE to rely on the 1987 wetlands delineation manual (U.S. Congress 1991). In 1992, Congress directed the National Academy of Sciences (NAS) to study the wetlands delineation issue. The NAS report is slated for release in fall 1994 and may ultimately lead to further changes in the wetlands delineation methodology.

One additional issue for the Intermountain West is the delineation and protection of riparian wetlands. These areas serve the same ecological functions as jurisdictional wetlands, yet may not receive the same regulatory protections. This situation occurs because riparian areas vegetated with wetland plants often do not meet the hydric soils or hydrologic conditions of the federal wetlands definition and wetlands delineation manuals. To address this regulatory gap, the U.S. Department of Interior (USDI) has recommended

that the NAS consider the feasibility of delineation methods for riparian wetlands, and that federal resource programs including livestock grazing be managed to maintain, restore, or improve riparian areas (USDI 1994).

WETLANDS REGULATORY PROGRAMS

Once a wetland area is identified, the next issue is ascertaining what wetlands regulatory programs may apply. Wetlands programs exist at the federal, state, local, and international levels. At the federal level, the primary regulatory authority is Section 404 of the Clean Water Act, which authorizes the ACE to issue permits for the discharge of dredged or fill material into navigable waters (U.S. Congress 1988). Wetlands are among the waters regulated by Section 404 (ACE 1993a, EPA 1993).

Some states have implemented their own wetlands programs in addition to the federal Section 404 regulations. Oregon has a program that applies to the fill and removal of >50 cubic yards affecting the waters of the state, including wetlands. Oregon's program includes the preparation of a statewide wetlands inventory, conservation plans, and mitigation banks (Oregon Legis. Assembly 1993). Local governing bodies may also protect wetlands. For instance, San Miguel County, Colorado, has adopted wetlands protection and restoration standards as part of its local land-use code (San Miguel Co. 1992). These standards contain county-level requirements for permitting and mitigation of wetlands development projects.

At the international level, Canada in 1991 developed a federal policy on wetlands conservation with goals of achieving no net loss of wetlands functions on federal lands and using wetlands in a sustainable manner (Can. Wildl. Serv. 1991). The primary international agreement on wetlands conservation is the Ramsar Convention, to which >60 countries, including the United States, are signatories. This agreement directs all participating governments to promote the conservation of wetlands through the establishment of nature reserves, and to formulate and implement planning methods to promote the wise use of wetlands in their territory. Also, each government is required to designate suitable wetlands within its territory for inclusion on the List of Wetlands of International Importance (U.S. Dep. State 1991).

CLEAN WATER ACT SECTION 404 PROGRAM

The primary wetlands regulatory program applicable throughout the United States is the Clean Water Act Section 404 program. The basic requirement of this program is that permits for the discharge of dredged or fill material into wetlands be obtained from the ACE. Federal responsibilities for the Section 404 program are divided between the ACE and the EPA. The ACE is the primary permitting agency, but the EPA retains a major role in overseeing the permitting process. Under Section 404(b)(1) of the Clean

Water Act, EPA has published *Guidelines for Specification of Disposal Sites for Dredged or Fill Material* (EPA 1993). These Section 404(b)(1) guidelines, which establish substantive criteria intended to assure that wetland discharges will not have an unacceptable adverse impact on aquatic ecosystems, must be applied by the ACE in issuing Section 404 permits. Under Section 404(c) of the Act, EPA is authorized to prohibit the use of a wetland area as a fill site whenever it determines that the discharge "will have an unacceptable adverse effect on municipal water supplies, shellfish beds, and fishery areas (including spawning and breeding areas), wildlife, or recreational areas" (U.S. Congress 1988:548).

Once a determination is made that an activity may involve a discharge into a wetland area, the Section 404 process provides 3 permitting options: (1) no permit will be required if the activity falls within an exemption, (2) an individual permit will not be required if the activity falls within the terms of a general nationwide permit, or (3) a complete individual Section 404 permit will be required. Two of the permit exemptions that may apply to rangeland management activities are those for normal farming, silviculture and ranching activities, and the construction and maintenance of forest or farm roads (ACE 1993b).

Nationwide permits are authorized under Section 404(e) of the Clean Water Act in lieu of individual permits for any category of activities that are similar and will cause only minimal adverse environmental effects. The ACE has established almost 40 different categories of nationwide permits. Among those that might apply to rangeland activities is Nationwide Permit 26 that authorizes discharges into wetlands above the headwaters of a nontidal stream or into isolated waters, so long as the work does not fill or have a substantial adverse effect on >10 acres of these waters. Several conditions must be met to come within the scope of this nationwide permit, and certain management practices must be followed to the maximum extent practicable. These practices include avoiding or minimizing the discharge through the use of other practical alternatives, and avoiding discharges into wetland areas (Addison and Burns 1991, ACE 1993c). Nationwide Permit 14 authorizes fills for minor road crossings involving <0.33 acre and no more than 200 linear feet of fill placed in special aquatic sites including wetlands. As with Nationwide Permit 26 and other nationwide permits, several management practices and special notice conditions may be required under this general permit (ACE 1993c).

If an individual permit process is required, the permit application is evaluated by the ACE under the EPA Section 404(b)(1) guidelines. Two key elements of these guidelines for an individual permit review are the alternatives analysis and the mitigation requirements. Under the alternatives analysis, no wetland discharge is allowed under Section 404 if there is a "practicable alternative" to the proposed discharge that would have less adverse impact on the aquatic ecosystem "so long as the alternative does not have other significant adverse environmental consequences" (EPA 1993:200-201). If a proposed discharge is into a wetland and the project is not water dependent, practicable alternatives not

involving wetlands are presumed to be available unless clearly demonstrated otherwise. A "practicable alternative" under the guidelines is one that is "available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes" (EPA 1993:201). Based on these factors, the determination of a project's purpose and whether or not it is water dependent plays a key role in the outcome of the alternatives analysis (Hanson 1993).

The Section 404 guidelines also require that appropriate and practical steps be taken to minimize potential adverse impacts on the aquatic ecosystem, including wetlands (EPA 1993). This mitigation requirement approach is developed in a 1990 Memorandum of Agreement (MOA) between the EPA and the ACE that recognizes 3 general types of mitigation and calls for their sequenced application in the wetlands permitting process (EPA and Dep. Army 1990). The mitigation types are avoidance, minimization, and compensatory mitigation. The sequencing approach provides that the final level of mitigation (compensation) is not reached until after the first 2 levels have been applied.

An example of the avoidance sequence includes the alternatives evaluation requirement under the Section 404(b)(1) guidelines. With the MOA sequencing approach, compensatory mitigation may not be considered as a reduction in environmental impacts for evaluation of the least environmentally damaging practical alternative. This standard is a change from previous application of the mitigation requirements that allowed wetlands developers to exchange compensatory mitigation wetlands for developed wetlands without a full review of practicable alternatives. Next, the minimization of wetlands impacts may occur through constraints on the location, technology used, and timing of the wetlands discharge. Lastly, the compensatory mitigation phase provides for appropriate and practicable compensatory mitigation for the unavoidable adverse impacts remaining after the first 2 mitigation sequences are applied.

Compensatory actions may include the restoration of existing degraded wetlands or the creation of artificial wetlands. Restoration encompasses activities such as fencing or other exclusionary devices to removing grazing impacts, whereas wetlands preservation measures may include the purchase of existing wetlands areas and their perpetual dedication to wetlands uses through a conservation easement or other means. Under the MOA, there is an expressed preference for in-kind mitigation. Thus, if on-site compensatory mitigation is not practicable, off-site compensatory mitigation should be undertaken in the same geographic area if practicable, preferably in the same watershed and in close physical proximity. The MOA incorporates an institutional skepticism regarding the functional values of created mitigation wetlands, and states that "[t]here is continued uncertainty regarding the success of wetland creation or other habitat development" (EPA and Dep. Army 1990:9212).

For compensatory mitigation, the MOA calls for a minimum 1:1 functional replacement ratio. That is, for every acre of wetlands area affected by a permitted discharge, 1

acre of replacement wetlands should be obtained. This 1:1 ratio is designed to serve as a reasonable surrogate to ensure no net loss of wetlands functions and values. However, the MOA also provides that the mitigation ratio required may be greater where the functional values of the area affected are demonstrably high and the compensatory wetlands have lower functional values, or where there is question as to the success of the proposed mitigation project. Similarly, a less than 1:1 ratio may be allowed where the functions and values of the wetland area affected are low and the compensatory mitigation project has high values or a high probability of success.

THE TAKINGS ISSUE

The growth of wetland regulatory programs, together with developments in the takings analysis applied by courts under the Fifth Amendment to the federal Constitution, has led to situations where the application of these regulations or a wetlands permit denial may give rise to a compensable taking. Pursuant to the Fifth Amendment, "private property [shall not] be taken for public use, without just compensation." Under the general legal framework applied by the Supreme Court, a law or regulatory program may impose a taking if it "does not substantially advance legitimate state interests or denies an owner economically viable use of his land" (*Agins v. City of Tiburon* 1980). Other decisions have held that government regulatory action can "take" private property by restricting its use even though the property owner retains title (*First English Evangelical Lutheran Church v. Los Angeles County* 1987, *Lucas v. South Carolina Coastal Council* 1992).

Recent federal case decisions indicate that the denial of a Section 404 wetlands permit can amount to a compensable taking. For instance, the Federal Circuit Court of Appeals recently held that the denial of a Section 404 wetlands permit by the ACE for a 12.5-acre development in New Jersey resulted in a compensable taking. The appellate court stated the issue as whether "when the Government fulfills its obligations to preserve and protect the public interest, may the cost of obtaining that public benefit fall solely upon the affected property owner, or is it to be shared by the community at large" (*Loveladies Harbor, Inc. v. United States* 1994). The Federal Circuit determined that the ACE wetland permit denial deprived the landowner of all economically viable use of the land, and it upheld the compensation award of \$2.6 million by the Court of Federal Claims.

The Supreme Court recently addressed the takings issue in a case arising out of Tigard, Oregon, that may have implications for the wetlands context. In *Dolan v. City of Tigard* (1994), a landowner sought a permit to redevelop her 1.67-acre commercial property partly located within the 100-year floodplain along Fanno Creek. The applicable city ordinance and comprehensive plan required the landowner to dedicate a portion of her property within the floodplain for

storm drain improvements, and also required the dedication of a 15-foot strip of land as a pedestrian/bicycle pathway along the creek.

The Court framed the issue as a 2-part inquiry. First, does the "essential nexus" exist between the "legitimate state interest" and the permit condition exacted by the government. Second, is there a "rough proportionality" between the required exaction and the proposed project. No precise mathematical calculation is required, but the regulatory entity must make some sort of individualized determination that the required dedication is related both in nature and extent to the impact of the proposed development (*Dolan v. City of Tigard* 1994).

Applying this standard, the Court found first that the essential nexus was present for both permit conditions, the floodplain dedication and the greenway. However, while the floodplain dedication for storm sewer improvements survived the second prong of the standard, the greenway dedication did not. The city never stated how a public greenway was required for its flood control purposes, and this requirement resulted in Dolan's loss of her ability to exclude others from her property. According to Chief Justice Rehnquist, "[i]t is difficult to see why recreational visitors trampling along petitioner's floodplain easement are sufficiently related to the city's legitimate interest in reducing floodplain problems along Fanno Creek, and the city has not attempted to make any individualized determination to support this part of its request." Thus, in a 5-4 decision, the Court held the required greenway dedication to be a compensable taking (*Dolan v. City of Tigard* 1994).

The "rough proportionality" test applied in *Dolan* may present interesting issues in wetlands cases of whether required mitigation measures and approved alternatives impose conditions that do not meet this standard and result in a taking by the federal government. At the least, the *Dolan* case may cause the ACE and the EPA to more carefully evaluate and articulate how a particular permit condition is justified by the nature and extent of the proposed wetlands activity.

SUMMARY: FUTURE WETLAND REGULATORY ISSUES

Several bills were introduced in the 104th Congress addressing various wetlands issues such as ranking the value of wetlands to prioritize their protection and providing tax relief for private landowner protection of wetlands. However, no significant changes to the federal Section 404 program are likely unless enacted as part of the reauthorization of the Clean Water Act that may be forthcoming in 1995. As with most natural resource issues, most policy developments in the wetlands arena will be at the less-visible level of incremental change in the agencies and the courts. The wetlands programs will continue to take shape through decisions made by the ACE and the EPA in the review of Section 404 permit applications, through various regulatory initiatives by

the agencies to refine their wetlands permitting programs and the interagency procedures to review these decisions, and through regulatory guidance letters issued by the ACE addressing interpretive issues under the federal wetlands program. Additionally, the NAS report on the wetlands delineation issues may have an effect on the revision and ultimate adoption of the agency manuals used to identify and delineate jurisdictional wetlands.

Most of the challenges and issues for the future in wetlands conservation will involve wetlands in private ownership. President Clinton's plan for protecting America's wetlands recognizes that about 75% of the remaining wetlands in the continental United States are held in private ownership (Off. Environ. Policy 1993). Moreover, the universe of restorable wetlands for compensatory mitigation projects and other wetlands improvement measures is located primarily on private land. This high degree of private ownership of the nation's remaining wetlands resources indicates that the takings issue will continue to play a key role in wetlands regulation. Also, various nonregulatory private conservation wetland measures such as stewardship programs and mitigation banking will attain increased importance in contributing to the Clinton administration's wetlands protection policies.

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LANDOWNER RIGHTS AND RESULTANT IMPLICATIONS FOR ECOSYSTEM MANAGEMENT

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Abstract: In the "Rangeland Reform '94" Draft Environmental Impact Statement, ecosystem management is defined as follows. "(A) The skillful use of ecological, economic, social, and managerial principles in managing ecosystems to produce, restore, or sustain ecosystem integrity and desired conditions, uses, products, values, and services over the long term. (B) A process of land and resource management that emphasizes the care and stewardship of an area to ensure that human activities will be carried out to protect natural resources, natural biodiversity, and ecological integrity." But ecosystems know no ownership boundaries, and may encompass both private and public lands with split estates resulting in private property interests in public lands. Generally, privately owned lands and property interests are managed, at least in part, for short-term profit maximization and long-term maximization of asset value. These private goals and resource management purposes are legally protected. Ecosystem management, if defined so narrowly as to preclude attainment of private property interest, goals and objectives, cannot be successful over the long term to the extent private property interests are ignored or severely compromised.

Key words: ecosystem management, landowner rights.

ECONOMIC DEPENDENCY AND COMMUNITY NARRATIVES ABOUT PUBLIC LANDS

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Abstract: Social assessments and community economic models were built for 7 communities in central Idaho. The economic models indicate that community economies are strongly differentiated, and therefore, economic dependency on federal public lands are also differentiated. This differentiation extends to a community's narrative about itself. Each community displayed differences in its narrative concerning the connection between uses of federal public lands. The connections of respondents to economic sectors in their communities are strong. Yet the forms that this connection embodied were different between communities. Three basic narratives are discerned and discussed in the context of potential community-level social impacts of changes in federal public lands policies. Finally, it is argued that understanding the roots of different community narratives can help local public land managers reduce local conflict over policy change.

Key words: community, economics, public lands, social impacts.

SEX DISCRIMINATION IN THE MANAGEMENT OF RANGELAND ECOSYSTEMS

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Abstract: Federal agencies and academic natural resource departments have a long history of being all-white, "old-boy" clubs. In spite of laws mandating that these groups open up their hiring practices so that women and minorities have the same opportunities for employment as white males, agencies and academia have resisted—first by ignoring the law, and more recently by sexual and racial harassment, biased evaluations for promotions, glass ceilings, and denying women and minorities visibility at scientific and management conferences. Because legal mandates and rhetoric from above have not rectified the situation, we will suggest other ways to combat sexism and racism in the field of natural resource management. The Oregon Natural Resources Council feels this is not only a human rights issue, but an environmental issue as well. Primarily, we will discuss how the hiring and promotion of women and minorities is (1) a fairness issue, because talented and highly trained women and minorities deserve the same recognition and promotions as white males; (2) a social issue, because all voices, not just the desires and ambitions of one segment, should be involved in decisions on management of resources owned by all Americans, and (3) an environmental issue, because the best and most effective management will come from using the best minds of the entire population, not just those of one group.

Key words: employment, minorities, sex discrimination, women.

RANGELAND RELATIONSHIPS OF GRAZING, FIRE, FISH, AND WILDLIFE

EFFECTS OF RANGELAND FIRES AND LIVESTOCK GRAZING ON HABITAT FOR NONGAME WILDLIFE

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Abstract: Nongame wildlife have a wide range of requisites that can be influenced by fire or livestock grazing. Responses of wildlife are variable, depending on habitat type and timing and intensity of fire or grazing. These tools generally reduce ground cover and set back succession to an earlier seral stage, consequently favoring species that prefer short cover or bare areas, while discouraging species that prefer dense ground cover or more structural diversity in vegetation. Degradation of riparian zones by fire or grazing generally lowers species diversity and density. Some nongame species prefer grazed sites or burned sites, and some prefer various successional stages following a perturbation such as fire or grazing. Given the widespread use of grazing, species that are dependent on ungrazed habitat are likely at risk of local extinction in some areas. Managing to provide a mosaic of grazed and ungrazed and burned and unburned habitats in rangeland ecosystems likely will help to preserve biological diversity. The responses of nongame populations to fire or livestock grazing are directly related to the modification of vegetative cover and food resources. Short-term impacts of fire include injury or death, loss of nests and nest sites, loss of food and cover, and increased exposure to predation. The long-term response of many nongame species following fire is increased numbers, largely because of the surge in growth of herbaceous and seed-producing plants.

Key words: prescribed burning, fire, livestock grazing, nongame wildlife, wildlife habitat.

Human use of fire and livestock grazing both have profound effects on habitat for nongame wildlife and therefore impact populations of wildlife on a landscape scale. Our habitat for nongame wildlife in western rangelands today has been shaped by our recent historical use of livestock grazing and our use and prevention of fire.

When Asian people first arrived on this continent they shared the land with many wildlife species that are no longer extant. Native habitats and fauna were shaped by about 13,000 years of human influence before European settlers arrived. It is likely that native Americans caused habitat changes and contributed to the extinction of species such as prehistoric horses, giant sloths, woolly mammoths, and saber-toothed tigers. Native Americans used fire extensively to manage habitats until about 1875 (Higgins et al. 1986). Millions of bison that grazed the grasslands on the Northern Great Plains and prairies were nearly exterminated by this time as well, resulting in major changes in natural forces acting to shape habitats.

Domestic livestock grazing was initiated in the West in the 1840s, and rapidly increased to peak around 1890 (Young and Sparks 1985). By 1900 most rangeland habitats had

been drastically altered by the combination of extreme drought and overgrazing by livestock (Yensen 1981, Young and Sparks 1985). By the 1930s the open range concept had been largely replaced by range management practices initiated to help restore damaged rangelands (Behnke and Raleigh 1979). Livestock grazing is the primary economic use of public lands in the western U.S. (Platts 1991). Approximately 86 million ha of federal land in 17 western states are used for livestock production (Sabadell 1982).

Following catastrophic fires in 1910, a public campaign to prevent wildfires was initiated. This created a growing public resistance to the use of fire since about 1940, largely because of media overemphasis of fire's harmful effects. This led to a strong fire suppression era that still haunts fire managers today. Because of improved understanding of natural functions of fire in ecosystems, the use of prescribed burning for resource management has increased dramatically in recent years.

Intensive grazing has indirectly resulted in altered fire regimes, changing natural fire behavior, including frequency, seasonality, and intensity. Overgrazing allowed extensive invasions of exotic plants (e.g., cheatgrass [*Bromus tectorum*])

and Russian thistle [*Salsola kali*] (Yensen 1981), and their component as fuels has also changed fire behavior by increasing fire frequency.

Grazing by native ungulates and fire are natural, ecological forces with which flora and fauna of western rangelands evolved. Domestic livestock grazing has intensified the influence of grazing on most of these ecosystems, and this influence has been especially damaging to those ecosystems where native grazing ungulates were scarce or absent. For certain habitats it is arguable that livestock grazing simulates a natural ecological process that some native flora and fauna tolerate or perhaps require.

The objective of this paper is to provide perspectives on livestock and fire management as they relate to nongame wildlife.

METHODS

I reviewed literature regarding effects of livestock grazing and fire on nongame wildlife in western North America. Information on the effects of livestock grazing and fire is presented for various groups of nongame species (birds, mammals, herptiles) in 3 major habitats of the region, grasslands, shrubsteppe, and riparian.

GRASSLAND BIRDS

Grassland habitats in the West are diverse, ranging from tallgrass prairie to semidesert grasslands. The same amount of grazing that creates good habitat for a species in a tallgrass prairie may destroy that same species' habitat in shortgrass prairie or semidesert grasslands. Therefore, management of grasslands should consider local information when possible, tailored to the types of grasslands involved.

Raptors

Little information is available on the effects of grassland grazing on raptors, probably because most of these birds have such large home ranges that their densities cannot be compared on small plots typically used in grazing studies (Bock and Bock 1988).

Bock et al. (1993) listed northern harriers (*Circus cyaneus*) and short-eared owls (*Asio flammeus*) as species responding negatively to grassland grazing, and ferruginous hawks (*Buteo regalis*) as a species nonresponsive to grazing. Duebbert and Lokemoen (1977) found that northern harriers and short-eared owls preferred tall, dense cover in ungrazed upland sites. Kantrud and Kologiski (1982) found northern harriers in high numbers in lightly grazed areas of the northern plains. Higher winter use was documented for northern harriers and rough-legged hawks (*B. lagopus*) in idle, ungrazed meadow habitats on Malheur National Wildlife Refuge (NWR) in Oregon (Littlefield and Thompson 1987, Littlefield et al. 1992). Littlefield et al. (1984) speculated that disappearance of native grasses and increase of

sagebrush as a result of overgrazing and drought may have been a reason for the decline of Swainson's hawks (*B. swainsoni*) in southeastern Oregon.

Ferruginous hawk and burrowing owl (*Athene cunicularia*) densities were highest in heavily grazed sites in northern plains grasslands that supported high populations of Richardson's ground squirrels (*Spermophilus richardsonii*) (Kantrud and Kologiski 1982). Burrowing owls usually nest in abandoned prairie dog (*Cynomys ludovicianus*) burrows on the Great Plains (Agnew et al. 1986) and livestock, like bison (*Bos bison*), facilitate the establishment of prairie dog towns by grazing down dense grasslands that the prairie dogs are otherwise unable to occupy. Snyder and Snyder (1975) also felt that grazing may benefit burrowing owls because it creates short-stature vegetation necessary for owl foraging. Barbed-wire fences used to control livestock commonly kill raptors and some other birds, especially owls (Allen 1990).

Shorebirds

Shorebird species generally prefer to nest in relatively sparse grasslands (Kantrud and Higgins 1992). Kantrud and Kologiski (1982) reported that killdeer (*Charadrius vociferus*) and mountain plover (*C. montanus*) densities were highest in heavily grazed sites in the Northern Great Plains.

Bicak et al. (1982) studied nesting of long-billed curlews (*Numenius americanus*) in southwestern Idaho in relation to grazing. They concluded that grazing of grassland habitats was beneficial to this species, as long as the grazing did not occur during the nesting period. Similarly, Ryan et al. (1984) concluded that livestock grazing (applied outside the nesting season) can enhance habitat conditions for nesting marbled godwits (*Limosa fedoa*).

Upland sandpipers (*Bartramia longicauda*), which breed primarily east of the continental divide, also occur in small disjunct populations in Oregon, Washington, and Idaho. They nest in wet meadow habitats at scattered locations in the West, where livestock grazing and haying are primary habitat uses. Kantrud (1981) found little effect of grazing intensity on this species. In Wisconsin and North Dakota, upland sandpipers preferred dense vegetative cover for nest sites (Higgins et al. 1969, Ailes 1976). Bowen and Kruse (1993) documented significantly lower nest densities of upland sandpipers where cattle were present during the nesting season and concluded that grazing during the nesting season reduced the density of upland sandpipers. Kirsch and Higgins (1976) found upland sandpiper nest success at 71% in burned and undisturbed prairie grasslands, compared with 48% in the grazed prairie. Upland sandpipers may feed and rear their broods in very different habitats from those preferred for nesting (Ailes 1976).

Passerines

Passerine birds exhibit a wide range of responses to livestock grazing and burning. Bock et al. (1993) included horned larks (*Eremophila alpestris*), northern mockingbirds (*Mimus polyglottos*), lark sparrows (*Chondestes grammacus*), black-throated sparrows (*Amphispiza bilineata*), and McCown's

longspurs (*Calcarius mccownii*) as grassland species that responded positively to grazing. They listed common yellowthroats (*Geothlypis trichas*), savannah sparrows (*Passerculus sandwichensis*), Cassin's sparrows (*Aimophila cassinii*), Botteri's sparrow (*A. botterii*), and Baird's sparrows (*Ammodramus bairdii*) as birds that exhibited negative responses to grassland grazing. They also listed species that responded positively to grazing in taller grasslands, but that responded negatively to grazing in shorter grasslands, including Sprague's pipit (*Anthus spragueii*), dickcissal (*Spiza americana*), lark bunting (*Calamospiza melanocorys*), grasshopper sparrows (*Ammodramus savannarum*), chestnut-collared longspurs (*Calcarius ornatus*), bobolink (*Dolichonyx oryzivorus*), red-winged blackbird (*Agelaius phoeniceus*), and western and eastern meadowlarks (*Sturnella neglecta* and *S. magna*). Species that studies showed to be unresponsive to grazing or mixed or uncertain responses include clay-colored sparrows (*Spizella pallida*), Brewer's sparrow (*S. breweri*), vesper sparrow (*Poocetes gramineus*), LeConte's sparrow (*Ammodramus leconteii*), and brown-headed cowbird (*Molothrus ater*).

Renwald (1977) documented that breeding densities of lark sparrows were highest in areas most recently burned, and that densities declined with increasing litter build-up because of large areas of matted grass. Western meadowlarks generally decreased immediately after spring burns in South Dakota (Forde et al. 1984). Huber and Streuter (1984) found similar declines in western meadowlarks following a spring grassland burn. Meadowlarks did increase within 2 months after the fire to higher numbers than on unburned plots. Petersen and Best (1987) also documented a slight increase in meadowlarks following an incomplete burn.

Grasshopper sparrows declined significantly immediately after spring burns in South Dakota (Forde et al. 1984) and Huber and Streuter (1984) documented a similar decline following a spring grassland burn.

Breeding Bird Survey data suggest that grassland birds as a group are showing greater population declines than any other group in North America (Robbins et al. 1993). These declines are attributed to livestock grazing, fire suppression, prairie dog control, cultivation, and plantings of exotic grasses (Saab et al. 1995).

SHRUBSTEPPE BIRDS

Intermountain rangelands contain approximately 40 million ha of sagebrush (*Artemisia* spp.) (Wright and Bailey 1982:158). Other important shrubs include saltbush (*Atriplex* spp.), rabbitbrush (*Chrysothamnus* spp.), bitterbrush (*Purshia tridentata*), and black greasewood (*Sarcobatus vermiculatus*), and the region is characterized by perennial bunchgrasses. Because shrubsteppe habitats did not coevolve with large herds of grazing animals, plant species in these habitats are not adapted to withstand severe or continuous grazing (Mack and Thompson 1982). Grazing of shrubsteppe habitats generally creates an increase in woody vegetation

and a decrease in grasses, whereas fire generally results in an opposite effect. Studies of shrubsteppe birds in relation to grazing and fire are limited.

Sharp-tailed Grouse

Miller and Graul (1980), in a survey of states and provincial wildlife agencies, found that intensive grazing was considered the primary factor responsible for the decline of the sharp-tailed grouse (*Tympanuchus phasianellus*) in shrubsteppe rangelands. Fire has apparently enhanced conditions for sharp-tailed grouse according to some studies (Kirsch and Kruse 1973, Sexton and Gillespie 1979).

Raptors

Bock et al. (1993) listed the golden eagle (*Aquila chrysaetos*) as a species that responds positively to grazing (primarily because of response of black-tailed jackrabbits [*Lepus californicus*]). They listed burrowing owls, short-eared owls, ferruginous hawks, red-tailed hawks (*Buteo jamaicensis*) and northern harriers as species showing negative responses to grazing in shrubsteppe habitats.

Passerines

Reynolds and Trost (1980) studied fauna in grazed and ungrazed sagebrush and planted crested wheatgrass (*Agropyron cristatum*) seedings. They found no significant differences in either the density or the diversity of birds nesting in ungrazed or grazed sagebrush. Conversely, both crested wheatgrass habitats had a significantly lower species diversity and relative density of nesting birds than grazed or ungrazed sagebrush.

Bock et al. (1993) listed brown-headed cowbirds and sage sparrows (*Amphispiza belli*) as species showing positive responses to grazing of shrubsteppe habitat. They listed vesper sparrows, Brewer's sparrows, western meadowlarks, savannah sparrows, grasshopper sparrows, and white-crowned sparrows (*Zonotrichia leucophrys*) as species responding negatively to grazing, and listed horned larks, loggerhead shrikes (*Lanius ludovicianus*) sage thrashers (*Oreoscoptes montanus*), lark sparrows, black-throated sparrows, and Brewer's blackbirds (*Euphagus cyanocephalus*) as species unresponsive or showing mixed results to grazing. After a fire in shrubsteppe habitat, McGee (1976) found total bird density decreased but species diversity increased. Wiens and Rotenberry (1981) found a positive relationship between bird species richness and structural diversity of habitat in a regional analysis of shrub-steppe systems. In burns that provide a good mosaic of burned and unburned vegetation, bird species richness will likely increase (Petersen and Best 1987).

Petersen and Best (1987) found sage thrasher population densities unchanged on burned plots compared to control plots, suggesting no response by this species to fire.

Sage and Brewer's sparrow populations showed little change following an incomplete (45%) burn (Petersen and Best 1987), whereas sage sparrows experienced a sharp decline after an 88% removal of sagebrush by fire (Rotenberry and Wiens 1978).

In sagebrush grasslands in Idaho, male sage sparrows expended significantly more time in territorial maintenance after a fall burn, whereas Brewer's sparrows spent about the same amount of time (Winter 1984).

Spring burns in Wyoming in sagebrush-grasslands initially reduced the breeding pair density of green-tailed towhees (*Pipilo chlorurus*), vesper sparrows, and white-crowned sparrows, but their breeding densities increased 2 years postburn (McGee 1982). Vesper sparrows generally increased immediately after spring burns in South Dakota (Forde et al. 1984).

Winter and Best (1985) found a significant difference in sage sparrow nest placement between pre- and postburn nesting seasons. One year preburn, all nests were located within sagebrush canopies. After the burn, 17% of the nests were located in depressions on the ground under small sagebrush plants, and 1 nest was located in a grass clump. After the burn, half of the early nests (6) were built in sites other than sagebrush canopies, while all late nests (17) were within sagebrush plants. They concluded the reduction of available sagebrush plants by fire required some of the sage sparrows to use areas other than their preferred habitat to obtain enough cover for their nests. Similarly, Petersen and Best (1987) documented all nesting by Brewer's and sage sparrows in big sagebrush (*A. tridentata*) before a fire, whereas a few nests were found in or under other plants or under sagebrush after a fire.

Petersen and Best (1987) suggested that in planning prescribed burns with nongame birds in consideration, burning should be directed at moderate (40–50%) removal of sagebrush. Mosaic-pattern, narrow-strip, or small block burns would provide considerable edge and excellent interspersions of habitat types.

Castrale (1982:951) suggested that management for nongame birds in sagebrush rangelands should be towards "providing patches of suitable habitat, ranging from near climax stands of large sagebrush plants to open stands to areas of high grass density to areas of sparse vegetation." Unburned blocks should be 100–200 m wide to provide sufficient area for sage thrasher territories.

RIPARIAN HABITATS

Although riparian zones comprise only 1–2% of the land area, they provide essential food, water, or cover to most wildlife species, and they are the most important habitat in the western U. S. (Bull 1978). The importance of these habitats for birds has been well documented (Carothers and Johnson 1975, Gaines 1977, Wauer 1977, Thomas et al. 1979). In the Great Basin of southeastern Oregon, 288 of

the 363 terrestrial wildlife species are either directly dependent on riparian zones or use them more than other habitats (Thomas et al. 1979).

Riparian habitats are specifically sensitive to grazing, and year-long and season-long grazing are especially detrimental (Sedgwick and Knopf 1987). The detrimental effects of overgrazing on riparian habitats and on the associated fish and wildlife have been discussed by numerous authors. Riparian habitats are most susceptible to grazing in arid and semi-arid regions where livestock tend to concentrate along streambanks because of the shade, water, shelter, and more palatable vegetation (Ames 1977, Behnke and Raleigh 1979, Dahlem 1979, Tubbs 1980). Some detrimental effects of grazing on woody riparian vegetation as described by Ames (1977), Brown et al. (1977), Kennedy (1977), Szaro (1980), Tubbs (1980), and Knopf and Cannon (1982) include:

- ♦ elimination of food and cover plants;
- ♦ reduction in availability of nest sites;
- ♦ elimination of herbaceous understory and stand reproduction, resulting in even-aged nonreproducing mature stands and ultimately disappearance (thus reducing habitat diversity);
- ♦ poor understory structure (shapes of shrubs and trees become like an inverted cone with decreased understory structure); and
- ♦ soil compaction and streambank erosion, resulting in wholesale loss of the riparian zone.

Such degradation results in reduced species diversity and density. Taylor (1984) found that bird species diversity decreased with increased grazing in woody riparian habitat along the Blitzen River on Malheur NWR. In his study, bird densities were 5–7 times greater on a transect ungrazed since 1940 than on 2 transects grazed annually until 1981, and 11–13 times greater than on a transect severely disturbed by grazing and dredging activities. He found a positive correlation between the length of time since an area had been grazed and bird abundance, shrub volume, and shrub height classes summed, and a negative correlation between grazing intensity and these factors. He also found that willow flycatchers (*Empidonax traillii*) were nearly limited to transects with the most shrub volume and they showed an inverse relationship to grazing frequency.

Duff (1979) found small mammal and songbird-raptor use increased 350% in a riparian area along Big Creek, Utah, where livestock were excluded for 8 years, compared to adjacent grazed riparian areas. Winegar (1977) reported 27 vertebrate species were recorded on 2.5 miles of an ungrazed enclosure on Camp Creek, eastern Oregon, while only 9 species were recorded on 2.5 miles of an adjacent grazed section. Schmidly and Ditton (1978) reported capture frequencies for small mammals were 4 times greater on ungrazed than on grazed woodland riparian habitats in Texas. Szaro et al. (1985) found numbers of wandering garter snakes (*Thamnophis elegans vagrans*) to be significantly higher

on ungrazed portions of an alder (*Alnus* sp.)-willow (*Salix* sp.) riparian community in New Mexico. They attributed differences to regeneration of vegetation and increased organic debris in the ungrazed habitat.

Grazing damage to riparian habitats is a function of the type, intensity, frequency, and seasonality of livestock use. Impacts tend to be less for fall-winter grazing than for spring-summer grazing; however, livestock may heavily use riparian vegetation in the fall if adjacent vegetation is less palatable. Discussions of different grazing systems used to lessen impacts of livestock on riparian habitat appear in Busby (1979), Storch (1979), Swan (1979), Platts (1981a), Schmidt (1983), Bryant (1985), and Marlow and Pogacnik (1985). Platts (1981a) summarized the effectiveness of different grazing systems on riparian-aquatic habitat and he rated all of them as either fair or poor and reported that only exclusion of livestock resulted in good to excellent condition. Platts (1981b) indicated that habitat alteration by grazing may be insignificant when use is $\leq 25\%$. Storch (1979) found that rest-rotation grazing worked for maintaining riparian habitat only if the habitat was in good condition before the program began. Busby (1979) stated that rest-rotation and deferred grazing systems do not work well for maintaining riparian zones in desert areas because the habitats do not receive enough moisture in 1 year to recover. Sedgwick and Knopf (1987) found moderate fall-winter grazing to be compatible with migratory bird breeding use of a cottonwood (*Populus* sp.) community.

Krueger and Anderson (1985) discussed the use of cattle as a management tool to thin dense shrub-willow habitat in Wyoming, thus increasing habitat diversity. They cautioned however, that managers must carefully control the distribution of grazers, and that enough riparian habitat is in poor condition because of grazing to create plenty of low density shrub-willow habitats.

The literature indicates that whereas fishery habitat recovers quickly from the results of overgrazing (Winegar 1977, Keller et al. 1979, Storch 1979, Van Velson 1979), rehabilitation of terrestrial riparian vegetation may require decades (Davis 1977, Duff 1979, Knopf and Cannon 1982). In a study of a grazing enclosure on Big Creek, Utah, Duff (1979) reported a 63% increase in streamside vegetation after 4 years; yet, after trespassing cattle occupied the enclosure for 6 weeks, vegetation was set back to pre-enclosure conditions.

The effects of fire on riparian ecosystems are poorly documented. Generally, the literature suggests that resilience of riparian habitat decreases with increased fire intensity (Ewel 1978). Willows often regenerate quickly after fire (Loveless 1959; Spencer and Hakala 1964; Leege 1968, 1969; Vallentine 1971; Rowe and Scotter 1973). Fire on Malheur NWR in Oregon has generally resulted in removal of about half of the above-ground willow structure, followed by vigorous resprouting. In some cases, a few decadent willows became a dense patch of young growth with improved structure following fire. Linde (1969) found that in Wisconsin, spring burning resulted in resprouting and increased den-

sity of willow stands, whereas fall burning tended to control willows. The difference was probably related to fire intensity.

Bock et al. (1993), after reviewing the literature, listed 8 of 43 bird species that responded positively to grazing of riparian habitats, 17 that were negatively affected, and 18 that were unresponsive or showed mixed responses to grazing. Because of historical loss and damage to riparian habitats, impacts on riparian obligate species have been severe. The western race of the yellow-billed cuckoo (*Coccyzus americanus occidentalis*) was historically common in all riparian systems of the West (Grinnel and Miller 1986). Its population is now estimated at 475-675 pairs, with the decline being caused primarily by habitat loss or modification (Layman and Halterman 1987). Other riparian obligates such as the southwest willow flycatcher (*Empidonax trailii extimus*), least Bell's vireo (*Vireo bellii*), and yellow warbler also have experienced drastic declines (Krueger 1993).

SMALL MAMMALS

Reynolds and Trost (1980) found the relative density of small mammals to be significantly higher in ungrazed sagebrush habitat than in grazed sagebrush, and grazed or ungrazed crested wheatgrass seedings. Conversely, grazed crested wheatgrass supported significantly lower relative density of small mammals than the other types.

Deer mice (*Peromyscus maniculatus*) generally respond positively to grazing (Black 1968, Johnson 1982, Medin and Clary 1990, Shulz and Leininger 1991). Studies of western jumping mice (*Zapus princeps*) showed this species to respond negatively to grazing in riparian sites (Rucks 1978, Hanley and Page 1982, Shulz and Leininger 1991); however, Medin and Clary (1989) found the species in both grazed and ungrazed riparian sites. Medin and Clary (1989) trapped more least chipmunks (*Tamias minimus*) and golden-mantled ground squirrels (*Spermophilus lateralis*) in ungrazed riparian habitats, and trapped more Great Basin pocket mice (*Perognathus parvus*) in grazed habitat. They trapped Townsend's ground squirrels (*S. townsendii*) only in grazed habitat. Bock et al. (1984) found significantly more hispid pocket mice (*P. hispidus*), western harvest mice (*Reithrodontomys megalotis*), white-footed mice (*Peromyscus leucopus*), southern grasshopper mice (*Onychomys torridus*), and hispid cotton rats (*Sigmodon hispidus*) in ungrazed semidesert grassland plots than on grazed plots. They found significantly more Merriam's kangaroo rats (*Dipodomys merriami*) on the grazed sites.

Samson et al. (1988) concluded that winter grazing did not seem to have an effect on small mammal populations in a Colorado floodplain.

Results from studies on the effects of fire on small mammals are highly variable, likely because preburn habitat conditions differed and because fire behaves differently (with respect to intensity, completeness, and pattern of burn) in different areas depending on weather conditions, fuel char-

acteristics, and season of burn (Brown 1982, Wright 1984). Information is needed from local burn sites to make more effective management decisions.

According to Higgins et al. (1986:29) "the small mammal response is not considered a direct response to fire but a reaction to fire altered habitat." Fire essentially sets back vegetation to an early seral stage, altering the small mammal community from species associated with climax community to those considered early successional species (McGee 1982). Over time, litter accumulation, flora, and the rodent fauna resemble those of an unburned site.

Most research indicates limited direct mortality from fire to rodents; however, several instances have been reported (Chew et al. 1958, Erwin and Stasiak 1979). An immediate, indirect cause of mortality from fire is predation. Lack of cover immediately following a fire exposes small mammals to avian and mammalian predators (Motobu 1978). Postburn predation may be more limiting to rodent populations than the burning itself (Lawrence 1966).

Stoudt et al. (1971) indicated a significantly reduced number of small mammals in the years following a severe burn. McGee (1982) reported that following spring burning, numbers of small mammals were at low levels, but numbers increased dramatically in a short time.

Removal of the litter layer increases availability of seeds and invertebrates for granivores and omnivores (Ahlgren 1966, Stoudt et al. 1971, Kaufmann et al. 1983). Some species increase in number in subsequent years after burns, apparently responding to early stages of recovery and enhanced food supplies. These include the deer mouse, western harvest mouse, house mouse (*Mus musculus*), kangaroo rats (*Dipodomys* spp.), hispid pocket mouse, ground squirrels, and chipmunks (*Tamias* spp.). Several authors reported deer mice to increase dramatically in subsequent years after a burn (Cook 1959, Lawrence 1966, McGee 1982).

Species considered herbivores generally are limited by fire, especially within complete burns. Species with specific niche requirements (e.g., voles [*Microtus* spp.], western jumping mice, and shrews [*Sorex* spp.]) cannot sustain their populations on intensively burned areas. Lack of cover is the restricting factor in reducing vole populations, which require 1 year of litter for runways (Cook 1959). Jumping mice require grass and herbs for nest cover (Burt and Grossenheider 1964) and lack of a well-developed herbaceous layer may exclude this species. Stoudt et al. (1971) correlated the absence of shrews on a burned area with lack of ground litter on the burned sites.

In order to maintain small mammal populations, McGee (1982:179) suggested that:

ideal sagebrush management should create a mosaic of different aged successional stages. The optimum proportion of unburned, spring and fall burned sites should mimic historic fire frequency and size where feasible.

REPTILES AND AMPHIBIANS

Little is known about the microhabitat requirements of many reptile and amphibian species. Even less is known about impacts of grazing or fire on these species.

Reynolds and Trost (1980) reported no significant differences in densities or diversity of lizards in grazed or ungrazed sagebrush habitat in Idaho. They found significantly lower densities of lizards in grazed and ungrazed crested wheatgrass seedings compared to the sagebrush sites.

Szaro et al. (1985) found numbers of wandering garter snakes to be significantly higher on ungrazed portions of an alder-willow riparian community in New Mexico. They attributed differences to regeneration of vegetation and increased organic debris in the ungrazed habitat.

MANAGEMENT CONSIDERATIONS

Given that livestock grazing is the common economic use of western rangelands, species dependent on ungrazed habitats are most at risk, and probably are at population levels far below historical numbers. These species are most subject to local extinction and therefore should be emphasized in future management decisions.

Shrubsteppe and grassland habitats should be managed to provide a mosaic of grazed and ungrazed, burned and unburned patches to meet the needs of diverse nongame species.

Riparian zones can be managed for nongame wildlife by maintaining high structural diversity of vegetation. Because of historical losses and damage of riparian habitats in the western states, it is critical to restore these areas to ensure sustainability of nongame wildlife that depend on them. Exclusion of livestock grazing will result in the fastest recovery of these areas; however, costs of fencing may make this impractical in many areas. Changing period of livestock use (e.g., late winter-early spring) or stocking and use rates can result in riparian recovery but grazing programs need to be designed for specific riparian areas (W. Elmore, this symposium).

CONCLUSION

Resource managers should strive to maintain populations of nongame wildlife in native habitats. Management decisions should consider value judgments on the worth of individual species (Balda 1975). Species that have narrow life requisites require special attention and management emphasis.

To sustain our nongame fauna, we need to make drastic efforts to preserve native plant communities in a variety of conditions that meet the needs of a wide range of species. Whereas burning and grazing can enhance habitat for some species, these management tools should be applied cautiously to prevent harm to declining species. In many areas, livestock grazing systems need to be modified to use more natu-

ral processes and benefit wildlife habitat. Nongame habitat management needs to be applied on a landscape scale to ensure large enough habitat patches are present to maintain all native species, and to provide adequate migration corridors between important habitats.

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LIVESTOCK GRAZING RELATIONSHIPS WITH FISHERIES

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Abstract: Although riparian or streamside areas cover <2% of the landscape, they are critical to overall fisheries health. Lands immediately adjacent to streams are primary contributors to fish habitat quality as they regulate water temperatures and the delivery of sediment and organic materials to the stream. Healthy riparian areas are resilient to the effects of flooding; they filter sediments eroded from the uplands, filter sediments carried in transport by the stream during flood events, resist streambank and channel erosion, provide shade to maintain cool water temperatures, and provide for ecosystem diversity important to aquatic and terrestrial wildlife. Alteration of riparian areas by land use practices during the past century has been dramatic, persistent, and unfavorable, according to aquatic scientists in the Northwest. Recent estimates for rangelands in the West indicate that about 66% of Bureau of Land Management riparian areas are not functioning properly or are functioning at risk, and 22% of U.S. Forest Service riparian areas are not meeting forest plan objectives for proper condition. Grazing primarily affects the streamside environment by changing or reducing the amount of hydrophytic vegetation immediately adjacent to the stream channel. Fish habitat quality can thus be degraded by changes in channel stability, increased water temperature, increased sediment and nutrient concentrations, and by changes in volume and timing of streamflow. Recent efforts to properly manage livestock grazing in the Bear Valley Basin focused on early season, light-intensity use within riparian areas. This approach seems to have reversed the downward trend in streambank stability and substrate sedimentation leading to increased survivals of endangered chinook salmon (*Oncorhynchus tshawytscha*).

Key words: aquatic ecosystem, channel stability, chinook salmon, fisheries, fish habitat, grazing, *Oncorhynchus tshawytscha*, riparian, sediment.

GRAZING IN THE STREAM OR RIPARIAN ENVIRONMENT

Streamside grazing's most significant, yet perhaps least perceptible, effect is to alter the composition of native herbaceous and woody plant communities gradually during long periods of time. These plant communities are critical to maintenance of streambank stability and channel form, key factors in the regulation of fisheries habitat quality (Swanson 1989, Clary and Webster 1990, Platts 1991). During long periods of improper use, riparian vegetation communities often experience a gradual reduction or elimination of streamside shrubs, sedges (*Carex* spp.), and rushes (*Juncus* spp.). Because they have water, shade, flatter terrain, and more succulent vegetation than upland areas, riparian areas often are grazed more heavily by livestock than nearby upland terrain (Armour 1977, Duff 1983, Platts and Nelson 1985).

Streamside vegetation strongly influences aquatic habitats by providing (1) protection and stability for streambanks, (2) shade and insolation to ameliorate water temperature extremes, (3) resistance to stream and ice erosion, (4) maintenance of channel stability and integrity, (5) increased subsurface storage of water with increased summer streamflow, (6) cover for fish, (7) detritus for aquatic food production, and (8) roots and overhanging branches that add biodiversity (Elmore and Beschta 1987, Platts 1991).

A field review of grazing on stream systems (Beschta et al. 1991:6) indicated that in many areas of the West, livestock grazing effects on aquatic habitat have been "... dramatic, persistent, and unfavorable." Grazing primarily has

influenced the streamside environment by changing or reducing the amount of hydric vegetation adjacent to the stream (Armour et al. 1991). These scientists now suggest changes in grazing management as the most effective means of improving riparian habitats.

Loss of the more favorable deep-rooted vegetation types that resist erosion and maintain channel integrity can be the principal cause of physical aquatic habitat disruption (Platts and Nelson 1989, Platts 1990). Elimination of such vegetation can result from livestock congregating along stream-sides, seeking shade, water, and more succulent vegetation. Excessive trampling and trailing adjacent to the stream channel adversely alters the riparian environment, leading to the collapse of overhanging banks and long-term changes in channel morphology. Streams without bank stability are often wider and shallower. They are subject to higher levels of sedimentation resulting from increased streambank erosion and hydraulic conditions more conducive to deposition of smaller substrate materials. Such physical changes lead to increasing water temperature, nutrients, and suspended sediments and changes in the timing and volume of streamflow. A stream with these characteristics is classified as "nonfunctioning" or improperly functioning (Bur of Land Manage. and U.S. For. Serv. 1994).

Properly functioning riparian areas reduce the adverse effects of drought, floods, landslides, and other natural catastrophic events in the watershed. They store and release water quantities in more even distribution, they filter sediment from high streamflows, protect the integrity of the channel system and valley-bottom aquifer, and provide increased shade and nutrients to enhance the quality of water in streams and lakes.

In degraded streams, restoration of streamside vegetation will be necessary to restore properly functioning aquatic habitats. Recent estimates for rangelands in the West indicate that about 66% of Bureau of Land Management (BLM) riparian areas are functioning improperly or are functioning at risk, and 22% of U.S. Forest Service (USFS) riparian areas are not meeting forest plan objectives for proper function (BLM and USFS 1994).

Stream and riparian changes caused by improper livestock grazing reduce the quality and productivity of fish habitats. As channel morphology is altered, adverse modifications are made to habitat diversity, cover, temperature, nutrient concentrations, rearing space, and incubation conditions. Reductions in bank cover related to overhanging vegetation, root vegetation, and undercut banks have been correlated to reductions in fish production (Binns 1979, Wesche 1980, Sullivan et al. 1987). Stream bank destabilization and resultant erosion can increase substrate embeddedness and reduce pool volume as well as increase water temperature because of reductions in streamside shade and increases in channel cross sectional area (Shepard 1989, Bauer and Burton 1993). Increases in substrate embeddedness impair food production and block refugia for young trout (Rinne 1990). At least 20 studies, summarized by Platts (1991), indicated that improper livestock grazing created adverse modifications that resulted in an impaired capability to produce and maintain populations of important cold water fish.

Improperly functioning riparian conditions can result from streamside livestock use in excess of "light" intensity (Platts 1981, 1990, 1991). To protect fisheries habitat, the Idaho Chapter of the American Fisheries Society (1993) recommends that "light" intensity of use should be applied to the streamside zone and be based on a herbaceous use objective of 75% of the biomass remaining at the end of the growing season. Clary and Webster (1990) suggested a similar objective to maintain the vigor of key riparian plant species and to protect stream banks.

GRAZING STRATEGIES THAT ACHIEVE PROPER USE FOR RIPARIAN AREAS

Grazing strategies that have high compatibility with stream or riparian environments often achieve light levels of livestock use. Many riverine habitats evolved naturally in the presence of wild ungulates under light use. To mimic natural conditions, livestock use and concentration normally need to be low enough to avoid adverse changes to riparian vegetation and stream banks. Systems rated as achieving this kind of proper use in riparian zones (Platts 1991, Kovalchik and Elmore 1991) include (1) riparian pasture—the stream zone is designated as 1 pasture and programmed not to exceed light levels of use; (2) riparian rest—the riparian area is rested until stream habitats are restored to meet stated goals; (3) rest-rotation with seasonal preference

(sheep)—the riparian area is grazed by sheep only during that period of the year when the least environmental change will occur; (4) spring grazing (short duration early season)—the riparian area is grazed for 2–3 weeks when forage is first available for use in the spring; and (5) winter grazing—the riparian area is grazed when stream banks are mainly frozen and plants are dormant, and snowfall is light enough to make grazing feasible.

Many popular grazing strategies, such as deferred, deferred rotation, and holistic systems, may not be as effective as those suggested above because of higher than desired levels of use. However such systems, if they achieve light levels of use in streamside areas (through herding and trailing controls, for example) can be just as compatible with stream habitats as the recommended systems. The key to achieving a good riparian grazing system is the ability to control the following (Platts 1991): (1) forage use, (2) livestock stocking rates, (3) livestock distribution, (4) the timing of forage use, and (5) livestock kind and class.

RIPARIAN GRAZING STRATEGIES IN THE BEAR VALLEY BASIN, IDAHO

Study Area

The Bear Valley drainage is divided into 3 grazing allotments, Bear Valley, Elk Creek, and Deer Creek. The Bear Valley Allotment is a 2-pasture deferred system with a riparian pasture that includes the mainstem of Bear Valley Creek, a prime chinook salmon (*Oncorhynchus tshawytscha*) spawning stream. Upstream and downstream from the riparian pasture, Bear Valley Creek is excluded from livestock grazing. Permitted cattle numbers are 880. The grazing sequence is (1) Bear Valley riparian pasture (3 weeks); (2) Big Meadows and Cache Creek Unit (grazed second in odd years, third in even years); (3) Bruce Meadows Unit and Sheep Trail Unit (grazed third in odd years, second in even years).

The Elk Creek Allotment is a 2-pasture deferred system (Stanfield and Poker-Ayers units) with a riparian pasture that includes the mainstem of Elk Creek, a primary production area for chinook salmon, from its mouth upstream to the Frank Church River of No Return Wilderness boundary. Permitted cattle numbers are 738. The grazing sequence is (1) Elk Creek riparian pasture (3 weeks); (2) Stanfield Unit (grazed second in odd years, third in even years); (3) Poker and Ayers Unit (grazed third in odd years, second in even years).

The Deer Creek Allotment is a 2-pasture deferred rest rotation system (Little Bear and Bearskin Unit and North Fork and South Fork Deer Creek Unit). Each unit is rested every other year.

The riparian use standard for chinook salmon production areas (mainstem of Bear Valley Creek and Elk Creek) is 25%. Nonriparian areas have a use standard of 40%. These standards apply to the Elk Creek and Bear Valley riparian pastures and a portion of the Stanfield Unit, primary production habitats for endangered chinook salmon.

Methods

To monitor stream bank stability, stream bank cover, and aquatic habitat condition, 51 permanent stations were established on primary chinook salmon production areas in the Bear Valley Basin. Each monitoring site was approximately 30 m long. All allotment units had monitoring stations. Several stations were established on meadow streams outside the grazing allotments, but within the Bear Valley Basin to isolate the effects of wild ungulates. We collected stream bank stability and cover data at each station. On salmon production areas, the mainstem of Elk and Bear Valley creeks, data were collected weekly while cattle were present in the grazing unit and monthly when cattle were absent in a grazing unit. On nonproduction areas, data were collected bi-weekly while cattle were present in the grazing unit and monthly when cattle were absent.

Stream bank instability was defined by the following features as described in Bauer and Burton (1993): (1) *breakdown*—obvious blocks of bank broken away and lying adjacent to the bank breakage; (2) *slumping or false bank*—bank has obviously slipped down, cracks may or may not be obvious, but the slump feature is obvious; (3) *fracture*—a crack is visibly obvious on the bank indicating that the block of bank is about to slump or move into the stream; (4) *vertical and eroding*—the bank is mostly uncovered as defined below and the bank angle is steeper than 80° from the horizontal.

Stream banks were considered covered if they showed any of the following features as described in Bauer and Burton (1993): (1) perennial vegetation ground cover is > 50%; (2) roots of vegetation cover >50% of the bank (deep-rooted plants such as willows [*Salix* spp.] and sedges provide such root cover); (3) $\geq 50\%$ of the bank surfaces are protected by rocks of cobble size or larger; or (5) $\geq 50\%$ of the bank surfaces are protected by logs of ≥ 10 cm diameter.

Stream bank stability was estimated using a simplified modification of the method described by Platts et al. (1983). This modification allowed for measuring bank stability in a more objective fashion. Stream banks were defined as the portion of the channel most susceptible to erosion during high water events. Bank cover was viewed at the vegetative green line located below the bankfull level but above the scour line or any natural undercut bank. The lengths of bank on both sides of the stream were measured and proportioned into 5 stability-cover classes as follows. (1) *Mostly covered and stable*—stream banks are >50% covered as defined above and stable as defined above. Banks associated with gravel bars having perennial vegetation above the scour line were placed in this class. (2) *Mostly covered and unstable*—stream banks are >50% covered and unstable as defined above. These banks are typically observed in meadows where breakdown, slumping, or fracturing is present along the bank yet vegetative cover is abundant. (3) *Mostly uncovered and stable*—stream banks are <50% covered and stable as defined above. Uncovered, stable banks are typical of stream-sides trampled by concentrations of cattle. Such trampling

flattens the bank so that slumping and breakdown do not occur even though vegetative cover is reduced or eliminated. (4) *Mostly uncovered and unstable*—stream banks are <50% covered and unstable as defined above. These are bare eroding stream banks and include all banks mostly uncovered that are at a steep angle to the water surface. (5) *False bank*—stream banks have slumped in the past but have been stabilized by vegetation. These banks are usually lower than existing banks and generally provide no cover for fish. In 1992, false banks were not placed in a distinct category but were considered as covered and unstable banks. In 1993, false banks were placed in a distinct category to more accurately detect stability recovery trends.

The length of stream bank in each stability class was recorded in order of occurrence within the monitoring station and initially marked with a wire staple marker for future reference and to reduce observer bias. On monitoring station revisits throughout the grazing season, comparisons were made to previous data. If no visual change had occurred, the previous visit's data were recorded. However, if change had occurred, all changed measurements were recorded.

Changes in stream bank stability and cover while cattle were present in the Elk Creek and Bear Valley riparian pastures and the Stanfield Unit were compared to livestock exclosed controls to determine if the rate of change caused by cattle differed from natural rates of change. Controls used were Big Meadows exclosure (Bear Valley riparian pasture), Poker and Ayers exclosure (Elk Creek riparian pasture) and Dagger and Porter creeks (Stanfield Unit). If the decreases in stream bank stability and cover in grazed units were different ($P \leq 0.25$; Mann-Whitney Test) than the decrease in stream bank stability and cover in control units, cattle would be removed from the grazed unit.

Livestock herbage use and stubble height were monitored in conjunction with stream bank stability and cover monitoring to link such use with changes observed along the stream bank. A utilization cage was placed on the green line within the monitoring station. It was located within 1 m of the stream bank on the dominant riparian plant community for the monitoring station. Ten randomly selected heights of each sedge species within the cage were recorded during each stability and cover evaluation. Graminoid species were used at some monitoring stations because sedge species were absent.

After plant heights within the cage were measured, 2 transects (1/bank) were placed along the green line to measure stubble height. Stubble height measurements were taken at 1-m intervals for only those species measured within the cage. If bare ground or a plant species not represented within the cage was encountered along the transect, the observer measured the next cage-represented plant encountered along the transect within one-half the distance to the next sampling point.

Average ungrazed and grazed heights were calculated for each species. Percent height remaining was then converted to percent weight remaining using height-weight

curves developed by Kinney and Clary (1994). A weighted percentage removed, based on species composition along the transects, was calculated for each station. An average use was computed for each unit.

We monitored pool frequency, woody stem regeneration, and water temperatures at many of the stations.

We used the underwater visual estimate method described by Thurow (1994) to determine fish abundance at 35 stations during mid-August. The distance snorkeled usually equaled the distance of a pool-ripple-pool sequence. Fish species and lengths were recorded. Density estimates of chinook salmon and other fish species were calculated for each snorkeled station.

Pebble counts (Wolman 1954) were done at 35 monitoring stations. One transect, 100 particle sample, was located in the pool tail areas or primary spawning substrate. Each transect was perpendicular to stream flow and encompassed the distance between water lines. Each pebble was measured along the intermediate axis and placed into 1 of 6 size categories, from silt-clay to boulder. Fines are defined as that size fraction <6 mm.

RESULTS

Declines in bank stability were detected in both riparian pastures in 1992 (Fig. 1). In 1993, controls were implemented that prevented late-season drift of livestock into these pastures, thereby allowing attainment of "light" use objectives that had been exceeded in 1992. As a result, bank stabilities improved after 1992. Starting in 1993, no significant difference ($P \leq 0.25$) was detected in the rate of change in stream bank stability between the riparian pastures and adjacent exclosures.

Bank stability trends have been positive in both exclosure units since implementation at the end of 1992 (Fig. 2). Changes in stream bank stability have been similar to those observed in the Bear Valley riparian pasture.

Bank stability trends in the Stanfield Unit, located within the Frank Church Wilderness area, were negative in 1993 and then improved slightly in 1994 (Fig. 3). Herding and

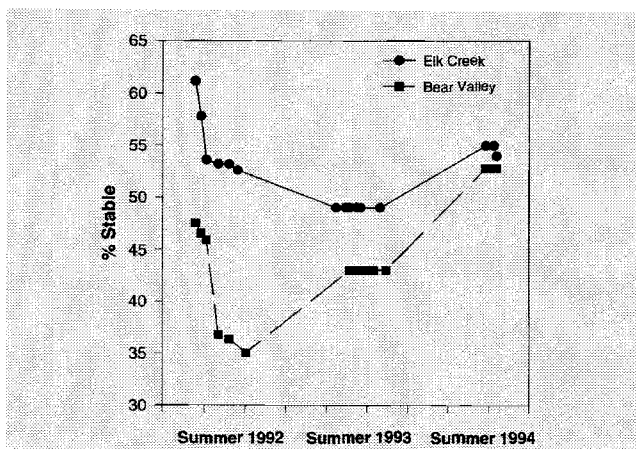


Fig. 1. Streambank stability trends for riparian pastures in the Bear Valley Basin, Idaho.

the installation of natural barriers adjacent to stream access points have been used to meet the "light" use objective along streambanks in this unit since 1993.

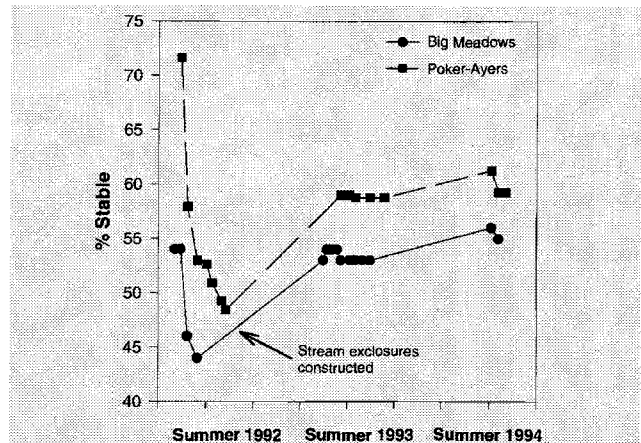


Fig. 2. Streambank stability trends for rested (exclosure) units in the Bear Valley Basin, Idaho.

Levels of spawning substrate fine sediments were increasing in the late 1980's and averaged 50–60% by composition (Fig. 4). Substrates were not monitored in 1992 and 1993. In 1994, substrate fine sediments were less by about 10% compared to 1990 and 1991 averages.

The rate of chinook salmon egg-to-smolt survival has been estimated annually since 1985 using estimates of spawner escapements and parr abundances (See Fig. 5 for Bear Valley Basin). Between 1985 and 1993, egg-to-smolt survival rates ranged between 0.2 and 0.8%. Preliminary estimates from 1994 parr density monitoring indicates that survival rates are approximately 1.3%, which is more than double the previous 10-year average.

DISCUSSION

Chinook salmon production has steadily declined in the Bear Valley Basin since the early 1950's. The decline in the number of chinook redds has been documented by Howell et

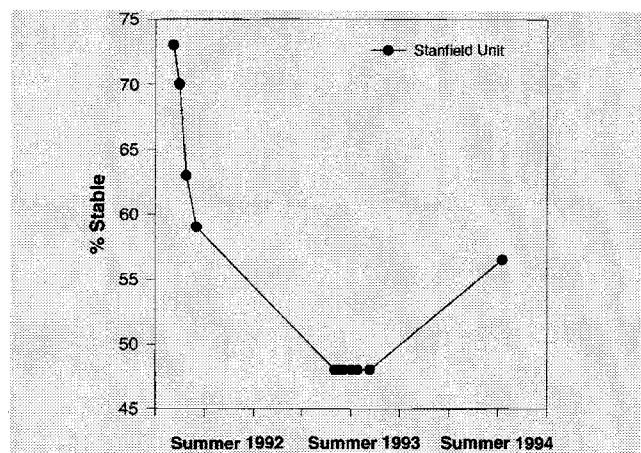


Fig. 3. Streambank stability trends for wilderness pasture reflecting the affects of herding and trailing deflection in the Bear Valley Basin, Idaho.

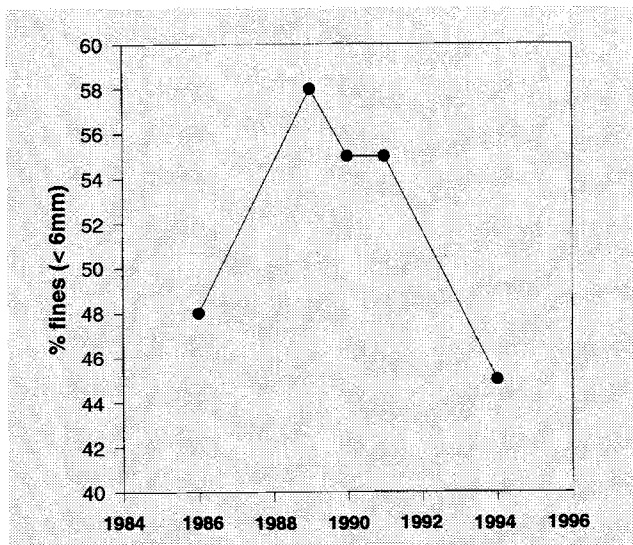


Fig. 4. Spawning substrate fine sediment trends in the Bear Valley Basin, Idaho.

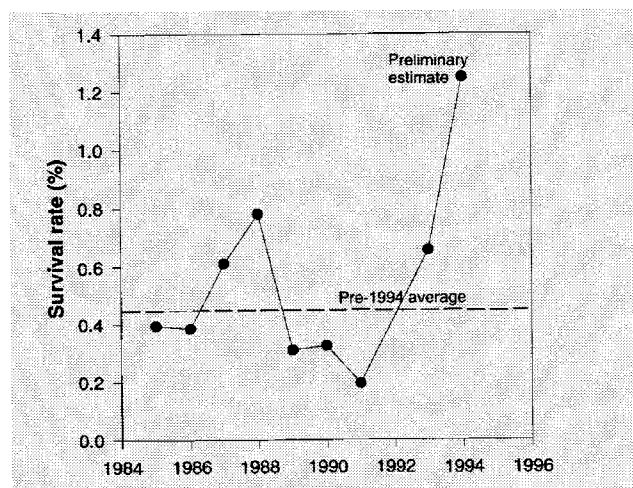


Fig. 5. Trends in chinook salmon egg-to-smolt survival rates in the Bear Valley Basin, Idaho.

al. (1985), Konopacky et al. (1985), Petrosky and Holubetz (1986) and Idaho Fish and Game file data. These declines are largely caused by factors outside the basin (smolt and adult passage) as well as degraded habitat conditions within the basin. Burton (1992) assessed the trends of other resident salmonids within Bear Valley Basin to determine what effect habitat condition and land management activities may have on chinook production. He found that recent data indicated a decline in resident salmonid densities. Increases in sediment from land use activities have impaired salmonid production.

Positive changes in stream bank stability and substrate sedimentation might indicate lower streamside use rates by livestock along chinook salmon primary production areas after 1992. Also, willow regeneration, as measured by the woody stem survey, was increasing at most monitoring sites since changes were implemented in 1993. Long-term trends in bank stability and influences on sediment production are

of concern because of the effect on egg-to-parr survival. Embryo survival has been shown to be impaired by increasing percentages of fine sediment in the intragravel environment (Tappel and Bjornn 1983, Irving and Bjornn 1984). Fine sediments reduce gravel permeability and therefore block delivery of dissolved oxygen needed for embryo survival (Burton et al. 1990). Furthermore, excessive fine sands and silts in the egg pockets can restrict upward movements of emerging fish, causing entrapment and mortality. Such conditions are apparently present in the Bear Valley drainage. Production of smolts in pristine Middle Fork Salmon River tributaries is estimated to be 6% of historical production whereas estimates for Bear Valley are <1% of historical production. Recent increases in egg-to-smolt survival rates, and the reversal of upward trend in substrate fines may indicate that range management strategies within the drainage are achieving goals for long-term chinook salmon habitat recovery. However, continued monitoring will be needed to ensure that these trends are real.

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EFFECTS OF FIRE AND GRAZING ON WATER QUALITY

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Abstract: Fire and grazing impact watershed function and therefore water quality to the degree that they impact soils via vegetation. Fire and grazing are negative or positive to the extent that (1) mineral soil is exposed to erosion, (2) temperature changes are induced that create hydrophobic soils and depress (or stimulate) nutrient cycling in mycorrhizae, and (3) plant community changes are encouraged (or discouraged). Fire and grazing can be used as tools to enhance watershed health if they encourage the nutrient cycling and infiltration of precipitation necessary for sustaining soils.

Key words: fire, grazing, water quality, watersheds.

Watershed management becomes a question of functioning soils. The crux of watershed management boils down to "the soils' ability to capture, hold, and beneficially release precipitation" (Barrett as quoted in Bedell 1993:1). These functions are influenced by a wide variety of factors including slope, soil texture, soil structure, antecedent moisture conditions, and vegetation and organics present (Satterlund and Adams 1992). Of these, a land manager has direct control over the vegetation and organics through her or his vegetation management practice(s). Thus, watershed management and its resultant feature, water quality, are functions of vegetation management.

The relationship of fire and grazing on water quality becomes, in reality, a question of vegetation response.

Bare Ground

Bare ground is probably the single most important feature over which a land manager has some level of control:

- ◆ Has fire or herbivory increased the aerial extent of unprotected soil?
- ◆ What are the patterns of exposed soil surfaces (large blocks, isolated fingers, pitchy, discontinuous openings)?
- ◆ Where are these openings located relative to aspect, slope, soil type, and riparian zones?

Obviously, size, continuity and location of bare ground play an important role in the amount of erosion and overland transport of nutrients and minerals.

Temperature

Temperatures at the earth's surface play extremely important roles in determining the degree to which a soil surface becomes hydrophobic to infiltrating precipitation and in determining the degree to which mycorrhizae are able to function in nutrient cycling. DeByle and Packer (1972) report that coarse grained soils tend to become more hydrophobic following fire than do finer grained soils and that temperatures in the following ranges tend to create the following responses: <300° F, no change in infiltration rate;

300°–900° F, problems develop with soil wettability; >600°–≥900° F, infiltration rate will approximate that of mineral soil.

Apparently this is caused by 2 physical responses: (1) redistribution of organic waxes and cutins from the vegetation structure to the soil surface, forming a restricting layer; and (2) redistribution of chemical and biochemical lattices of the subsurface organics and colloids (depending on temperature these are unaffected, radically changed, or totally consumed).

In addition to temperature, changes associated with fire temperature or herbivory will change the amount of biomass at the soil surface and therefore affect the amount of incoming solar radiation at that site. Eddleman (pers. commun., Dep. Rangeland Resour., Oreg. State Univ., Corvallis) has measured temperature differences of 50° F at the soil surface between bare and shaded sites. Because mycorrhizal function is temperature and moisture related, the hotter, drier direct sunlight sites cycle nutrients slowly, if at all.

Nutrient Cycling

DeByle and Packer (1972) indicated that wildfires in forested Montana sites would redistribute such that calcium, phosphorous, sodium, and potassium accumulated in the ash following fire. Nitrogen, however, apparently was volatilized by the heat and significant amounts were lost to the system. Overall, they estimated that the nutrients released from the biomass to the soil surface represented the equivalent of 12 pounds/acre of a general purpose fertilizer.

Carlson et al. (1994) studied sheep grazing and suggested that a positive value of herbivory was the redistribution of nitrogen, phosphorous, and other "fertilizer" elements back on-site in the form of feces and urine.

These redistributions of plant-growth elements are positive if they can be recaptured on-site for renewed vegetation production. They are negative if they are eroded from the site, causing a loss of production on-site and the potential for nutrient enriched waters (eutrophication) off-site.

Bacteria

Larsen et al. (1994) demonstrated that livestock feces were unlikely to enter the stream if they were deposited more than a few decimeters from the water column. Sherer et al. (1988) and Briskie et al. (1988) showed that bacteria reaching the water column tended to settle rapidly to the sediments at the bottom and survived approximately 6 weeks.

Plant Community Structure

Through herbivory and fire, composition changes in plant communities are possible. Noxious, weedy, or unproductive sites can be altered through vegetation removal associated with each mechanism. Depending on season of vegetation removal, growing conditions, seed stock(s) remaining, and managerial input, these changes can encourage or discourage any given plant community.

MANAGEMENT IMPLICATIONS

Fire or grazing can be positive or negative in terms of water quality. The conditions under which grazing and burning occur influence the amount of bare ground that is created and subjected to erosion, the amount of infiltration or repellence that precipitation encounters, the degree to which nutrients are redistributed on- and off-site, the rate at which nutrient cycling occurs, the level of sedimentation that is experienced, and the amount of bacteria that may become waterborne.

Herbivory and fire, if used indiscriminently, will change plant communities to the detriment of uplands and riparian zones. However, if they are used under careful managerial prescription, they can serve as tools to enhance those plant communities that will improve water quality. The key lies in

understanding the soil-vegetation-infiltration relationships that these land uses affect. Properly used, they are powerful instruments for sustainable, functioning watersheds.

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MANAGEMENT CONSIDERATIONS FOR WETLAND BIRDS IN WESTERN RANGELANDS

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Abstract: Wetland birds have a variety of requisites that can be influenced by grazing, haying, or fire. Grazing, haying, or prescribed burning of wetlands within rangeland ecosystems can be managed to provide for certain needs of wetland birds. The availability of green browse for birds can be enhanced by grazing, haying, or fire. These tools remove cover and allow solar radiation to warm soil and promote fast early plant growth. Shorebirds generally prefer open, short-grass vegetation as nesting habitat. This habitat can be enhanced by grazing, haying, or burning. Grazing, haying, or burning can be detrimental to species such as ducks that rely on dense cover to hide their nests from predators, and to species that rely on dense structure of vegetation for cover. Fire can destroy nests and eliminate cover. Livestock in wetlands during the nesting season can cause nest abandonment and occasionally trample nests or young. Early mowing of meadows can result in mortality of young birds. These conflicts can be minimized by (1) avoiding use of these tools in sensitive habitats, (2) considering wildlife needs in planning wetland management, and (3) proper timing in application of livestock grazing, haying, or prescribed burning to avoid conflicts with wetland birds.

Key words: fire, haying, livestock grazing, sandhill cranes, shorebirds, waterfowl, wetland birds.

Managers of private and public wetland vegetation within western rangelands should consider the requisites of wildlife in management decisions. Whereas livestock grazing, haying, and burning can enhance habitat to meet requirements of some wildlife, these practices can be detrimental to other wildlife.

Removal of meadow vegetation, using fire, livestock grazing, or haying can be beneficial to migrating and breeding ducks and geese, sandhill cranes (*Grus canadensis*), and shorebirds if these "treated" areas are subsequently flooded during early spring. These treatments result in increased solar radiation to the ground surface, earlier thawing of frozen soils, and earlier growth of plants and availability of soil and aquatic invertebrates. New green plant growth and invertebrates provide high-protein foods needed by birds to prepare for the energy demands of breeding, egg-laying, and nesting, and these areas receive extensive use by waterbirds. Shorebirds prefer open, sparsely vegetated areas for nesting, and treatment of meadow vegetation results in attractive nesting habitats for this group of birds.

Removal of vegetative cover by grazing, haying, or fire can be detrimental to wildlife that depend on cover to hide nests from predators, and to provide shelter from severe weather. Early nesting ducks rely on residual cover from the previous year's growth because they initiate nesting before new plant growth begins. The presence of livestock in wetlands during the nesting season can cause nest abandonment and result in trampling of nests and young birds.

SANDHILL CRANES

Based on data collected at Malheur National Wildlife Refuge in Oregon, sandhill crane nest initiation ranged from 16 March to 30 May (average 17 Apr); crane eggs hatched from 19 April to 4 July (average 20 May); and young cranes fledged from 27 June to 11 September (average 29 Jul).

Sandhill cranes require approximately 70 days after hatching to reach flight stage. During this time, young cranes are particularly vulnerable to predators. Young cranes also are vulnerable to meadow mowing equipment because they hide in vegetation when threatened, and remain hidden until killed by mowers. Livestock grazing causes some losses of both nests and young because of nest abandonment and trampling of young (Littlefield 1989); winter livestock grazing can reduce nesting success by eliminating residual nesting cover (Littlefield and Paullin 1990).

One management action that can be particularly disruptive to cranes is early season mowing by ranchers as part of their hay operations. Early dewatering to facilitate haying programs reduces the quality and quantity of moist meadow feeding areas, causing cranes to move to wetter sites. These forced brood movements stress crane colts and cause increased mortality because of predation, intraspecific aggression, fence entanglements, collision with vehicles, and other accidents. Actual mowing activity disrupts normal feeding and movement patterns while also posing a direct mortality threat. Finally, mowing attracts predators, particularly coyotes (*Canis latrans*), which move into mowed fields where hunting for small rodents is good. Crane chicks commonly "disappear" shortly after mowing begins and we believe many of these are killed by coyotes attracted to mowed areas.

The standard mowing date established on Malheur Refuge is 10 August. This date was established to protect young sandhill cranes. Mowing is further delayed in fields that are known to contain unfledged crane colts.

DUCKS

Clark (1977) studied duck nesting in the Blitzen Valley of Malheur Refuge and found the density of residual cover (idle) to be the most important characteristic of nest sites as the nesting season began. Refuge fields with residual cover supported greater duck nest densities, greater nest success, and more ducklings hatched than fields that were hayed, or hayed and grazed (Clark 1977, Ivey 1979, Jarvis 1980). Nest studies conducted on the refuge (Clark 1977, Ivey 1979, Foster 1985, and Paullin 1989), have shown that duck nest densities were consistently greatest in idle vegetation. Densities in idle vegetation were 2–3 times greater than in treated vegetation.

Three common ducks nesting in intermountain wetlands include mallards (*Anas platyrhynchos*), gadwalls (*A. strepera*), and cinnamon teal (*A. discors*).

Mallards nest very early in tall residual upland, marsh, or meadow vegetation, and are flexible in their choice of nest sites. Mallard nest initiation has ranged from 29 March to 22 June (average 10 May) at Malheur Refuge. Nests hatched from 5 May to 29 July (average 16 Jun), and broods fledged from 29 June to 22 September (average 10 Aug).

Cinnamon teal initiated nesting from 10 April to 3 July (average 20 May). Nests hatched from 11 May to 3 August (average 20 Jun), and broods fledged from 25 June to 17 September (average 4 Aug). Cinnamon teal prefer mid-height meadow vegetation in drier sites for nesting.

Gadwalls are a late-nesting species, with nest initiation ranging from 30 April to 14 July (average 1 Jun). Their nests hatched from 5 June to 19 August (average 7 Jul), and broods fledged from 26 July to 9 October (average 27 Aug). Gadwalls select tall cover and often select new growth of forbs as nesting substrate.

OTHER BIRDS

A large variety of other birds such as owls and hawks, shorebirds, and several species of marsh birds also nest within wet meadow habitats. Most of these species begin nesting in May and broods are mostly fledged by late July.

MANAGEMENT CONSIDERATIONS

Barbed-wire fences used to control livestock kill many birds annually (Allen 1990). Fences in grasslands and wetlands are the biggest problems, especially where they cross watercourses, ponds, and other wetlands. To reduce mortality, fences could be modified by providing a smooth wire on top and could be flagged where they cross water for better visibility for the birds. On private wetlands, ranchers

often begin cutting meadows in mid-June. To facilitate haying, these areas must be dewatered about 2 weeks before haying can commence. Generally, birds nesting on floating platforms over-water will abandon their nests if the water is removed. Dewatering also forces broods to move farther distances to water, resulting in lower brood survival. In mid-June, many nests have yet to hatch, and birds, their nests, and their broods are vulnerable to destruction by mowers. Mowing enhances feeding opportunities for raptors and other predators and attracts hawks, owls, and coyotes to the area. Young birds that escape the mowers are often killed by predators.

If more permanent wetlands could be constructed and managed near private hay fields, brood survival would likely increase and many birds would be attracted away from hay fields before mowing. In general, a 25 July hay date would allow most birds to reach fledging stage.

Agencies should work together to develop incentives for ranchers to delay haying on important wetlands and to provide good nesting cover and brood habitat for wetland birds where possible. The U.S. Fish and Wildlife Service's "Partners for Wildlife" could perhaps facilitate this program.

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GRAZING MANAGEMENT STRATEGIES FOR LAHONTAN CUTTHROAT TROUT STREAM HABITATS

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Abstract: The Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) is the native trout of the Lahontan Basin. The subspecies currently occurs in 155 streams with approximately 771 km of occupied habitat, and is present on >100 livestock-use allotments. Most remaining populations exist in small, desert, mountain headwater streams. Livestock grazing has been an active part of western rangelands in the Great Basin for nearly 150 years. Research has documented the detrimental effects of improper livestock grazing on riparian and associated stream habitats. Riparian and stream habitats are considered the most threatened habitats in the Great Basin. Research has also shown that riparian habitat degradation is generally insignificant if use is $\leq 25\%$ and has also concluded that good or excellent riparian conditions were maintained by grazing systems that removed hot season grazing by livestock. Riparian vegetation controls streambank stability, offers shade and cover from predators, provides sources of terrestrial food for fish, and helps moderate water temperatures and improve water quality. For Lahontan cutthroat trout habitat enhancement, we recommend the streamside management zone and riparian areas be in good to excellent condition and the stream and fish populations be sustained. Intensive management of livestock is necessary to adequately enhance and protect fragile desert riparian areas.

Key words: Lahontan Basin, Lahontan cutthroat trout, livestock grazing, livestock-use allotments, *Oncorhynchus clarki henshawi*, riparian, streamside management zone.

Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) is the native trout of the Lahontan Basin of northern Nevada, eastern California, and southern Oregon. The subspecies was once widespread throughout the Lahontan Basin and was associated with Pleistocene Lake Lahontan that covered about 22,100 km² and had a 117,000-km² drainage area (LaRivers 1962). In 1844 there were 11 known lacustrine populations and 400–600 fluvial populations in >5,760 km of streams (Gerstung 1988).

Lahontan cutthroat trout currently occur in 155 streams with approximately 771 km of occupied habitat. In addition, 2 small, indigenous lake populations occur in Summit and Independence lakes, Nevada. A number of lakes have populations maintained by hatchery planting and are used as recreational fisheries. Currently, self-sustaining populations occur in 10.7% of the historical stream habitat, and 0.4% of the historical lake habitat. The subspecies was listed by the U.S. Fish and Wildlife Service as endangered in 1970 and subsequently reclassified as threatened in 1975. The subspecies has no designated critical habitat. Most populations exist in small headwater streams, disjunct from other populations and remnants of a much wider distribution. In many habitats, if a population goes extinct, there is no potential for re-establishment of the population by natural means.

Livestock grazing has been an active part of western rangelands in the Great Basin for nearly 150 years. In the past, federal land management agencies generally considered the riparian area a sacrifice area, impossible to manage because of its small size compared to general rangeland. Many livestock concentrated in the riparian areas along small desert streams because of green, succulent forage, shade, water, more level topography, and a unique microclimate. Even after rangelands began to improve in recent decades,

the condition of riparian areas still declined. Even though riparian areas represent a small proportion of total rangelands, they provide $\geq 80\%$ of the vegetation consumed by livestock in many allotments because they are such preferred grazing areas. Most traditional grazing systems developed for uplands do not accommodate riparian recovery (Myers 1989). According to Minshall et al. (1989), riparian and stream habitats are the most threatened habitats in the Great Basin.

But as their significance and value have become better understood, their management has started to improve. Only recently have riparian areas been given full credit for their ability to control water yield, peak stream discharge, storm-flow runoff, and water quality. Studies have shown that grazing intensity causes soil compaction, changes in vegetation structure, accelerated soil erosion from increased runoff, and consequently alters the habitat for fish and invertebrate populations. Heavily grazed Great Basin streams are generally wide and shallow, with unstable, partially vegetated streambanks; they lack quality pools and have seasonally elevated water temperatures, where water temperatures may fluctuate 19.4°C or more in a 24-hour period during the hottest part of the summer. Many of these streams also become intermittent during the summer. Many studies have now documented improvement in fish populations after changes in livestock use patterns in riparian areas. Research by Platts (1981) has shown that riparian habitat degradation is generally insignificant if use is $\leq 25\%$. Clary and Webster (1989) stated that riparian area grazing should be avoided during mid- and late summer. Myers (1989) provided several recommendations that should be considered in managing graz-

ing on stream riparian sites including restricting hot season use, duration of grazing, growing season rest, and strict compliance with grazing plans.

Most land use managers now recognize the problems associated with riparian grazing practices, and what constitutes a riparian area in good condition. The challenge is in determining what grazing system is compatible with good riparian objectives and is still feasible for agencies and livestock permittees. Problems associated with most grazing systems include the concentration of livestock at favored locations (riparian areas, springs, aspen (*Populus tremuloides*) stands, and meadows), and overuse and trampling of more desirable plant species. None of the more common grazing systems (season-long or continuous grazing, deferred-rotation grazing, and rest-rotation grazing) seem suitable for riparian systems without additional grazing management control practices. Modern grazing systems seek to improve livestock production while protecting range conditions. Resource managers also need to know how these grazing systems influence aquatic resources including coldwater fish and invertebrate populations. Skovlin (1981) concluded that conventional management strategies tailored to extensive range grazing for livestock production and forage maintenance did not achieve acceptable animal distribution in the highly preferred riparian zones.

GRAZING MANAGEMENT STRATEGIES

For Lahontan cutthroat trout habitat enhancement, we recommend the streamside management zone and riparian areas be in good to excellent condition. This includes intensive livestock management to assure that (1) desired key riparian plant community types or species (woody and herbaceous) are present, reproducing, and have high vigor; (2) cover of key species is $\geq 90\%$ of estimated potential; (3) soil productivity is not significantly reduced by compaction from estimated potential; and (4) streambank stability is restored to estimated potential condition (U.S. For. Serv. 1990). Riparian areas differ in their potential for response to changes in livestock use practices and in individual unique site factors (Myers 1989). Conservative standards are recommended as a baseline for establishing grazing management strategies for Lahontan cutthroat trout streams. These standards provide the best opportunity for recovery of this and other threatened aquatic species while still allowing livestock grazing.

- Maximum allowable use levels in riparian areas during the authorized grazing season should not exceed 20% of the annual growth of woody species and no more than 30% of the annual growth of other key riparian species.
- Stubble height of grasses and sedges should be >6 inches at the end of the authorized grazing season in riparian areas and streamside management zones (Myers 1989). Six-inch stubble height generally represents 24–

32% use (Clary and Webster 1989), although it may vary because of elevation, topography, soils, moisture, weather, and other factors.

- Limit streambank trampling or chiseling damage to 10%, as measured by the sum of both banks.
- Grazing plans should include some periods of rest during critical plant growth or regrowth. Myers (1989) recommends providing for residual vegetative cover either through regrowth or rest treatment during at least 75% of the years or annually, if possible.
- Livestock access to the stream should be prevented in those seasons and areas where grazing could damage important resources, such as trout spawning areas during the spawning season.
- Reduce the duration and intensity of grazing to the greatest extent possible. Low intensity grazing use averaging ≤ 28 days was more successful than longer grazing use systems. Season-long grazing should not be part of a riparian management strategy.
- Design grazing programs to take advantage of favorable seasonal livestock use dispersal behavior patterns. Hot season use should be extensively monitored and livestock herded away from riparian areas.
- Watersheds should be grazed at levels that permit the accumulation of litter and duff, and leave residual grass and other vegetation to slow and absorb runoff. No more than 50% use of annual growth is recommended to protect watershed values.
- Grazing use should be extensively monitored, and livestock removed when use levels are reached. Mid-season monitoring can assist in determining use patterns and when to remove livestock.
- Noncompliance with grazing plans and standards can be considered exceeding authorized take for a listed species such as Lahontan cutthroat trout.

In summary, by affecting the health and vigor of vegetation in riparian areas, poor grazing management practices can significantly damage aquatic ecosystems. Intensive management of livestock is necessary to adequately enhance and protect fragile riparian areas, and consequently enhance the status of threatened and endangered aquatic species. Because of their nature, riparian areas can attract livestock use and abuse.

MONITORING

Monitoring is an important tool in developing suitable riparian grazing strategies. Agencies need to complete 3 types of monitoring for effective management; implementation, effectiveness, and validation (U.S. For. Serv. 1992). Implementation monitoring provides a permanent record of what management was actually applied. It should be completed annually and should provide details such as stream and range improvements, natural events, date and number of animals grazing a pasture, herding reports, salt

locations, etc. Effectiveness monitoring annually records the applied management in relation to other important natural and anthropogenic events. It may include the effect of grazing on vegetation or streambanks as well as growing conditions, the occurrence of floods, fires, or anything that is likely to affect the attainment of the objectives. Validation monitoring determines if predictions and assumptions of applied management are appropriate to attain the desired objective. Validation monitoring often requires long-term data collection to establish an adequate data base and would be conducted to validate results of effectiveness monitoring. Interpretations for future management rely on a combination of implementation, effectiveness, and validation monitoring. The task of management planning is cyclic and never ending.

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STATUS AND RECOVERY OF SAGE AND SHARP-TAILED GROUSE IN OREGON

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Abstract: Sage grouse (*Centrocercus urophasianus*) populations declined in Oregon during the past 30 years apparently as a result of impaired productivity. Several sage grouse research projects have been conducted in Oregon and results identified key factors associated with productivity of sage grouse, including the amount and variety of native forbs and grasses available to females during the reproductive period (March through August). Succulent forbs are important foods for adult females and chicks during spring and summer and tall residual grass cover within sagebrush (*Artemisia* sp.) stands seems to enhance nest success. Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*) once ranged across the eastern two-thirds of Oregon. Their last reported sighting in Oregon was in Baker County in the late 1960s. Columbian sharp-tailed grouse were reintroduced into Oregon in Wallowa County in 1991. Sharp-tailed grouse habitat is characterized by rangelands with a diversity of native shrubs, forbs, and grasses. Key habitat components during winter include deciduous shrubs and riparian vegetation. Ecological factors associated with the decline of habitat quality for sage and sharp-tailed grouse include excessive grazing, exclusion of fire, and introduction of exotic plants. An ecosystem or landscape approach to management is required to enhance populations of both grouse species in Oregon.

Key words: cover, exotic plants, fire, forbs, grazing, sage grouse, sharp-tailed grouse.

SNAKE RIVER CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*) IN OREGON'S RANGELANDS

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Abstract: Fishery biologists have long advocated better management of riparian zones, especially to correct the impacts from livestock grazing. During the last few decades, some progress has been made in realizing this goal; significant progress, however, was elusive. The lack of progress was exemplified when Snake River salmon were listed under the Endangered Species Act, adding new requirements to protect salmon. Now each federal grazing allotment must show improvement to salmon populations or their habitat. Progress for some of the worst allotments will take time, as the riparian zones and badly silted streams begin to recover. However, it is possible to accelerate restorative actions, for instance, by planting riparian vegetation, stabilizing stream banks, improving water quality, and keeping cattle from trampling redds.

Key words: endangered species, livestock grazing, riparian management, Snake River.

MILKVETCHES, NOW AND FOREVER

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Abstract: Milkvetches are native legumes in the genus *Astragalus*. Some species are poisonous and have commonly been referred to as locoweeds. The name milkvetch refers to the more palatable and most prevalent members of this large genus, with >375 species (+122 varieties) in North America, many of them endemic and rare. Some species have a crude protein content higher than alfalfa. Many are "habitat endemic" species that are restricted to unique habitats or soil types. These species and their habitats will need special management protection to ensure their sustainability. The "geographic endemic" milkvetches occur in general rangeland habitats, but their distributions are limited geographically. These species may require only minor management modifications for continued sustainability. A third group is the "successional sensitive" species that occur in habitats maintained by disturbance, such as fire-dependent vegetation types. These species will continue to decline until fire and other ecological processes are returned to historical frequencies and intensities.

Key words: endemic, fire, grazing, habitat, management, milkvetches, rangeland.

THREATENED, ENDANGERED, AND SENSITIVE WILDLIFE SPECIES AFFECTED BY LIVESTOCK PRODUCTION

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Abstract: Because of the controversy about the effects of livestock production on semi-arid and arid ecosystems of the western United States, the impacts of livestock grazing and trampling, predator control, water diversion, conversion of habitat to pasture, fire suppression, and introduction of livestock diseases on special-status wildlife species were reviewed. One or more aspects of livestock production were found to be a primary or significant factor in the decline of 46 wildlife species in the West. Over half of these species were fish. Another 128 species were thought to be negatively impacted by livestock production. This identification of the wildlife species and groups most affected by livestock production can help guide management decisions and be useful in focusing future research priorities so that further impacts on special-status species can be minimized. Copies of this report and a computer disk containing the data base are available from the Audubon Society of Portland, 5151 N.W. Cornell Road, Portland, OR 97210.

Key words: endangered species, grazing, livestock.

UNGULATE RELATIONSHIPS ON RANGELANDS

LARGE HERBIVORE-VEGETATIVE FEEDBACK RELATIONS IN THE BLUE MOUNTAINS ECOREGION

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Abstract: We present a brief review of large herbivore-vegetative relationships under high ecological densities of herbivores, with emphasis on forest ecosystems in the Blue Mountains Ecoregion of northeastern Oregon and southeastern Washington. A large body of literature clearly indicates that wild and domestic herbivores have considerable influences on vegetative communities, and that density-dependent negative feedback relations often operate to regulate wild herbivore populations via nutritional pathways. A less extensive set of literature also suggests that herbivory, under high-intensity grazing, may reduce ecosystem productivity, sustainability, and biodiversity. In the Blue Mountains, growing evidence suggests herbivory by wild and domestic herbivores has altered species composition of plant communities that, in turn, may detrimentally affect ecosystem attributes and account for declining productivity of big game herds. Considerable research will be required to assess the magnitude of herbivory effects, identify the long-term implications, and identify appropriate management strategies to positively affect herbivory-vegetative interactions.

Key words: ecosystems, grazing, herbivory, nutrition, rangelands, vegetation.

Consensus is growing for support of integrated land management programs that ensure long-term maintenance of ecosystem productivity, biological diversity, and productive wild ungulate herds in managed forests. Identifying superior long-term management strategies requires detailed knowledge of production potential of forested sites and its relation to land use options including both silviculture and herbivory by large ungulates. While much effort has been expended to understand the importance of site potential and silviculture, ungulates have received relatively little scrutiny as potential determinants of long-term ecosystem structure and function.

Herein, we briefly review selected aspects of these topics, primarily the influences of ungulate herbivores on vegetation in forest ecosystems and negative feedback relationships that ultimately may influence productivity of wild herbivore populations. We also review information concerning vegetative-herbivore interactions in the Blue Mountains Ecoregion. Finally, we describe current and future research that will help clarify interactive relations among herbivore populations, vegetative conditions, and ecosystem structure and processes.

HERBIVORY EFFECTS ON VEGETATION

The literature clearly indicates that large vertebrate herbivores significantly influence vegetative structure, diver-

sity, and productivity (Putman 1986). Substantial detrimental effects of vertebrate herbivory on plant communities typically are attributed to high stocking rates of domestic livestock. Although less recognized, the detrimental effects of herbivory by wild ungulates at high densities also is well documented (e.g., Rasmussen 1941, Stoeckler et al. 1957, Curtis and Rushmore 1958, Beals et al. 1960, Pimlott 1965, Tierson et al. 1966, Caughley 1970, Ross et al. 1970, Griffin 1976, Snyder and Janke 1976, Anderson and Loucks 1979, Bobek et al. 1979, Dzieciolowski 1980, Stevens 1980, Marquis 1981, Horsley and Marquis 1983, Frelich and Lorimer 1985, Austin et al. 1986, Kroll et al. 1986, Rose and Platt 1987, Stewart et al. 1987, Alverson et al. 1988, Reuss and McNaughton 1988, Mark 1989, Pastor et al. 1988, Stewart and Burrows 1989, Tilghman 1989, Brandner et al. 1990, Strole and Anderson 1992, Anderson and Katz 1993, Milchunas and Lauenroth 1993, Kay 1994).

Most of these papers document compositional changes in plant communities, but generally leave unanswered questions about how herbivory affects ecosystem productivity, sustainability, biodiversity, and successional trajectories. The relationship between herbivory and ecosystem structure and function is a relatively new topic of research (Briske and Heitschmidt 1991). Evidence supports hypotheses that herbivory of sufficient intensity to significantly alter composition of plants may exert various other effects: reduced soil

fertility (Pastor et al. 1988, Archer and Smeins 1991) and size of nutrient pools (Tiedemann and Berndt 1972, Pastor et al. 1988, Archer and Smeins 1991), reduced abundance of underground fauna important for recycling nutrients (Pastor et al. 1988), reduced vegetative productivity (Putman 1986) including growth rates of trees (Weigand et al. 1993), reduced reproduction of above-ground flora (Allison 1990, Kay 1994), reduced floral (Archer and Smeins 1991) and faunal diversity (Putman 1986), and perhaps reduced potential of ecosystems to recover from the effects of long-term herbivory.

Evidence for herbivory effects in the Blue Mountains of northeastern Oregon and southeastern Washington comes from 7 large-herbivore exclosures constructed 25–56 years ago. At every known exclosure located in forested ecosystems in the Blue Mountains, shrubs increased moderately to dramatically after the exclosures were erected, suggesting substantial influences of herbivores on understory vegetative composition (Irwin et al. 1994). Edgerton (1987) reported that shrub cover increased 4-fold in an exclosure after clearcutting in a grand fir (*Abies grandis*) community in the Blue Mountains, but remained relatively constant outside the exclosure during an 11-year period. These changes apparently occurred in the *absence* of livestock grazing. Krueger and Winward (1974, 1976) reported 18 and 1.4 times greater cover of shrubs inside exclosures than outside, 12–14 years after excluding herbivores, the former in a mature Douglas-fir (*Pseudotsuga menziesii*)–ponderosa pine (*Pinus ponderosa*) community and the latter in a selectively cut grand fir community. Tiedemann and Berndt (1972) reported that cover of shrubs averaged 5 times higher inside than outside an exclosure after clearcutting in a ponderosa pine–Douglas-fir community near Wenatchee, Washington. Studies of herbivory effects on soil nutrient dynamics and site productivity in interior northwest forests are limited to Tiedemann and Berndt (1972). These authors found that organic matter on the forest floor and standing biomass of shrubs were greater where large ungulate herbivory was excluded, suggesting substantially greater nutrient pools inside the exclosure, but soil fertility was similar between treatments.

VEGETATIVE FEEDBACK EFFECTS ON HERBIVORE POPULATIONS

Current theory holds that populations of many species of large wild herbivores are regulated through density-dependent negative feedback relations between animals and vegetation, particularly in the absence of abundant large predators. Such negative feedback relationships comprise the primary theoretical basis linking herbivore productivity to herbivore density and vegetative conditions (Caughley 1979; Fowler 1981, 1987; Caughley and Krebs 1983; Sinclair et al. 1985; McCullough 1984), and the literature is replete with empirical examples (e.g., Klein 1968; Caughley 1970; Geist 1971; Guinness et al. 1978; Albon et al. 1983; Sauer and Boyce 1983; Sinclair et al. 1985; Skogland 1985, 1986,

1990; Houston and Stevens 1988; Clutton-Brock et al. 1987, 1988; Messier 1991; Kojola and Helle 1993). As animal densities approach ecological carrying capacity, inter- and intraspecific competition increases and nutrient intake of herbivores declines. Concomitant alterations of vegetative composition caused by selective feeding on palatable forage species can further reduce nutrient consumption. Regulation of herbivore populations primarily results from nutritional effects on birth rates and juvenile survival, ultimately reducing recruitment of juveniles into the population.

Population size and dynamics of big game herds in northeastern Oregon during the last half-century are consistent with classic density-dependent patterns of population fluctuations (Caughley 1979). Big game herds were severely depleted in the late 1800s. Since then, Rocky Mountain elk (*Cervus elaphus nelsoni*) and mule deer (*Odocoileus hemionus*) populations rebounded dramatically. Deer numbers increased to about 60,000 animals in the 1960s but declined by about half since then on the Wallowa-Whitman National Forest in northeastern Oregon (Schommer 1991a). Fawn recruitment (post-winter fawn:doe ratios) since the late 1960s has been variable, low, and generally has declined (Schommer 1991a). Elk increased from several hundred animals in the 1920s to an estimated 60,000 in eastern Oregon by the early 1980s (Bryant and Maser 1982). Elk herds have been roughly stable since then, in part because of increasing harvest of cows. Since the 1950s, when annual surveys were initiated, recruitment of elk calves declined steadily by about 50%, from 60–70 calves/100 cows in the mid-1950s to 30–40 in the late 1980s (Irwin et al. 1994). Additional evidence indicates birth dates of calves tend to be late and birth weights low in the Blue Mountains (Cook et al. 1994), suggesting nutritional influences that might predispose juveniles to mortality.

DISCUSSION

Evidence of the influence of herbivory on plant communities in the Blue Mountains forest ecosystems is limited to a small number of large-herbivore exclosures. How well the data from this small sample represent the effects of herbivory across the Blue Mountains is unknown. In all instances where exclosures have been constructed, however, marked increases in shrub cover have resulted. Data from the exclosures also indicate that herbivory effects are not restricted to specific silvicultural treatments because vegetative responses have occurred following construction of exclosures in unharvested, selectively harvested, and clearcut forest communities. Findings from these exclosures are consistent with predictions of the large body of literature dealing with herbivory-vegetation relations. Thus it is prudent to assume that results from the extant exclosure studies are probably representative of herbivore influences across the Blue Mountains, although further research will be required to produce definitive conclusions.

Implications of herbivory for ecosystem function in the Blue Mountains is unknown. Exclosure studies generally have addressed only changes in species composition, but such changes do not necessarily reduce biodiversity and ecosystem productivity and sustainability. Specific functional responses of ecosystems to herbivory across landscapes are difficult to predict, because these responses are highly dependent on grazing intensity and other biotic and abiotic factors (Archer and Smeins 1991, Briske and Heitschmidt 1991).

Increases in population size of big game herds in the Blue Mountains followed by declines in population productivity and declines in numbers of deer, combined with evidence of herbivore-driven changes in plant communities, are consistent with predictions of density-dependence theory. If density-dependence is in fact responsible for declining productivity, then tradeoffs likely exist between herbivore numbers, productivity of herbivore herds, and vegetative characteristics that present various options for management (Caughley 1979, McCullough 1984). Declining productivity of big game herds, however, may be caused by other factors. The low ratios of mature bulls:cows (1–6 bulls/100 cows [Schommer 1991b]) may be responsible for delayed and extended parturition in elk (B. Johnson, Oreg. Dep. of Fish and Wildlife, unpubl. data), and may explain to some extent the declines in calf recruitment. Inadequate forage quality after mid-summer (Skovlin 1962, Berry 1982, Irwin et al. 1994) may compound the effects of late parturition on calf survival (Guinness et al. 1978, Clutton-Brock et al. 1987). Increased human access and reduced cover as timber harvesting activities spread to remote, unharvested areas also have been blamed (Schommer 1991b). Finally, predation, particularly by black bears (*Ursus americana*) and cougars (*Felis concolor*), may be increasing because of reductions in predator control during the last 2 decades. Bears under certain conditions are effective predators of juvenile ruminants (Schlegel 1976). Clearly, inadequate information currently precludes reliable sifting and ranking of hypothetical causes of declines in big game productivity.

Considerable research is required to fully articulate the mechanisms and consequences of herbivore-vegetative relationships in the Blue Mountains. Currently, (1) vegetative composition data are being collected and analyzed for all known herbivore exclosures in the Blue Mountains, (2) effects of herbivory on nutrient pools and soil fertility are being assessed, and (3) foraging trials are being conducted at the exclosures to assess the tenet that nutrition may be contributing to reduced productivity of elk herds. In addition, however, studies are required that will (1) create additional exclosures to better assess the magnitude and geographic extent of herbivore effects on vegetation across the Blue Mountains; (2) examine how silvicultural options and herbivory regimes interact to affect the productivity and successional pathways of forest communities and other ecosystem properties; and (3) articulate the interrelationships of birth date, nutrition, predation, and other factors on productivity of ungulate herds in the Blue Mountains Ecoregion. The Pacific Northwest Research Station of the U.S. Forest

Service, Boise Cascade Corporation, National Council of the Paper Industry for Air and Stream Improvement, Eastern Oregon Agriculture Experiment Station, and the Oregon Department of Fish and Wildlife are cooperating on these research efforts.

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MANAGING UNGULATES TO ALLOW RECOVERY OF RIPARIAN VEGETATION

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Abstract: The literature evaluating grazing of large ungulates and sustainability of riparian systems is largely case history and observationally based. This literature clarifies the site specificity of management influences on vegetation in riparian zones. It is clear that cattle can be managed to sustain riparian systems and that the reverse can also be true. Grazing strategies for livestock and big game can be effective when they integrate knowledge of animal behavior, forage palatability, plant responses to grazing, plant community responses, hydrology, and practicality. Grazing strategies developed on principles in the above areas can be integrated into social and ecological needs to accomplish ecosystem management. A protocol to meet all legal obligations for public and private land in a coordinated resource management framework is described.

Key words: ecosystem, grazing, livestock, management, plant physiology, riparian, ungulates.

A review of >1,000 riparian-focused publications yielded 90 that were related to management of ungulates with emphasis on riparian vegetation. This literature, specifically relating large ungulates to riparian vegetation, is largely based on documented case histories or observation and comment. Some have data and about a third are largely observational; <5% are experimentally based, i.e., replicated and statistically valid, without pseudoreplication. The experimentally based papers, though well replicated and statistically valid, usually lack pretreatment data and cover short time frames, <4 years. They are mostly specific and deal with fine detail. They do not always come to the same conclusions. For example, Schultz and Leininger (1990) reported density of willows (*Salix* spp.) was unaffected by grass competition whereas Billig (1992) found that grass significantly impacted density of willows.

The case history literature is heavily oriented to the relationship of cattle to riparian vegetation. The results are highly varied and difficult to synthesize for generalizations. The difficulty in interpretation results from the following problems. The specific grazing influence often is described as grazed versus ungrazed or described so vaguely I cannot get a very clear idea of the grazing practices being reported. Frequently the report is based on an enclosure set up for a different purpose than evaluating relationships of grazing on riparian vegetation. There is a tendency in the literature to report on enclosures that were installed to protect a stream reach from abusive grazing practices. These yield benefits to riparian systems but only explain the obvious, that riparian zones are resilient and usually recover rapidly when an abusive practice ends. Finally, the historical land use practices are almost never explained. Historical use can have a great bearing on status and potential of riparian zones. Even though riparian zones are resilient and recover rapidly, there can be long-term impacts from engineering practices, veg-

etation control, and other practices. Understanding the history is as important to understanding current conditions as is understanding current ungulate grazing practices.

Even with the conflicting results associated with this varied literature base, a few broad generalizations are reasonable. It is clear that livestock or big game can and do coexist within sustainable riparian systems. Likewise, ungulates can and do change riparian vegetation structure in undesirable ways. Vegetation responses are highly site specific. Consequently, every grazing strategy won't work somewhere. There is no formula or template that can be used to guarantee success. Ecosystems are highly variable in time and space. Most driving forces that change ecosystems seem to result from interactions of factors. Determining a grazing strategy needs to be based on this point. The obvious and simple relationships can be relatively unimportant in directing long-term changes. A careful evaluation of the riparian zone potential, the forces (interacting factors) that will direct change, what the desired vegetation complex should be, and how ungulates can fit into the system can be a foundation to develop a practical grazing prescription that will work.

DEVELOPING A GRAZING STRATEGY

Based on the understanding that riparian zones and their associated uplands are varied and the inherent site specificity is a key in riparian zone response, it is reasonable to conclude that any set grazing system will have limited utility. Rather, a grazing prescription based on site potential and clear objectives is necessary. By understanding the nuances of specific watersheds, in specific settings, during specific weather patterns, with specific livestock or big game herds, and involving specific people, a program with a high degree of potential for success can be developed. The nature of this will be a form of adaptive management that is frequently described as an effective concept to achieve ecosystem management on public lands.

A grazing strategy should consciously incorporate:

- ♦ animal behavior
- ♦ forage palatability
- ♦ plant responses
- ♦ plant community change
- ♦ hydrology
- ♦ practicality

I will discuss each of these factors in the context of vegetation management and grazing. Beyond the specifics of vegetation responses, an effective grazing strategy should also be placed in the context of an ecosystem and the totality of ecosystem response. This will include the relations of one animal to another, stream hydrology, and geomorphology, water quality, landscape interactions (scale in time and space), and others. An ecosystem management strategy should include ecosystem structure, function, and social needs. An ungulate grazing strategy needs to include all of these aspects as well. This paper is by design focused on vegetation responses and is incomplete as a guide to develop an ecosystem focused grazing plan.

Animal Behavior

In dealing with animal behavior we need to recognize that it is difficult to force an animal to perform contrary to natural preferences and instincts. A knowledge of the behavioral tendencies of large ungulates can help us learn to direct their actions. We can design grazing programs that attract animals to specific areas at specific times to encourage grazing patterns that yield a desirable response of the vegetation.

For example, we know that there are distinct seasonal differences in the way livestock will graze riparian zones. Early in the grazing season cattle disperse more easily than later in the season. Consequently, early turnout will reduce the need to protect some riparian zones from cattle, because the cattle will not be attracted to the riparian zone. Conversely, if the pasture needs to be grazed during the season when the riparian zone is attractive, then specific management practices may be necessary to avoid excessive cattle use in the riparian zone. A simple matter such as turn on date can bring about major positive or negative responses of the vegetation.

Many riparian areas of concern are in forested areas. As these areas are logged there often is an erosion seeding made. Various grass species are used and all of them have some ability to control erosion. At the same time, most plant species have different palatability or attractiveness to cattle. For example, intermediate wheatgrass (*Agropyron intermedium*) is palatable early in the season but in the pine zone it becomes unpalatable by early summer, often as early as mid-June. Orchardgrass (*Dactylus glomerata*) is also used for erosion seedings and its palatability remains high through much of the summer. Selecting a plant species to seed can

attract or repel free-ranging animals depending on the season and maturity of the plant. This creates options to use practices like erosion control seedings to manipulate animal behavior. A similar scenario could be drawn for using fertilizer to make areas more attractive and concentrate cattle or big game use, perhaps reducing use of other areas.

Every year is different and the results of weather patterns are manifested in the vegetation. A drought can cause the growing season to be earlier and shorter. This, in turn, means animals will change their grazing patterns to reflect the drought. This may mean riparian zones will be most attractive much earlier in the grazing season and the dates of grazing may need adjustment. Beyond the indirect effect of drought on grazing behavior there may well be other considerations of the effect of the drought on functioning of the riparian zone. Will these changes affect the ability of the riparian zone to support cattle or big game grazing? Some degree of flexibility in specific practices is necessary to accommodate yearly weather differences.

The kind and background of animals is a consideration in anticipating behavior. Cows with calves are usually less mobile than yearlings and consequently set up different grazing patterns in a pasture. The experience of the cattle has a major influence on how they graze a given area. Cows set up home ranges much like big game and can be expected to stay in particular areas. Inexperienced cattle will have much less predictable behavior in a pasture when compared to cattle that traditionally use an area. The level of stress also contributes to animal behavior. It is often said that if you have good grass you don't need good fences. Keeping animals on sufficient quantity and quality of feed minimizes management difficulties.

Finally, we need to remember that in large forested or diverse pastures, animals naturally use only a small part of the pasture. Focusing management practices to encourage use of a larger area reduces the impacts of grazing in areas of preference. A major enhancement of riparian zone vegetation may be achieved by making the uplands more attractive to the grazing animal.

Forage Palatability

Forage palatability has a substantial influence on grazing behavior, as just reviewed. Palatability is a dynamic plant characteristic that changes throughout the annual plant growth cycle. Consequently, a knowledge of the relative palatability of plant species of concern is needed to develop management strategies that yield the desired result. There are generalizations that fit many situations, e.g., in riparian areas cattle don't browse woody plants if they have a sufficient supply of palatable grass. There are exceptions to most generalizations and refinements that necessitate knowledge of the specific situation being managed. Once specific grazing results are defined, it is usually possible to use knowledge of palatability to achieve the desired result from grazing.

Plant Responses

The most easily managed aspect of grazing is achieving the desired plant response after the animal behavior and palatability aspects of grazing are understood. The most important consideration is to have the animals graze a specific way in relation to the growing point (bud) of the plant. The growing point is the area of active meristematic tissue that differentiates each plant part. In grasses the growing point is close to the ground before the individual stems start to elongate to eventually support the seed head (Fig. 1). When a plant is grazed without removing the growing point, growth continues and there is little impact on seasonality of growth. The plant keeps growing and matures at about the same time as an ungrazed plant. If the growing point of a grass stem is elevated during elongation of the stem, and it is removed, the plant must activate a new bud and begin growth over for the year. This can defer growth for 2–3 weeks and results in a different growth form with different palatability. For forbs and shrubs the growing point is usually elevated and they respond more similarly to grazing or browsing as grasses that have elevated the growing point (Fig. 2).

Timing of grazing with respect to elevation of the growing point provides an effective tool to manage the annual growth cycle of grasses. Management of plant responses of grazed forbs and shrubs is primarily done to defer maturity, since a grazed or browsed forb or shrub will respond by activating a new bud and beginning the annual cycle later in the season. This will result in a leveling of nutrient supply over the season for animals that can use regrowth of the vegetation, since the regrowth from activated buds will be younger and more nutritious than that from ungrazed forages.

In riparian zones the soil moisture is more abundant than on uplands so limitation of regrowth is usually caused by temperature or other environmental factors. The opportunity to graze in various seasons and intensities is multifaceted and in this area opportunities to fine-tune results of grazing are only limited by degree of control of grazing animals.

Because forbs and shrubs usually have their growing point available to be grazed, it is much easier to reduce the vigor of these plants than for grasses with grazing. When the relation of grazing to the position of the growing point of the plants grazed is considered, the ability to manage plant responses is enhanced.

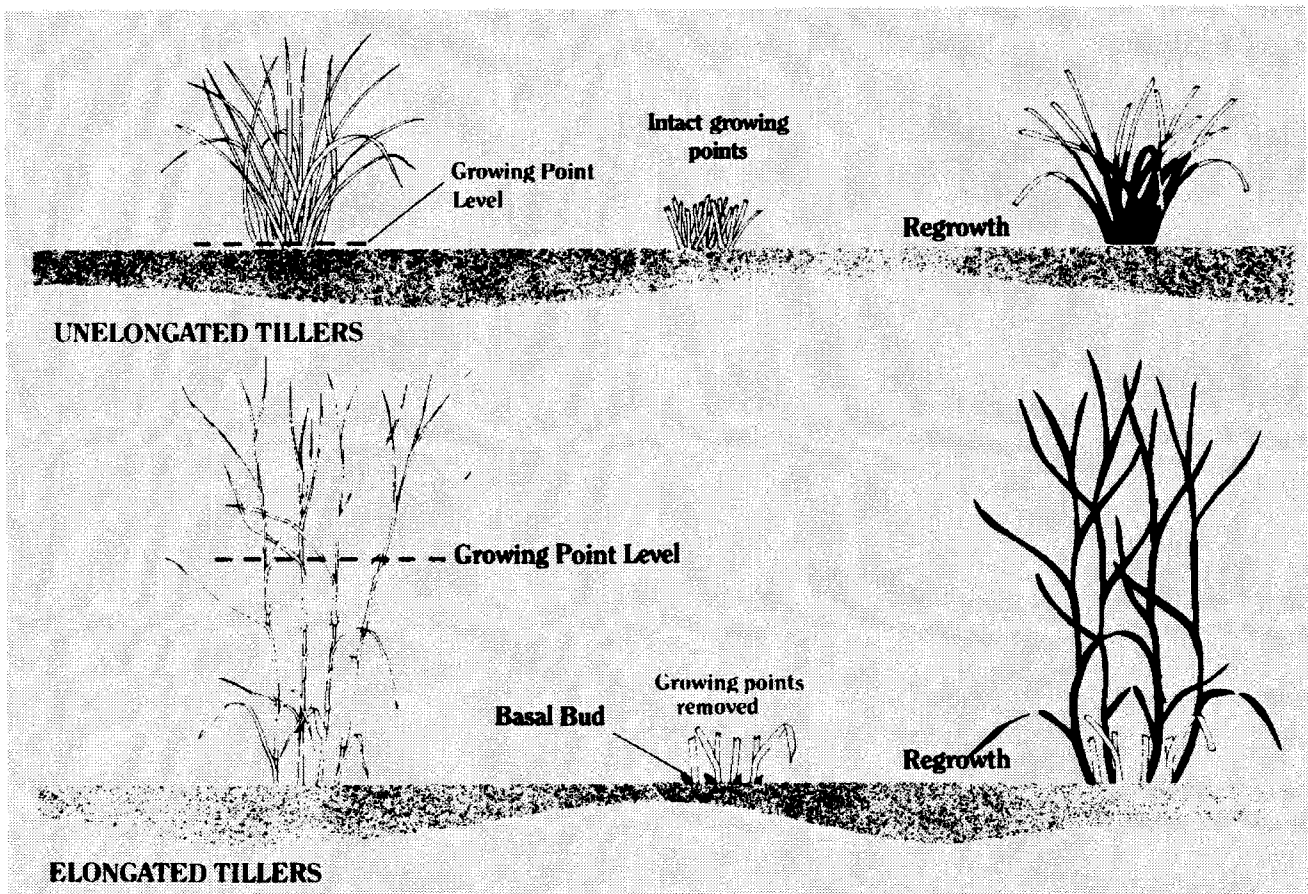


Fig. 1. Regrowth of grass from intact growing points compared to regrowth from basal buds (from Waller et al. 1985:12). Used with permission.

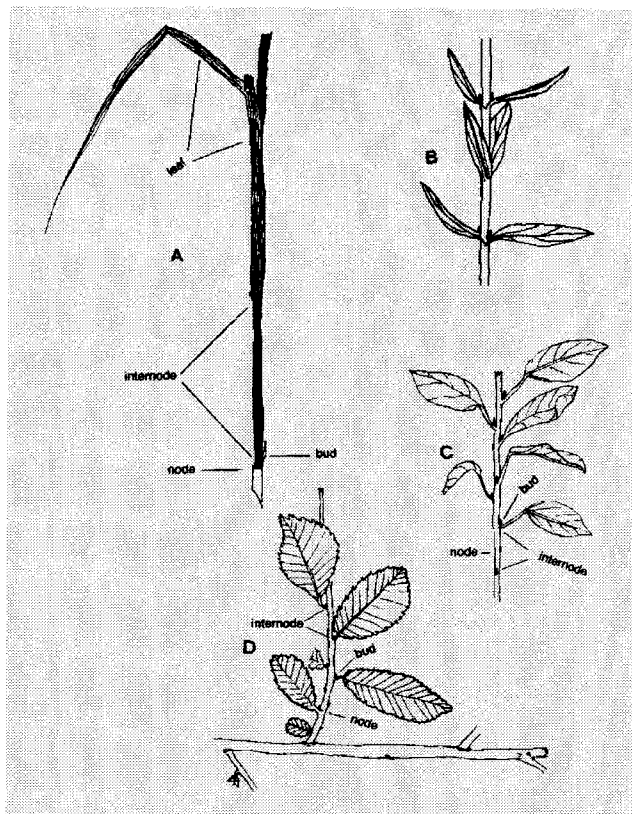


Fig. 2. Phytomers of (a) grass, (b and c) forbs, and (d) shrub illustrating the location of axillary buds (from Dahl and Hyder 1977:263). Used with permission.

Changes in Plant Communities

Riparian plant communities can change rapidly during the growing season. The rich soils and good moisture supply result in abundant and varied growth of different plant species. This coupled with strong year effects due to residual biomass and annual weather patterns creates an exceptionally diverse assemblage of vegetation. Because of this complexity and highly variable year differences, it will be difficult to direct or even understand plant community changes on a fine scale.

However, it is realistic to graze livestock in ways that favor woody vegetation or that reduce woody vegetation, depending on objectives. Management strategies can be designed to favor plants with inaccessible growing points over those with exposed growing points. The key is to develop a grazing strategy with emphasis on season of use to influence plant communities in desirable ways. Intensity of use or stocking intensity is far less important than season of use, within reasonable limits of intensity. However, even a relatively light intensity of use can profoundly affect shrub growth if the growing point is removed, so that the objectives for shrub growth cannot be met. This can be corrected by changing season of use for livestock. Big game animals provide a very difficult problem when they retard the shrub component of riparian plant communities, even with relatively low stocking densities.

Hydrology

Water and the hydrological forces associated with water are the driving forces for vegetation production and to some degree animal behavior in riparian zones. Water can affect vegetation directly by promoting and extending growth. When the soil profile fills with water, oxygen is displaced. These anaerobic soils support specially adapted vegetation and perform chemical processes much like a water treatment plant. This function of water purification often is touted as a critical function of riparian systems but there is little quantification of its ecological importance. To some degree the anaerobic nature of soils is a function of water supply and to some degree it is probably a function of management. Grazing semi-wet meadows can dry the system by reducing mulch layers and promoting growth of grasses over sedges (*Carex* spp.) and rushes (*Juncus* spp.). When this occurs, the ability of the soil to remove nitrogen and other pollutants is lessened. This is worth consideration in developing riparian grazing strategies though the total ecosystem impact of this kind of change needs clarification.

Hydrology has a major influence on seasonality of vegetation development as well as quantity and quality of riparian forages. This is expressed in large year effects that may require significant changes in grazing strategies to achieve ecosystem objectives. As channels move and hydrological forces change, the relation to management will likewise change. Meadows that become marshy require less attention than drier wet meadows because cows avoid wet areas when possible.

Practicality

Poverty is the worst enemy of conservation. Poor people usually severely damage the resources before they go broke. Consequently, in the final analysis, any management strategy has to be accomplished within the financial and skill limitations of ranchers, who ultimately have to make the grazing programs work, or wildlife managers as they work with big game herds. Ranchers must show a profit or they cannot conduct a grazing program. Wildlife managers are limited in their ability to control big game numbers and seasons of use for any particular area.

In grazing livestock, from a business sense, the rancher is essentially trading time for money. A grazing strategy that takes excessive time is just as impractical as one that takes excessive money to properly implement. A major factor is a consideration of risk. The lower the risk the more likely it is that a rancher will be able to successfully implement a program.

The essence of practicality is to focus on what will work. That is, fence only where fencing is needed to accomplish an objective; ride to move cows when they will go where you want them to go and graze pastures when the cows will direct vegetation change according to clear objectives. Consider the relationship of public and private land. In many cases the requirements of grazing public land forces specific grazing practices on private land. It doesn't make much

sense to force damage to a private riparian zone in order to protect a public riparian zone. There may well need to be changes in both areas. Grazing to enhance Kentucky bluegrass (*Poa pratensis*) will optimize livestock yield (Korpela 1992). Yet biodiversity goals may require a different complex of vegetation. Can we develop a grazing strategy for the typical blend of public and private land that works for everyone's needs? Or will we rigidly manage public lands for a species mix that will force reasonable private landowners to manage for Kentucky bluegrass pastures in private riparian zones?

ECOSYSTEM MANAGEMENT

Grazing management of livestock and management of big game as well are important components of ecosystem management. There are many other components of any ecosystem management plan. My view of an ecosystem management scenario focuses heavily on the people involved in designing the ecosystem management strategy. The first step is to determine a vision of success. When ecosystem management is successful, what will the landscape look like? What will it do in terms of ecosystem function, i.e., water quality, yield, nutrient cycling, and other aspects relating to sustainability? How will people benefit from management of the ecosystem? Will it produce healthy businesses, quality recreation, aesthetic pleasure, desirable fish and wildlife populations, etc.?

Once the vision is set, then specific objectives that will eventually result in attainment of the vision need to be defined. This needs to be clear and in the context of manageable units. Coordinated resource management (CRM) is an excellent process to define and accomplish ecosystem management objectives (Anderson and Baum 1988). CRM has been proven effective in setting, implementing, and monitoring livestock and wildlife habitat objectives. The process is readily adaptable to a multitude of land management practices.

The key is to define the objectives, implement management, monitor results of management, and adapt. The adaptations should be based on what is learned from monitoring to refocus management practices to more precisely achieve the objectives.

The Land Issues Forum (LIFE) in central Oregon developed an excellent process to implement a coordinated resource management planning protocol (Table 1). This process was based on several years of work and attempted to integrate public and private land use to meet the vision of various interest groups from commercial, to agency, to environmental. The protocol will help to design and implement complicated coordinated resource management plans in a

reasonable time frame. It meets all of the legal mandates of public and private agencies as well as resource needs of commodity and amenity users.

CONCLUSION

Developing a riparian management strategy for grazing animals is a necessary component of ecosystem management. It needs clear understanding of landscape relationships and should focus on sound grazing management principles. The specific and individualized characteristics of riparian zones need careful attention. When this is done with full involvement of the people affected by the management program, effective grazing programs can be developed. The keys to successful management are (1) develop the vision, (2) design management to the vision, and (3) emphasize communication and mutual understanding. Involvement of the people is key, since people will support what they create themselves.

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Table 1. The Land Issues Forum (LIFe) Coordinated Resource Management Planning Protocol.

WHEN	WHO	WHAT	PRODUCT
First month	LIFe	<p>SCOPING: Define the area of land, what got us here (basic issues), where do we want to be a year from now, draft landscape description and desired future condition, existing resources and issues to focus on, sideboards, goals and objectives, possible methods to reach goals, and objectives. (Possible field trip).</p> <p>SOLICIT PARTICIPATION: Identify people, skills, viewpoints, and groups that need to be represented.</p>	<p>First draft of project scope and plan of attack.</p> <p>Schedule for completion</p> <p>Work group definition by expertise and source.</p> <p>Mailing list</p> <p>Letter requesting comment and participation.</p>
Second month	LIFe	<p>FINALIZE LANDSCAPE DESCRIPTION: Bring new people up to speed. Review all comments received. Develop final landscape description.</p> <p>(THIS MEETING SHOULD BE HELD AT FIELD SITE)</p>	<p>Written marching orders for work group.</p>
Third and fourth month	Work group	<p>DEVELOP DRAFT PLAN: Analyze issues and develop plan and actions to reach goals and objectives. Use FOCUS groups to gain additional understanding. Identify issues that are resolved through consensus, compromise, or that are unresolved.</p>	<p>Written draft of plan.</p> <p>List of issues that were resolved through consensus and compromise.</p> <p>List of unresolved issues.</p> <p>Identify list of potential projects to begin NEPA clearances.</p>
Fifth month	LIFe group	<p>REVIEW DRAFT: Review draft and provide comment on format, content, and adequacy to accomplish goals and objectives. Provide guidance on unresolved issues.</p>	<p>Written guidance on revisions needed.</p> <p>Written guidance and direction for dealing with unresolved issues.</p>
Sixth month	Work group	<p>FINALIZE PLAN: Using guidance from LIFe group develop final proposal, actions, and alternatives.</p>	<p>Written proposed plan to be submitted to agency.</p>
Seventh and eighth month	Agency	<p>NEPA Documentation.</p>	<p>Environmental assessment.</p>
Ninth and tenth month	Agency	<p>Public review and comment.</p> <p>Provide feedback from and to LIFe (possible meeting).</p>	<p>Response to comments.</p> <p>Decision.</p>
Eleventh month	Agency and landowners per plan.	<p>Implementation.</p>	<p>Improved resource conditions, realization of landscape description.</p>

ALLOCATING FORAGE AMONG WILD AND DOMESTIC UNGULATES—A NEW APPROACH

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Abstract: One of the most challenging aspects of range management is allocating forage among domestic and wild ungulates. Many methods have been used, but none have proven satisfactory. Past problems of forage allocation were related to the difficulty of combining static and dynamic environmental factors on a seasonal basis to quantify and predict distributions of ungulates and vegetation. Environmental factors that do not change within a year include slope, aspect, elevation, and distances to roads, water, fences, and cover. Dynamic environmental factors, such as weather and forage quality and quantity, change on a seasonal basis. We present a case study using computer-aided spatial analysis models and linear programming formulation to allocate forage among elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), and cattle. Animal responses to interactions of static and dynamic environmental factors were modeled to predict seasonal distributions of ungulates on a landscape. Those predicted distributions were combined with distribution, quality and quantity of forage, and diets and energy requirements of mule deer, elk, and cattle to allocate forage. Results were then displayed on 3-dimensional computer-generated images to show where forage was removed by each species on a monthly basis.

Key words: cattle, *Cervus elaphus*, deer, elk, forage allocation, GIS, linear model, *Odocoileus hemionus*, rangeland.

Attempts to allocate forage to ungulates on public rangelands have been ongoing for >100 years. By the early 1880s overgrazing of rangelands was evident within the Blue Mountains of Oregon and throughout the West. Overgrazing led to conflicts that sometimes resulted in violence as graziers competed for their livestock's forage. Often the conflict was between allocation of forage for sheep and cattle. The U.S. Forest Service, created in 1905, inherited this conflict and early administrators solved the problem by creating grazing allotments. Sheep were usually assigned to higher elevations and rougher terrain, whereas cattle were usually sent to areas with more gentle terrain. This system institutionalized the process of forage allocation based on behavioral foraging characteristics of cattle and sheep. Skovlin (1991) summarized this early period of forage allocation conflict by quoting Henry Ireland, the first supervisor of the Blue Mountain Forest Reserve,

"I . . . feel safe in saying that the administration of grazing within the National Forests has been responsible for the elimination of range wars, the saving of large numbers of livestock and human lives" (Skovlin 1991:10).

It was not until the 1930s when mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*) numbers and distribution were beginning to recover back to their historical status that managers expressed concern over allocation between wild and domestic ungulates (Shantz 1939). The concern centered on forage allocation on winter ranges. Forage allo-

cation on summer range was not considered a problem because extensive areas in mountainous terrain were considered available for wild ungulates and not used by domestic livestock as long as "each species were stocked at appropriate densities" (Douglas 1939:365).

With the evolution of the science and art of range management, guidelines were developed for setting stocking rates based on proper use of vegetation (Stoddart and Smith 1955). Techniques were developed to measure condition and trend of the vegetation (Box 1995). Forage allocation was based on weight equivalents (Soc. Range Manage. 1989), with 1 cow-calf pair consuming about what 2.5 elk cow-calf or 6 deer doe-fawn pairs would eat. This simplistic view, however, did not consider differences among species in dietary or spatial habitat selection.

Later, carrying capacity models were developed based on nutritional demands of the animals and forage quality and quantity (Wallmo et al. 1977, Hobbs and Swift 1985). These models assumed forage and animals were distributed across the landscape uniformly.

Components needed in forage allocation models were reviewed by Van Dyne et al. (1984a). Cooperrider and Bailey (1984) developed a simulation model for allocating forage among 4 wild and 2 domestic ungulate species in Colorado. Van Dyne et al. (1984b) compared linear programming formulations to simulation models and concluded it was, at that time, impractical to use simulation models extensively in

allocating forage. They developed a linear model constrained by several functions for allocating forage and maximizing use. Stated weaknesses of both models (Cooperrider and Bailey 1984, Van Dyne et al. 1984b) were their inability to evaluate spatial relationships of vegetation and animal distribution and output that was difficult to use and interpret. Also, data were lacking on the net primary plant production, *in vitro* digestibility, and protein for many of the major and minor plant species that composed animal diets. Distributions of species relative to various features of the landscape also were not modeled. Consequently, the models served only as crude approximations of forage removal and allocation.

Only recently have scientists combined aspects of landscape with nutritional requirements or animal behavior to estimate stocking rates (McInnis et al. 1990) or predict distributions (Seagle and McNaughton 1992, Turner et al. 1993). McInnis et al. (1990) developed a deterministic model for stocking rangelands with cattle in which cattle distributions were limited by distance from water and slope. Seagle and McNaughton (1992) used a linear programming model to predict ungulate distributions in the Serengeti based on spatial variation in forage quality. Wisdom and Thomas (1995) argued that before forage can be allocated among ungulates, one must understand how distributions of each species are affected by different environmental variables.

The major challenge in modeling forage allocation is predicting vegetation quality and quantity and spatial distributions of ungulates on a temporal scale. In the relatively simple case of domestic sheep and cattle, hard and fast decisions were made about allocation to end the range wars in the late 1800s. Administrators recognized that the 2 species used the landscape differently and forage use was assigned accordingly. Cooperrider and Bailey (1984) attempted to simulate distributions of ungulates by estimating habitat preferences, but their efforts still did not take into account various other factors affecting seasonal distributions of elk, mule deer, and cattle on public lands. For example, consider the seasonal shift in distributions of elk as plant phenology and forage quality change. In early spring, elk may use south-facing, open slopes, followed by use of meadows in early summer. As the vegetation matures in mid-summer, use of open pine (*Pinus* spp.) stands increases with elk moving into dense forests by late summer. Cattle also use different habitats as the year progresses and in a different manner than do elk (Wisdom and Thomas 1995).

Our paper reports initial attempts to allocate forage using a linear programming formulation that combines predictions of ungulate and forage distributions on a landscape. Animal distributions are based on their responses to environmental variables, with seasonal estimates of forage quantity and quality produced in various habitat types. To our knowledge, there are no forage allocation models directly linked to a landscape geographical information system (GIS) to predict animal distributions based on environmental variables in order to allocate forage among ungulates in either a simulation or linear programming formulation.

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METHODS

The forage allocation model was developed in FORPLAN (Johnson et al. 1986) by Sarah Crim, Region 6 planning, and its development is still in progress. It is a linear programming formulation that models forage use by elk, mule deer, and cattle during 7 1-month periods (Apr–Oct) using spatial and temporal information on habitat preferences, forage production, and forage quality. Habitat preference data were derived from the literature, and included species-specific animal responses to 6 environmental variables: slope, distance to water, distance to roads, aspect, distance from cover, and slope position (Johnson et al. 1994). Each variable was divided into a number of categories (e.g., 3 slope categories) and a habitat preference value from 0.0 to 1.0 was assigned to each category for each species. The overall animal preference for each combination of environmental variables was computed as a geometric mean of preference values for each variable. This quantity was used to calculate an animal avoidance score (1 = preference). The avoidance score was an output that accrued when forage was allocated (removed) by 1 of the 3 species. By minimizing the avoidance score in the model objective function, we forced the model to first allocate forage from the preferred habitats for each species.

Forage production data were derived from published results of studies in the Blue Mountains (Svejcar and Vavra 1985, Sheehy 1987, Johnson and Hall 1990) and from data collected from the Starkey Experimental Forest and Range (SEF). Net forage production was estimated for 7 time periods and 4 plant associations: grasslands, riparian, open conifer (<40% canopy cover), and closed conifer (\geq 40% canopy cover). Forage quality, as measured by *in vitro* digestibility, was estimated from cattle diets (Holechek et al. 1981, 1982) at the SEF or from clipped vegetation (Svejcar and Vavra 1985, Sheehy 1987, Westenskow 1991). Forage production and quality data were converted to digestible energy (McInnis et al. 1990), which was used to calculate animal production with energy demand data from the literature (Wallmo et al. 1977, Nelson and Leege 1982, Sheehy 1987). We used standard metabolic rates for energy demands and added demand for gestation and lactation. We did not differentiate between sex and age classes of animals.

In our model, forage was produced on each habitat each month, and could be consumed by 1 species or by all combinations of animals within each habitat type. Ten percent of the biomass was allocated to each species, and 70% was allocated communally. The communal allocation represented diet overlap of 70%. The forage in a polygon could be consumed by elk only, deer only, cattle only, elk and deer only, deer and cattle only, elk and cattle only or all 3 species. Thus,

up to 80% of the forage could be removed by any 1 species. This relationship can be used in the future to control dietary overlap.

For initial testing of the model, we built a habitat landscape using GIS data from the SEF and tried to replicate animal distributions within the SEF as determined from existing telemetry data on elk, mule deer, and cattle. The model was run with floor constraints on animal numbers to replicate the animal populations currently in the SEF. Animal production outputs from the model were distributed back to GIS data and visually examined using UTOOLS software (Ager and McGaughey 1994).

RESULTS AND DISCUSSION

Our goal was to determine if we could merge models that predict distributions with those that allocate forage. We were successful in that goal, but a fully developed and tested forage allocation model was not produced. These first runs indicated that our modeling approach may have some merit. Comparison of predicted animal distributions and actual telemetry data from the Starkey experiment showed some strong similarities. Some inconsistencies between the 2 data sets were, however, apparent. We believe that further work to refine the model will resolve these problems.

Our procedure represents a potentially powerful tool that can be used to describe distributions of ungulates and associated forage use within an allotment or other landscape. The linear programming formulation allows managers and the public to explore alternatives and the costs of proposed actions.

Two areas in the model need improvement. One is a better model to predict animal distributions. The second requires a clear understanding of the seasonal dietary relationships among elk, mule deer, and cattle on various habitats. We did not attempt to develop a model predicting monthly distributions, but used 1 model for the entire year. The Animal-Unit-Equivalencies Study, 1 of 4 primary studies being conducted at the SEF, addresses these needs. Two goals of that study are to develop models predicting distributions of elk, mule deer, and cattle on summer range, and to measure their diets where distributions overlap (Johnson et al. 1991). A possible extension of that work would be to develop a forage allocation model. This is our first attempt to assess the feasibility of that task.

Following are areas where our model can be improved:

- ◆ The parameters for the distribution model were developed from the literature, and can be improved based on work being done at the SEF.
- ◆ Habitats were separated into 4 broad categories. Better estimates of forage composition and production can be obtained.
- ◆ Diets were assumed to be 70% identical, but we know that is seldom the case.

- ◆ Energy requirements were based on reproductively active females. The only constraint on energy intake in this model was total kilocalories of energy needed, and it was not limited by maximum daily intake rates.

Many of these weaknesses can be eliminated with data from models already published. For example, Cooperrider and Bailey (1984) extensively described seasonal energy requirements of different sex and age classes of animals.

The framework of our forage allocation model corrects some weaknesses identified by Van Dyne et al. (1984a) of previous allocation models. We are able to model the spatial and temporal variability of the vegetation and predict animal distribution, and display animal responses graphically in 3-dimensional maps. A fully developed model such as this could help managers and the public understand how ungulates use the landscape and how forage is removed and provide opportunities to explore alternative management scenarios.

One note of caution from Van Dyne et al. (1984a:22) seems appropriate:

"To managers of natural resources, the most important discovery of this century is our growing awareness of the complexity and diversity of natural ecosystems. The most carefully conceived forage allocation decisions, based on the most carefully conceived study of local conditions, will always be first approximations—our best guesses of how we should manage resources and how the resources (and the public) will respond. Each land management plan should address how results will be monitored, predictions tested, and treatments adjusted to account for the unexpected responses."

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RELATIONSHIPS OF PRONGHORN AND LIVESTOCK IN THE GREAT BASIN: A REVIEW

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Abstract: A literature review was completed regarding the relationships of pronghorn (*Antilocapra americana*) and livestock management in the Great Basin. Findings from published records indicated livestock may directly impact pronghorn deleteriously by changing composition of preferred forage, altering vegetation structure, competing for nutritious succulent forage, interfering with fawn production, and acting as a reservoir of diseases. During the past 100 years, vegetation has greatly changed because of livestock grazing and fire suppression—apparently contributing to lower pronghorn densities. Other reports substantiate that livestock management may beneficially impact pronghorn by enhancing vegetation and water and conducting predator control. Although few, the complimentary and adverse effects of pronghorn on the livestock industry also are provided.

Key words: *Antilocapra americana*, cattle, compatibility, domestic sheep, Great Basin, horses, livestock, pronghorn, rangeland, vegetation restoration.

Pronghorn (*Antilocapra americana*)-livestock relationships in the Great Basin have been perplexing issues for the past century. Certain publications have referred to problems caused by livestock regarding forage competition and other incompatible influences to pronghorn (Ellis 1970, Smith and Beale 1980, Clary and Holmgren 1982, Kindschy et al. 1982, McNay and O'Gara 1982, Tsukamoto 1983, Pysora 1987, U.S. Fish and Wildl. Serv. [USFWS] 1994, Pyle and Yoakum In Press), whereas other reports infer livestock management can enhance habitat conditions for pronghorn (USFWS 1970, 1980; Kindschy et al. 1982; Anderson et al. 1990a,b).

Attempts have been made to document both beneficial and detrimental relationships between pronghorn and livestock. Einarsen (1948) reported on these impacts, and 26 years later Yoakum (1975) updated subsequent findings. Within the past 4 years, 2 publications have provided additional information (Yoakum and O'Gara 1990, O'Gara and Yoakum 1992). Currently 2 major manuscripts are scheduled for publication that assess interrelationships of pronghorn and livestock throughout North America (Yoakum et al. In Press, Yoakum and O'Gara In Press).

Severson (1990) identified the responsibility of wildlife and range managers, as well as the scientific community, to define where and how livestock can be used as a management practice to improve habitats for wildlife such as pronghorn. The above mentioned reports and manuscripts provide interpretations of current data with various recommended management practices for rangelands dually occupied by these wild and domestic ungulates.

The objective of this paper was to review and assess literature regarding the management of rangelands used in common by pronghorn and livestock in the Great Basin ecoregion.

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METHODS

I conducted a literature search during the last 8 years to review and evaluate publications reporting the impacts of pronghorn and livestock on each other. Three bibliographies (Prenzlow 1965; Yoakum 1967, 1991) and 2 compendia (Yoakum and Spalinger 1979, O'Gara and Yoakum 1992) were most helpful.

Reviewed publications were listed according to the following categories as they related to the influence of livestock on pronghorn and pronghorn on livestock: indirect negative, direct negative, operational, and beneficial (Mackie 1978, Wagner 1978, Kie et al. 1994). In addition, concepts or practices that could not be substantiated by written reports were listed under the category of "possible myths and/or unknowns." Also, although few in number, cases where pronghorn had positive or negative influences on livestock management were reported.

The following terms were used: livestock referred to cattle, sheep, and horses; the Great Basin region referred to the large western watershed (mainly in Nevada and Utah with peripheral locations in California, Idaho, Oregon, and Wyoming) containing watercourses that did not flow to any ocean (Skibitzke et al. 1963).

RESULTS

More than 60 reports were reviewed; most were anecdotal. However, 29 contained major findings relative to livestock impacts on pronghorn (Table 1), and 2 reported influences of pronghorn on livestock management (Table 2). For the major articles, each was evaluated and classified into the following categories regarding the influences of each to the other.

Table 1. Literature regarding the impacts and influences of livestock on pronghorn in the Great Basin.

Source	Indirect negative	Direct negative	Operational	Beneficial
Anderson et al. 1990a			T	T
Anderson et al. 1990b				T
Bailey 1991				T
Clary and Holmgren 1982		T		
DeLong and Yoakum 1994	T	T		
Einarsen 1948	T		T	
Ellis 1970	T	T		
Good and Crawford 1978	T			T
Heady and Bartholome 1977			T	T
Kie et al. 1994	T		T	
Kindschy et al. 1982	T	T	T	T
McNay and O'Gara 1982		T	T	
Meeker 1979			T	
Mosley 1994	T		T	T
O'Gara and Yoakum 1992	T	T	T	T
Pyle and Yoakum In Press	T	T	T	
Pysora 1987		T		T
Salwasser 1980	T	T	T	
Salwasser and Shimamoto 1984	T		T	
Smith and Beale 1980	T	T		
Tsukamoto 1983	T	T	T	
U.S. Fish and Wildl. Serv. 1970			T	T
U.S. Fish and Wildl. Serv. 1980			T	T
U.S. Fish and Wildl. Serv. 1994	T	T	T	
Wagner 1978	T	T	T	
Yoakum 1975	T	T	T	T
Yoakum 1978	T		T	
Yoakum 1980	T	T	T	T

Table 2. Literature regarding the impacts and influences of pronghorn on livestock management in the Great Basin.

Source	Indirect negative	Direct negative	Operational	Beneficial
O'Gara and Yoakum 1992	T	T	T	T
Pysora 1987	T		T	T

Indirect Negative Influences of Livestock on Pronghorn

Livestock can and have altered vegetation structure resulting in vegetation communities unfavorable for pronghorn habitat (Pyle and Yoakum In Press, USFWS 1994). Changes in vegetation structure that result in heights >76 cm decrease favorable habitat conditions for pronghorn. A cardinal characteristic of habitat requirements for pronghorn is vegetation <76 cm, which allows these animals to see and flee—an adaptation for survival (Kindschy et al. 1982, O'Gara and Yoakum 1992). During the past century, vegetative communities have changed from lower to taller structure, resulting in habitat conditions changing from desirable to less desirable habitat for pronghorn (Tueller and Monroe 1975, Yoakum 1978).

Livestock grazing during the past century has contributed to changing vegetation composition by reducing herbaceous plants and increasing the density and cover of shrubs (Ellison 1960, Young et al. 1976, Branson 1985, Miller et al. 1994). Vegetative communities averaging composition of α each of grasses, forbs, and shrubs better meet pronghorn habitat requirements because of the greater variety of preferred, succulent, and nutritious forage species throughout the year. However, during the past century, livestock have heavily grazed forbs thereby decreasing their availability and resulting in dominant stands of shrubs that are beyond the pronghorn's needs of forage or protective cover. This change in vegetative composition apparently resulted in decreased carrying capacity for pronghorn (Ellis 1970, Yoakum 1978).

Direct Negative Influences of Livestock on Pronghorn

Ellis (1970) reported that rangelands grazed by cattle resulted in less available forbs during the pronghorn's last 2 months of pregnancy and the first 2 months of lactation. These were spring and summer months, when pronghorn needed nutritious forage to produce healthy fawns and abundant milk production for fawn survival. Pronghorn parturition was limited to 1 month annually. The highest loss of fawns occurs in the month following parturition; malnutrition is suspect (Yoakum 1957, Ellis 1970).

A study of winter rangelands in Utah disclosed the importance of shrub forage to pronghorn survival (Smith and Beale 1980, Clary and Holmgren 1982). At this time of year, shrubs were more nutritious and available than forbs. When domestic sheep heavily grazed shrubs, insufficient browse was left for pronghorn, resulting in malnutrition and decreased pronghorn densities.

Operational Influences of Livestock on Pronghorn

The compatibility of pronghorn and livestock management was reported in 3 different cases. McNay and O'Gara (1982) investigated rangelands on the Sheldon National

Wildlife Refuge in Nevada where they noted that cattle apparently displaced parturient pronghorn. Because pronghorn does seek seclusion for parturition, they move to isolated areas when livestock dually occupy pronghorn natal areas. McNay and O'Gara (1982) reported cases where parturient does were displaced from historical successful fawning areas to adjacent, less-preferred sites. Einarsen (1948) reported that close-herded domestic sheep bands in Oregon caused pronghorn does and fawns to separate and that fawns were abandoned.

Another study conducted on the Sheldon National Wildlife Refuge noted the dominance of horses at water sources, which affected the drinking habits of pronghorn (Meeker 1979). Such stress increases incompatible relationships during periods of drought, or in areas with limited availability of drinking water during summer and autumn.

Thousands of miles of fencing have been constructed on western rangelands—primarily for the control of livestock (Yoakum et al. 1980). These fences have had various impacts on pronghorn, resulting in litigation that has gone to the U.S. Supreme Court. Such fences affect pronghorn welfare in the Great Basin by direct mortality, by aiding coyote predation, and by affecting seasonal movement for forage and water (Yoakum 1978, McNay and O'Gara 1982). Pronghorn survival requires swift flight; anything that impedes or restricts this movement directly affects the welfare of the species (O'Gara and Yoakum 1992).

An important pronghorn-livestock interaction is that of livestock acting as reservoirs of diseases that may affect pronghorn mortality (O'Gara and Yoakum 1992). One case of blue-tongue in Wyoming killed hundreds of pronghorn on sagebrush (*Artemisia* spp.) grasslands where cattle were suspected of being a reservoir for the disease (Thorne et al. 1988). In another case, infection and loss of pronghorn were related to parasitized domestic sheep that severely grazed a rangeland in North Dakota (Bever 1957).

Beneficial Influences of Livestock Management on Pronghorn

Hundreds of drinking water sources, primarily for livestock, have been developed during the past century on western rangelands. These developments have aided pronghorn herds (Yoakum et al. 1980, Kindschy et al. 1982, Mosley 1994). During 1 decade, 1,037 reservoirs were constructed in Malheur County, Oregon (Heady and Bartholome 1977). Such structures increase the availability and distribution of drinking water for pronghorn and other wildlife. Sundstrom (1968) conducted a 5-year study on the shrubsteppes of Wyoming, where he observed livestock and pronghorn drinking concurrently from the same water sources. The Great Basin has numerous playas where trench reservoirs have been constructed for livestock and these structures have been used extensively by pronghorn (Good and Crawford 1978).

The implementation of predator control programs by the livestock industry has been beneficial to pronghorn. For example, about 250 times as much money was spent on the

protection of livestock during 1976 as was spent on wildlife management (Connolly 1978, Mosley 1994). Connolly (1978) listed numerous cases where predator control increased pronghorn populations.

In 2 cases, vegetation manipulation projects primarily designed to improve forage for livestock also resulted in increased preferred succulent forage for pronghorn (Yoakum 1978, 1980). Both cases occurred in Oregon, one on private lands. The projects decreased shrubs, and wheatgrasses (*Agropyron* spp.) and dryland alfalfa were planted. Vegetation structure was improved and succulent, nutritious forbs were available during summer and autumn, resulting in increased use by pronghorn of treated sites compared to adjacent untreated areas.

Operational and Beneficial Effects of Pronghorn on Livestock

Pronghorn consume many plants classified as noxious or poisonous to livestock such as larkspurs (*Delphinium* spp.) death camas (*Zygademas* spp.), and halogetons (*Halogeton* spp.). These plants often are highly preferred and readily consumed without apparent harm to pronghorn (O'Gara and Yoakum 1992).

A negative influence of pronghorn to ranchers was the increased frequency of depredations on alfalfa crops. With pronghorn herds now >3,000% greater than what they were in the early 1900s, the frequency of crop damage has likewise increased. The California Department of Fish and Game recently trapped and translocated herds causing depredation problems—a management practice intensified during the last 20 years in response to complaints from alfalfa producers (Pysora 1987).

Myths and Unknowns

A number of concepts and recommendations regarding how livestock grazing can enhance vegetation for pronghorn were encountered during this review. These are discussed below.

The use of livestock to improve habitat in the Great Basin for wildlife has been recommended (Bailey 1991). Assumptions were that cattle replaced bison (*Bos bison*) as ungulate grazers in the Great Basin. However, no records could be located reporting that bison inhabited the Great Basin at the time of Anglo-American arrival. Apparently grasses adapted to the Great Basin experienced light grazing compared to herbaceous forage in the Great Plains that sustained heavy grazing by large herbivores (Miller et al. 1994).

The use of livestock to improve vegetation for wildlife on 2 National Wildlife Refuges in Oregon and Nevada was advocated in management plans (USFWS 1970, 1980). Subsequent monitoring on both refuges, 15–25 years later, suggested that preferred vegetation for pronghorn had not improved substantially; consequently, new management plans were implemented and prescribed burning was identified as an alternative practice to enhance vegetation for pronghorn (USFWS 1994, Pyle and Yoakum In Press). Apparently,

livestock grazing in vegetation communities dominated by shrubs had minor effects on herbaceous production—the result required to increase preferred forage for pronghorn on many shrubsteppe habitats in the Great Basin.

The use of livestock to “precondition” forage on Hart Mountain National Antelope Refuge, Oregon, was described by Anderson et al. (1990a,b). Although these reports inferred that prescription livestock grazing improved nutritional quality of forage for pronghorn, no data were included to infer that nutritional quality of forbs or grasses preferred by, or available to, pronghorn had been improved (DeLong and Yoakum 1994). It seems from the literature that there is little, if any, support for the use of livestock to improve forage for pronghorn under existing vegetation conditions on Hart Mountain (USFWS 1994).

The use of cattle to increase forbs in dominant upland shrub communities has been suggested as a management practice (Bailey 1991). This treatment may have potential for rangelands in mid- to late-seral condition, but other areas in late succession for shrubs apparently will not readily respond to forage class changes unless a major disturbance (e.g., fire, mechanical, or herbicidal treatment) is accomplished (Miller et al. 1994, USFWS 1994).

IMPLICATIONS AND DISCUSSION

As the human population continues to escalate in North America, demands on vegetation, water, and space on western rangelands will likewise accelerate. Society will require new dimensions for biodiversity and ecosystem management of public rangelands. This will require better understandings of relationships between commensal and competitive wild and domestic ungulates.

Attempts, not always successful, have been made during the past quarter century to manage rangelands for pronghorn and livestock. Two assumptions contributing to this management were (1) speculation that cattle replaced bison in the Great Basin and therefore were compatible herbivores to native wildlife, and (2) pronghorn were primarily grazers of grasses and shrubs, whereas their preferred forage classes apparently are forbs first and shrubs second (Yoakum 1990).

A factor of livestock management, often unrecognized, is the enhancement of forage and water resulting in improved habitat conditions for pronghorn at certain sites. Both domestic and wild ungulates prosper when there is an abundance of herbaceous forage and drinking water. Both likewise benefit when predators are controlled and infectious diseases are arrested. The key to managing rangelands for these domestic and wild animals is to know and enhance not only those rangeland characteristics that are favorable to both, but also the specific requirements of each in order to sustain healthy populations.

Sometimes the old adage “to know a little about something can be dangerous” seems so true. For example, knowledge that grasses average <10% of pronghorn year-long diets may lead to the conclusion that grasses are unimportant

for sustaining pronghorn in any one season. However, findings reveal that grasses, in combination with forbs, are highly nutritious and succulent during late spring and early summer (periods of late gestation and lactation for pronghorn); consequently, the quantity and quality of herbaceous forage is directly related to the successful production and survival of pronghorn fawns during this crucial season, producing the entire year’s herd recruitment (Ellis 1970). Conversely, insufficient herbaceous forage can result in depressed populations.

A similar principle pertains to drinking water. Although it has been reported (Yoakum and O’Gara In Press) that pronghorn can subsist without permanent drinking water, populations maintaining greatest densities inhabit rangelands with well-distributed drinking water available yearlong.

The above 2 cases of forage and water quantity and quality requirements for pronghorn are briefly stated, but they present similarities of pronghorn and livestock needs on rangelands. With a thorough understanding of these life requirements for both species, management standards and guidelines may be developed and implemented to sustain both on the same rangelands.

Wildlife managers stress the need to not only know the major factors of forage, water, and space for pronghorn habitat requirements, but also emphasize knowledge of the other specific requirements that should be considered to sustain a healthy population, e.g., seclusion on natal areas, behavioral responses to different fence types, and others. Consideration for these requirements may determine whether a Resource Management Plan for livestock and pronghorn will or will not be effective.

Managers and the scientific community have provided many needed principles and practices to sustain pronghorn and livestock on western rangelands. The question is, will the practicing managers of today and tomorrow recognize and properly apply these standards and guidelines? Herein lies the future destiny of pronghorn and livestock herds on the public’s western rangelands.

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EFFECTS OF LIVESTOCK GRAZING ON WINTER ELK DISTRIBUTION

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Abstract: Although the question of whether livestock grazing has detrimental or beneficial effects on elk (*Cervus elaphus nelsoni*) habitat has been strongly debated, there have been few design-based experiments conducted to quantify these effects. We are testing how sheep grazing during the boot phenological stage of *Agropyron spicatum* affects distribution of elk during the following winter. Plots of similar topography and vegetative structure and composition were paired and blocked by geographic location. The treatment (controlled sheep grazing) and the control (exclusion of sheep grazing) assignments were randomized within the blocks. The treatment was applied in early June of 1993 and 1994. Elk distribution response was measured during the winter of 1993-94 by use sampling of forage species within the plots and by telemetry tracking of radio-collared elk. Results of 1993-94 use sampling indicate that mean winter use on the control plots was 2.6% and 7.7% on the treatment plots. The experiment will continue for 1 more year.

Key words: elk, sheep grazing, winter.

GEOGRAPHIC INFORMATION SYSTEM (GIS) STRATEGIES FOR UPDATING SAGOONICK REINDEER RANGE PLAN, NORTHWESTERN ALASKA

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Abstract: The Sagoonick range (400,107 acres) borders Eastern Norton Sound in northwestern Alaska (between 64° 02'-64° 33' N latitude and 160° 18'-161° 32' W longitude). Dominant vegetation is subarctic tundra and taiga that is grazed by 2,000 reindeer (*Rangifer tarandus tarandus*) and by caribou (*Rangifer tarandus granti*) migrating through the area. Land is owned by Native Corporations and the Bureau of Land Management. Reindeer were introduced to Shaktoolik in the mid-1920s, the population reached 40,000 and subsequently disappeared in 1939. In 1958, 89 were reintroduced. A plan to improve ecological condition was needed to reduce conflicts with caribou, wolf (*Canis lupus*) and grizzly bear (*Ursus arctos*). Surveys were completed and rotation grazing attempted to improve lichen (*Cladina* spp. and *Cetraria* spp.)-dominated range. Starting in 1992, the following land-based data was automated: hydrology, boundary, ownership, ecological sites, soils, ecological condition, grazed/nongrazed, snow, land survey, and management. A Sparc 10 Sun Station with GRASS 4.0 software was used for data analysis. Analysis has facilitated locating preferred winter range. GIS technology simplified balancing all forage needs while helping to maintain native plant communities. Trail clearing through floodplain forests (*Picea glauca*, *Populus balsamifera*, *Salix* spp., and *Alnus* spp.) has been explored. GIS has provided a new tool for presenting alternatives to landowners. GIS has facilitated economic evaluation of alternative trail development and herding. The analysis has not resolved all major conflicts, but significantly improved management strategies to facilitate sustained resource use.

Key words: caribou, geographic information system, lichen, *Rangifer tarandus*, reindeer.

PARTNERSHIPS FOR RANGELAND MANAGEMENT: SUCCESSSES AND FAILURES

HISTORY OF THE TROUT CREEK MOUNTAIN WORKING GROUP

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Abstract: Much of our personal effort the past 10 years has been spent building bridges between concerned urban environmentalists and long-term ranchers who depend on the land for their livelihood. Putting folks with different backgrounds and values together for the purpose of making positive change on the land a reality is a slow, painful, but rewarding process. The Trout Creek Mountain experience is an example of how the land and the people can win. As "public" citizens we have the power and obligation to take responsibility for the destiny of the private lands we own and the public lands we depend on for many needs. Local communities can determine their own future. But the definition of "local" must be expanded to include not only the people who live in the area, but the people in urban areas who depend on that land for their quality of life and relation to a "natural" world. Success on the land comes when a diverse group of interested "public" acknowledge one another as human beings and develop a vision for what a healthy land and community needs to be. The main obstacle is overcoming the frontier mentality we've lived on in the West for the past century—that the land is a source of unlimited products to be used for humankind's immediate benefit.

Key words: citizens, consensus, coalition-building, public land, private land, rangeland management.

Much of our personal effort the past 10 years has been spent building bridges between concerned urban environmentalists and long-term ranchers who depend on the land for their livelihood. Putting folks with different backgrounds and values together for the purpose of making positive change on the land a reality is a slow, painful, but rewarding process. The Trout Creek Mountain experience is an example of how the land and the people can win.

HISTORY AND BACKGROUND

Evolution of the Trout Creek Mountain Working Group began in June of 1988. We and Wayne Elmore were invited by the Oregon Bureau of Land Management (BLM) Vale District to give a talk to ranchers in the Trout Creek Mountain area of southeastern Oregon. The purpose of the talk was to give examples of how ranchers in the Prineville BLM District have been able to work cooperatively with the BLM to generate management changes that better the ecological health of the land.

The Prineville, Oregon, area has been well publicized by Wayne Elmore, a BLM riparian specialist, who has presented his slide show talk all over the country and has become "Mr. Riparian," a well-deserved title. Wayne has worked out of the same area for 18 years. The dramatic results he shows on the Bear Creek watershed were possible because

- ◆ Prineville district and area managers have been willing to take substantial managerial risks to benefit ecological health.
- ◆ The BLM-rancher grazing advisory board has provided financial and positive peer pressure support.
- ◆ The range con (Earl McKinney) stayed in place and built trust and credibility with the ranchers. With that he was able to negotiate and implement nontraditional, biologically sound grazing strategies that produced watershed and riparian improvement.

Enough on the history of the Prineville program, let's get back to the sensitive and fragile Trout Creek Mountain area and the June 1988 meeting at the school house in the tiny border town of McDermitt, Nevada. Picture the setting: 1 very angry manager of the Whitehorse Ranch, 5 other unbelievably frustrated ranchers, and several BLM folks including the area manager, range cons, a wildlife biologist, and a hydrologist.

Visualize "the mountain" that occupies nearly a quarter of a million acres of mostly BLM-managed federal land in the southeastern corner of Oregon. Part of the mountain is in the Vale BLM District, part in the Burns District and a small part of the south side is in Nevada. Most of the area is in wilderness study, and is part of Oregon BLM's top priority for wilderness designation.

This unique range of desert mountain country rises from a 4,000-foot base to nearly 8,000 feet. No evergreen trees grow in this rugged country, but many native grasses, shrubs,

and trees thrive here. On top, the grass waves in the wind among the sagebrush (*Artemisia* sp.) and bitterbrush (*Purshia tridentata*), surrounded by patches of mountain mahogany (*Cercocarpus* sp.). Aspen (*Populus tremuloides*) grow in the basins just off the top and continue in large scattered groves down numerous scenic, steep, rock-rimmed canyon walls. A successful transplanted group of bighorn sheep (*Ovis canadensis*) roams the mountain, which also contains trophy mule deer (*Odocoileus hemionus*), cougar (*Felis concolor*), and sage grouse (*Centrocercus urophasianus*), to mention a few of the more "politically sensitive" wildlife species. Many small, wet meadows, which are dry meadows during drought, form the headwaters of several hundred miles of creeks that flow out to the flat desert floor. Willows (*Salix* spp.), wild rose (*Rosa* sp.), and additional aspen grow in the wet green areas (riparian zones) along the creeks.

The creeks are the source of irrigation water for the ranches that are scattered around the base of the mountain at the mouth of the streams. Most are family owned and historically have produced wild hay and some alfalfa on their flood-irrigated meadows. Since settlement in the late 1800s, the cattle operations have been based on grazing the mountain in the summer, the flat desert in the winter, with the remainder of the feed requirements being met with hay. These ranches would be described in ranching circles as well-balanced, natural, cow-calf range outfits.

Pastures on the mountain vary from several thousand acres up to 50,000 acres in size. Nearly all of them contain live creeks that support trout. Some of the trout are hybrids that resulted when the Nevada Fish and Game Department released rainbow (*Salmo gairdneri*) and brook trout (*Salvelinus fontinalis*) from the early 1930s through the 1950s to "improve" the fisheries. These "exotics" bred with the native Lahontan cutthroat trout (*Salmo clarki*) and produced what has over time stabilized into a desirable game fish.

Several of the streams where the "exotics" were not released, or where a natural stream barrier prevented intermingling, still contain pure strains of the original Lahontan cutthroat. It was in these streams in the Vale BLM District where the primary land management concern existed. These remaining pure Lahontans are held in great respect by an increasing number of folks interested in wild natural ecosystems in general and wild trout in particular.

Ranchers in the area have been aware of the uniqueness of these trout and made efforts in the past by riding to keep their cattle off the creeks in the hot parts of the summer. However, in reality this did not prove to be very effective. Fencing was impractical because of the size and roughness of the country. Also, because it is a wilderness study area, new fences are nearly impossible to get approved. It is no wonder the ranchers were frustrated that June of 1988.

Likewise, it is no wonder that folks concerned about the native trout were frustrated. One critical factor for trout production is water temperature. Keeping water cool in these desert streams requires shade from grassy overhanging banks, willows, and aspen. Beaver (*Castor canadensis*) harvest of

willows and aspen coupled by cattle grazing of their sprouts and new seedlings had taken its toll on the tree population along the creeks for more than a century. Besides providing shade, the willow roots are important to hold the banks together during floods. Finally, heavier concentrations of cattle in the creeks in late summer had caved off the overhanging banks. The result was warmer water temperatures and marginal trout habitat.

Compounding the situation was a past history of "paper- and process-driven" BLM management. Couple that with a new range con on the ground every few years with never enough time to build trust and a true working relationship with the rancher permittees. Remember that for 21 years riparian conditions and the fate of the resident trout had been a concern of the Oregon Department of Fish and Wildlife, numerous BLM resource professionals, and the Whitehorse Ranch owners themselves. These concerns had been echoed by environmental organizations including the Izaak Walton League, the National Audubon Society, the National Wildlife Federation, Oregon Environmental Council, Trout Unlimited, Oregon Trout, etc.—21 years of environmental concern and frustration with **no significant change on the land**. No change, that is, except for a number of study enclosures that showed the potential of the riparian areas.

Viewed with a historical perspective, it is understandable why no change had occurred in grazing management. Cattle had been summer-grazed on the mountain under open-range conditions since the late 1800s, establishing an accepted tradition that was backed up by legally adjudicated grazing preferences. The BLM's primary role during the 1940s, '50s and '60s was to license and administer these grazing permits. It was not until the late 1960s and 1970s that the importance of the environmental effects of grazing were clearly spelled out through environmental lawsuits and legislation. It was at this time that the mountain was fenced into several separate grazing allotments. However, the pastures were still very large, and the fencing in a number of instances actually concentrated cattle in the stream bottoms. Finally, during the 1980s, political appointees in the Interior Department, sympathetic to the sagebrush rebellion, frequently issued policies that were in direct opposition to the intent of existing environmental legislation. The BLM was caught in the middle, attempting to respond to a series of conflicting signals.

Back to the scene being played in the small bordertown of McDermitt, Nevada, that June of 1988. Wayne Elmore gave his 45-minute riparian talk in 2 hours. Angry discussion accompanied each slide and the day ended with a number of talks, including Doc's, not given. There was not time to see how positive results had been accomplished cooperatively only 250 miles away. The frustrations of the past were so prevalent in the room that the message would not have been heard anyway.

The next day was a tour on the mountain. The riparian areas had limited numbers of willow and aspen and most of those were old citizens of the tree world. The history was of

130 years of continual livestock grazing from June to October each year. Even though one of the objectives of the massive Vale range improvement project of the 1960s was to provide management alternatives to rest the mountain from continuous grazing, these alternatives had never been used.

At the end of the day, Connie could stand it no longer. As a "public citizen" she expressed her right to try and get some changes made that could benefit the land and the people. With substantial help from Bob Skinner, President of the Oregon Cattlemen's Association, and some friends in the environmental community, we were able to put together a meeting 1 month later at the 14th-floor offices of the BLM State Director in Portland.

Present at that first meeting of what would become the Trout Creek Mountain Working Group were: Whitehorse Ranch (2 representatives); Izaak Walton League (2 representatives); Oregon Trout (1 representative); Oregon Cattlemen's Association (4 representatives); Vale District and Area Managers; State Director, BLM; Chief of Resources; and Head of the Range Program statewide.

The tension, energy, fear, care, and concern in that room for 4 hours was overwhelming. At the end of the day it was obvious that changes had to be made, or everyone, and the land, was going to lose big after a long battle in court. Regardless of the grazing decision made by District Manager Bill Calkins, ranchers or environmentalists were going to challenge it with a lawsuit. And under current procedures, while a lawsuit is in process, management reverts to historical precedent that would have meant several more years with no change on the ground.

FORMATION AND ACTION OF THE TROUT CREEK MOUNTAIN WORKING GROUP

Folks from this meeting in Portland with the addition of a representative from the Oregon Environmental Council and family member representatives from 3 neighboring ranches in the Trout Creek area became the "Trout Creek Mountain Working Group." The group's purpose was to see that change in management occurred **immediately** that would **"make a positive difference" on the land**. The future of the trout and the ranching community and culture depended on improving the health of the watershed and its streams.

The Trout Creek group, working closely with the Vale BLM and full support of the state director, was able to build enough understanding of the immediate need for watershed improvement that the ranchers involved voluntarily removed their cattle for a 3-year period of rest.

The Whitehorse and Oregon Canyon watersheds of the Trout Creek Mountain located in the Vale BLM District completed their third year of rest the fall of 1991. Despite severe drought conditions, the response of 100 miles of critical riparian area was encouraging. A lot of credit for the results

needs to go to the Whitehorse management who recognized that the past 130 years of traditional summer-long grazing on the mountain was not going to be acceptable in the future.

The Whitehorse Ranch made a major financial commitment to the recovery of the watershed by leasing another ranch during this 3-year rest period and drastically changing their grazing program on the lower reaches of the watershed. Four neighboring ranches who also run cattle in the watersheds on the northeastern side of the mountain made unprecedented management changes to rest their areas of use on the mountain. These changes involved considerable water hauling and 100-pound reductions in weaning weights. This weaning weight loss came primarily from grazing dried-up bunchgrass in August and September at 4,000- or 5,000-foot elevations instead of at the greener, more nutritious bunchgrass and meadows at 6,000- to 8,000-foot elevations. The cattle were not short on grass, but their food quality was considerably reduced.

During this period of voluntary rest, the Trout Creek Working Group met regularly to help develop a solution for the land that included grazing. Some examples of the strength of diversified working group follow. Monte Montgomery (Izaak Walton League) was invaluable in stimulating better communication between the Vale and Burns BLM districts. Mary Hanson from the Oregon Environmental Council helped facilitate the meetings. She also communicated to other members the importance of doing everything in accordance with legally mandated public planning procedures. Kathi Myron from Oregon Trout clearly communicated to everyone in the group her genuine care and love of the wild Lahontan and the importance of its habitat. And because of Kathi and Oregon Trout's diligence and review, their protest of the first plan made it a much better document. The original document was vague on what acceptable condition of the streamside shrubs, trees, and grasses needed to look like in the future. Spelling out what was expected in ecological improvement assured trout habitat conditions and also gave the ranchers a clear goal to achieve. Because the plan received so much review, when the final decision was appealed by an out-of-state activist, the administrative law judge dismissed the appeal.

The District Manager from Vale issued a grazing decision for the Whitehorse Butte Allotment that became effective in late 1990. The grazing strategy was specifically designed for the benefit of the watershed and the fish that depend on that watershed for their existence. It is important to understand that the mountain received 2 years of voluntary rest before any formal grazing decision was issued for the Whitehorse Ranch. And although allotment management plans are in process for the 4 neighboring northeastern slope ranches and 2 additional ranches on the southern side of the mountain, formal grazing decisions for these ranches are yet to come. Despite the lack of formal allotment management plans, these ranches are 5 years into a grazing program that has been reviewed by the U.S. Fish and Wildlife Service (USFWS) as being compatible with Endangered Species Act requirements for Lahontan cutthroat trout.

These results were possible only because environmentalists, ranchers, the BLM, Oregon Department of Fish and Wildlife, and USFWS all worked together to find solutions for the land and people.

It was in the late spring of 1992 when the moment of truth and the test of 3 years of working together arrived. In the seventh year of the worst drought since the 1930s, cattle were returned to the mountain to graze pastures containing endangered Lahontan cutthroat trout. Turning these cows out as planned demonstrated to everyone that the Vale BLM did indeed have the ability to follow through on a management program if it was biologically sound and had diverse public support.

The management strategy on the higher elevation mountain pastures is to graze from May to mid-July in an area for 2 years; then rest that area for 2 years. This program is based on the growth requirements of the plants and the behavior of the cows. Willows and aspen do most of their growing after mid-July, which is the same time that the bunchgrass is drying up and becoming less palatable. When the hills dry up and it gets hot, cattle, like people, find it more comfortable to congregate in the cool shade along the creeks. By removing the cows in mid-July, new willow and aspen sprouts and seedlings are seldom grazed. The grass along the creeks, which was grazed in May and June, has time for full regrowth before fall. Since the bunchgrass on the hills is of excellent quality and palatability before mid-July, the cows spend less physical time on the streams, and trampling of overhanging banks is minimal. The 2 years of rest that follows each 2 years of grazing allows the upland bunchgrass plants time to fully recover from being cropped at a sensitive time in their growth cycle.

This program is what ecosystem management is all about. The biological assessment of the management program written by Tom Miles, supervisory range con, was extremely thorough and accurate, which enabled the U.S. Fish Biologist to accept it. Bob Kindschy, wildlife biologist in the area for 37 years, deserves considerable credit for having the interest and foresight to have conducted monitoring baseline studies that now are being used to scientifically document that ecological health is truly improving.

In September of 1993, after the mountain had received 3 years of rest and the cattle had completed the first 2 years of the planned 4-year grazing cycle, a 2-day tour was conducted with the Trout Creek group. The USFWS Biologist directly responsible for the Oregon Lahontan program was satisfied with the results. The streambanks now have sufficient young willow, aspen, and grass cover so that the riparian system was able to benefit from a modest flood event in the spring of 1993. And the prospect of the land becoming healthier in the future is a lot more than just some dream on paper.

Unfortunately, the traditional season-long summer grazing program on the Trout Creek Mountains that was in place 5 years ago is not that unusual in the West today. Most areas

have not had as much public interest as did Trout Creek. Too much ecologically unsound grazing continues to be licensed year after year with no changes.

There are several reasons for our current predicament in the West. Improving land management through laws and bureaucracy alone has not proved to be very effective. The BLM is a politically directed entity that has basically been paralyzed since 1974 from the conflicting messages and constraints it receives regularly from Washington D.C. and various lawsuits. This paralysis can be overcome through a consensus group such as the Trout Creek Working Group. When understanding exists between ranchers, environmentalists, BLM managers and resource professionals, and state and USFWS representatives, decisions that benefit the land and people can be implemented without years in court.

"Social-political" factors that allowed the Trout Creek group to exist, function, and stimulate positive change on the land are as follows.

- ◆ Trust and respect existed between ranchers and environmentalists in Oregon before formation of the Trout Creek Working Group.
- ◆ The problem on the ground was recognized by both the ranching public and the environmental public who together asked the BLM to participate in a unique process to find solutions. Public land management agencies such as the BLM and U.S. Forest Service exist to serve the public's best interest. And, to quote our Oregon State Director, D. Dean Bibles:

"When a group of diverse interests with full participation by the Bureau of Land Management develop and support a sustainable resource management plan which is ecologically sound, economically feasible, and socially acceptable, it is extremely difficult for any individual or group to stop implementation of that plan."

- ◆ Strong support existed at all BLM managerial levels throughout the process. But, a key role of the joint rancher-environmentalist "public" involvement was making sure this support continued with each new manager. During 5 years, the Trout Creek effort included 2 state directors, 2 district managers, 3 area managers, and several interim managers.
- ◆ State Range Conservationist Chad Bacon was detailed by the State Director to maintain communication between the ranch community, the environmental community, and the Vale BLM both at the management and ground level. Chad's credibility and personal relationships with leaders of the Oregon Cattlemen's Association, the participating environmental organizations, and local ranchers in southeastern Oregon was and continues to be an important key to the success of this pioneering group.
- ◆ A pilot "range specialist" classification is being tested in Oregon, and Tom Forre, Rangeland Manager Specialist/Ecologist in the area for the past 5 years, has this

position. The key in this new job description is that it enables range cons the opportunity to be **promoted in place** and become **responsible for land health rather than land products**. Tom has had this responsibility for 5 years now and has built trusting relationships with ranchers and environmentalists.

Trust, respect, credibility, and communication are 4 simple words to write; they are incredibly difficult terms to build and maintain. But for lasting success on the land, they must exist.

THE PROCESS AT GROUP MEETINGS THAT MAKES CONSENSUS AND ACTION POSSIBLE

Everyone sits in a circle and speaks in turn. A question starts each meeting such as "How do you feel about being here and what would **you** like to **help** make happen today?" According to conflict resolution consultant, Bob Chadwick, no one is at a meeting until their voice enters the room. By having to think about how you feel (most folks feel anxious and frightened, which may be expressed as anger), the right brain is activated. The right brain is where our creativity is located.

Answering the question, "What would **you** like to **help** make happen today?" affirms that something is going to happen and you are going to be an important part of it. This is an empowering experience for the participants and changes the focus of the meeting from pointing out problems to developing solutions.

Ranch wives are specifically and personally invited to participate. Ranch men frequently are bound by tradition to the way it always has been, which makes opportunities for change difficult to see. Women in general tend to be more right-brained and better able to understand the feeling of environmental folks who are viewing the situation from a much different perspective than the ranchers. The feelings of everyone—ranchers, environmentalists, and agency folks—have to be acknowledged before true consensus for change can occur.

After everyone's voice enters the room, 2 or 3 "opportunities in disguise" (more commonly known as "significant problems") are discussed. This is in the circle as a whole, or in smaller breakout groups, but always with each person given the opportunity to speak in turn and be listened to with respect.

During the meetings of the working group, BLM representatives participate in turn as people with concerns and cares, not just as BLM employees doing their job.

Efforts of the group are goal oriented. The group's future "Big Picture" includes

- ♦ Baby aspen, teenage aspen, middle-age aspen, and old aspen, willows, trout, and wildlife throughout a watershed covered by a thick stand of vigorous perennial grass.

- ♦ Baby, teenage, middle-age, and old ranchers and their livestock operating in an economically and ecologically sound manner.

There was considerable relief in the room when the ranchers had no problem working to achieve "point A," and the environmentalists had no difficulty with "point B." Descriptions for how the land needs to look throughout the watershed in the future were visualized by including statements such as, "How McDermitt Creek looks now at the upper access, and how the upper watershed looks now at the head of Oregon Canyon."

At the close of each meeting, realistic commitments for accomplishing certain tasks and clearances are made by the ranchers, environmentalists, and BLM folks. The ranchers and environmentalists network with their peers to build understanding on what is occurring. The BLM's commitment prioritizes their work toward tasks that will make a difference on the ground. The BLM presently is buried under paperwork requirements without the staff or funding to accomplish those demands. For success to occur on the land, some sort of outside consensus pressure or support is required. Also it is critical that the BLM State Director creates an atmosphere in the state that supports working together and rewards positive change on the land.

In September of 1993, a 2-day working group tour concentrated on looking at riparian areas that had been grazed in 1992-93.

Compliance in meeting the grazing objectives was 100%. The fate of the Lahontan trout seems in good hands. The USFWS biologist responsible for threatened and endangered species, Ron Rhue, was enthusiastically positive, not to mention greatly relieved, about the results on the land. The ranchers involved felt the working group experience had been a positive one even though the management changes have been stressful and expensive, and ranch capacity and annual profit has been reduced. However, the bottom line is that a management plan that meets the criteria for endangered species in a wilderness study area provides a stable basis for a sustainable ranching operation in the future.

It takes people to improve land. We already have more laws and technical information than we need. Time is not on our side in the struggle to solve problems on the public land. But the time is right for more "people-to-people" alliances where landowners, environmentalists, and state and federal agency folks work cooperatively to produce action on the ground.

LESSONS LEARNED

As "public" citizens we have the power and obligation to take responsibility for the destiny of the private lands we own and the public lands we depend on for many needs. Local communities can determine their own future. But the definition of "local" must be expanded to include not only the

people who live in the area, but the people in urban areas who depend on that land for their quality of life and relation to a "natural" world.

Success on the land comes when a diverse group of interested "public" acknowledge one another as human beings and develop a vision for what a healthy land and community

needs to be. The main obstacle is overcoming the frontier mentality we've fostered in the West for the past century—that the land is a source of unlimited products to be used for people's immediate benefit.

BLUE MOUNTAIN ELK INITIATIVE: GOVERNMENT PROPAGANDA OR REAL PROGRESS

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Abstract: The Blue Mountain Elk Initiative (BMEI), a federal, state, tribal, and private sector partnership to manage elk (*Cervus elaphus*) in the Blue Mountains of Oregon and Washington began in 1990 with the signing of a 5-year Charter Agreement. Twenty-five cooperators have spent \$ 1 million on 100 projects to address 16 goals. Cooperators will revisit the charter in 1995. Mutual cooperator agreement to recharter BMEI for the next 5 years will indicate success.

Key words: Blue Mountains, elk, Oregon, Washington.

BONNEVILLE POWER ADMINISTRATION'S FISH AND WILDLIFE PROGRAM IN TRANSITION

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Abstract: Bonneville Power Administration (BPA) is attempting to change the basic way it does business. The change is not a matter of convenience, but rather a function of staying in business. The goal is to operate in a more competitive business-like manner, compared to the present large government bureaucracy operations. BPA is fast approaching the day when it is no longer the "power supply of choice." As revenues are affected, the ability to implement all programs is threatened. Every area of BPA has been affected, and the Division of Fish and Wildlife (FWL) is no exception. Each area has developed a 10-year business plan. The basis of FWL's business plan is subbasin-watershed planning and implementation. Using the principles of adaptive management, and such tools as ecosystem diagnosis and treatment, FWL will cooperatively implement a program that will be cost effective, and accountable to both the BPA rate payer and meet BPA fish and wildlife mitigation responsibilities.

Key words: adaptive management, Bonneville Power Administration, Fish and Wildlife Program, watershed planning.

COORDINATED RESOURCE MANAGEMENT PLAN FOR THE KEATING RANGE: ACCOMPLISHMENTS AND LESSONS LEARNED

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Abstract: To resolve the problems of the lack of forage and cover for wintering mule deer (*Odocoileus hemionus*) in the Keating Wildlife Management Unit, a Coordinated Resource Management Plan was initiated and implemented that involved ranchers, federal land management agencies, the state wildlife agency, and others. On-the-ground accomplishments were fencing, fertilization, spring developments, shrub plantings, and seedings. A spirit of trust, coordination, and a sense of ownership in this effort were developed.

Key words: cooperation, coordinated resource management plan, Keating, mule deer, Oregon, planning.

The idea of forming a cooperative between private land owners and government land managers was triggered by the concern expressed by Oregon Department of Fish and Wildlife (ODFW) and Bureau of Land Management (BLM) wildlife biologists. The issues were the lack of adequate forage and cover for wintering mule deer (*Odocoileus hemionus*) and the body condition of deer as they entered the lower elevation winter range within the Keating Wildlife Management Unit. The Keating Unit is located northeast of Baker City, Oregon, and north of State Highway 86, between the Medical Springs Highway on the west and Richland on the east, and the crest of the Eagle Cap Wilderness Area on the north. The area encompasses >30,000 acres and is a mixture of private and federal land ownerships: private land 34%, U.S. Forest Service 52%, and BLM 14%.

The Wallowa-Whitman National Forest manages the higher elevation, forested tracts that are primary deer summer range. Private land owners and the BLM Baker Resource Area manages the lower elevation rangelands that are deer winter range. These areas also are grazed by livestock.

The Keating Unit has been a source of conflict between ranchers, hunters, and wildlife managers since the 1940s. Ranchers wanted fewer deer, hunters wanted to maintain high deer numbers, and ODFW was caught in the middle. ODFW has tried to satisfy both groups by being responsive to game depredation on private lands as well as providing ample hunting opportunities.

Renewed attention has been focused on this area in the last 14 years primarily because of the high number of deer winter kills caused by severe weather. Deer often are in poor physical condition when they come off the summer range, and during severe winters, die in large numbers on lower elevational winter ranges. Concerns have been expressed by ranchers, agencies, and the general public.

Because of the intermingled land ownership pattern and because much of the lower elevation deer winter range is privately owned, concerned parties felt that a new approach must be taken that involves all landowners in a geographic area. This involvement is necessary to solve the existing problems.

The idea of forming a cooperative between private and government landowners was initiated by Dr. Michael Geist, then Senior Soil Scientist with the Pacific Northwest Range and Wildlife Laboratory in La Grande, Oregon. Dr. Geist had been working with the BLM and interested private landowners in the Keating Unit since about 1983 to test the establishment of various shrubs and grasses to improve the productivity of the land. He formed a close relationship with several of the ranchers and through his efforts helped to bridge the communication gap between ranchers and public land managers.

In June 1989, the Keating Rangeland Improvement Cooperative (KRIC) was formed to (1) solve current resource conditions, and (2) initiate land improvements on a landscape basis.

A steering group was formed that consisted of 2 interested ranchers from the Keating Unit, and representatives from the Soil Conservation Service, Keating and Eagle Valley Soil and Water Conservation Districts, the U.S. Forest Service, the BLM, ODFW, the Pacific Northwest Range and Wildlife Lab, Eastern Oregon State College, and the Oregon Hunter's Association.

The catalyst that brought this diverse group together was the major deer winter mortality. As the process developed, however, other larger issues began to surface:

- ◆ the overall condition of the watershed and soil resources needed to be improved; and
- ◆ range condition and productivity were not satisfactory for livestock, wintering mule deer, or other wildlife species.

A common goal agreed to by all was that we would provide a working environment that allows for optimum production of watershed and other resource values to meet current and future demands within the capability of the resource.

Several tours were conducted during the 1989 field season to acquaint participants with the area and issues, and to seek some common ground within the diverse group. Because the Keating Unit is so large, the area was prioritized and divided into manageable subunits.

The following criteria were developed for setting priorities: (1) the need—public outcry over the high deer mortality during severe winters; (2) current resource knowledge base; (3) cooperation available—agency or landowner flexibility to allow rest; (4) the available land—size, distribution, ownership; (5) areas that have the greatest chance of success, because of soils, topography, and precipitation; and (6) availability of funding from ODFW, Rocky Mountain Elk Foundation, Powder River Sportsmen's Club, and Federal Challenge Cost Share monies.

Because of the complexity of the issues and diversity of opinion, the group agreed that an outside consultant familiar with coordinated resource management should be hired. William Anderson, considered to be the father of Coordinated Resource Management Planning, was hired as the moderator. The first meeting was held in March 1990, and its immediate task was to select a manageable area within the larger watershed area on which to begin implementation. The Crystal Palace Area was selected as the first priority. The area is located about halfway between Baker City and Richland on the north side of the Powder River and State Highway 86. The area (low rolling hills dominated by grasslands) is the primary winter range for 600–800 mule deer and is grazed by cattle in the spring and fall. The area is 9,370 acres of which 60% is private land and 40% BLM land. Principal vegetation is basin big sagebrush (*Artemisia tridentata*), crested wheatgrass (*Agropyron cristatum*), cheatgrass (*Bromus tectorum*), and small patches of coniferous forests on the northern end. Elevation ranges from 2,500 to 4,300 feet.

WHAT IS A COORDINATED RESOURCE MANAGEMENT PLAN OR CRMP?

It is a decision-making process that allows owners, managers, and users of the resource in the planned area to all be involved, working as a team from beginning to end, to develop and implement a resource management plan.

Some key elements of a CRMP are:

- ◆ open and honest discussion of issues,
- ◆ consensus,
- ◆ listening attentively to another person's point of view even though it may differ from yours,
- ◆ dovetail all major resources and resource users into 1 unified program of development and management,
- ◆ management units must be manageable,
- ◆ must be open ended so it can be amended as needed,
- ◆ should be reviewed and updated by the planning group at least annually during the first several years.

The successful development and implementation of a CRMP depends on the involvement, commitment and active participation of all members of the group, especially the affected grazing permittees and private landowners. Mem-

bers of the Crystal Palace CRMP were the grazing permittees John Randall, Fred Phillips, Tom Trindle, and Donovan Martin, plus all the public agencies previously mentioned.

Because of the complexity of the issues, the diversity of opinions and the unfamiliarity of the group with the CRMP process, the plan took longer than expected. Starting March, 1990, it took 3 2- to 3-day sessions over 5 months to complete the development of the CRMP. During this period the level of trust and credibility among the group was greatly enhanced.

MAJOR COMPONENTS OF OUR CRMP

I. Mission Statement

Improve on-the-ground rangeland conditions for soil, water, livestock forage, and big game and other wildlife habitats across a *large landscape* involving multiple ownership by creating trust and sharing resource management experience.

II. Goal

Provide a working environment that allows for optimum production of watershed and other resource values to meet current and future demands within the capability of the resource.

III. Major Objectives

- ◆ Enhance hydrological and watershed conditions to improve water quality, increase precipitation intake rates of soils, reduce peak flows, extend higher streamflow, and stabilize soil through increased perennial vegetative cover and litter along riparian zones and on uplands.
- ◆ Stabilize mule deer populations through habitat improvement by establishing grass-forb seedings, planting shrubs, and maintaining thermal cover.
- ◆ Ensure viability of livestock production by improving livestock forage, applying range improvements, implementing revised grazing systems, and continued monitoring of use.
- ◆ Educate the public on resource management objectives by increasing public communication, involvement, and support.
- ◆ Improve agency, user, and landowner commitments and reduce frustrations through successful application of on-the-ground conservation measures.
- ◆ Substantially reduce or eliminate the need for supplemental winter deer feeding.
- ◆ Manage predator populations to minimize depredation on wildlife and livestock while maintaining their role in controlling other prey populations.

- ◆ Reverse noxious weed invasion (yellow star thistle [*Centaurea solstitialis*], knapweeds [*Centaurea* spp.], Medusa head-rye [*Taeniatherum caput-medusae*], white top [*Cardaria draba*], puncture vine [*Tribulus terrestris*]).

IV. Issues and Problems

- ◆ Unsatisfactory watershed conditions.
- ◆ Degraded riparian zones.
- ◆ Low range productivity.
- ◆ Noxious weed invasion.
- ◆ Frustration by all because very little gets done on-the-ground.
- ◆ Poor quality habitat for deer, especially under severe winter conditions.
- ◆ Depredation by deer on croplands and hay stacks.
- ◆ Lack of agency and landowner commitment.
- ◆ Lack of habitat diversity.

V. Resource Management Systems and Decisions Agreed on to Correct Problems

- ◆ Big game—improve the thermal cover for deer on the winter range by planting shrubs and trees in selected riparian zones.
- ◆ Improve the forage available for deer by plowing and seeding a selected area with a mixture of grasses, forbs, and shrubs.
- ◆ Livestock grazing—redesign the grazing system to precondition the grasses for livestock and deer. Divide the allotment into 4 pastures to get better livestock distribution and use.
- ◆ On-the-ground implementation was started in early 1991 and is still on-going.

ACCOMPLISHMENTS TO DATE

- ◆ Improved grazing system by preconditioning the grass.
- ◆ Constructed fences to create 1 more pasture and to reduce size of pastures to get better livestock distribution and use.
- ◆ Developed 4 ponds.
- ◆ Fertilized 60 acres to provide increased forage for livestock in the short term.
- ◆ Developed 8 springs to improve livestock distribution.
- ◆ Plowed and reseeded 130 acres to grasses, forbs, and shrubs. Livestock have been excluded since 1991. Another 200 acres were seeded to grasses and forbs.
- ◆ Planted 26,000 shrubs to improve browse for wintering deer.
- ◆ Fenced 2 riparian areas to exclude livestock.
- ◆ Constructed a fence along the rim of the Powder River to exclude livestock from the most critical portion of the deer winter range.

VI. Monitoring

Evaluations were done on the fertilized areas to determine biomass produced and use by cattle and deer; seedings to determine establishment of grasses, forbs, and shrubs and use by deer; and shrub survival. Because of the continuous drought conditions most of the shrubs were lost.

LESSONS LEARNED FROM THIS CRMP AND WHY IS IT WORKING

- ◆ A spirit of trust and cooperation developed among the participants over time.
- ◆ All affected parties were involved and have ownership in the plan and a commitment to make it work.
- ◆ The group was determined to change the status quo and do some on-the-ground management.
- ◆ Timing is right—the political climate changed because of public pressure.

In addition to the Crystal Palace CRMP, portions of the Red Ridge CRMP also have been implemented. The Red Ridge CRMP lies directly north of the Crystal Palace CRMP and encompasses >36,000 acres of which 75% are managed by the U.S. Forest Service. Among the projects that have been implemented are a 300-acre prescribed burn on spring-fall range for deer and installation of watering devices for numerous bird species.

In summary, we still have a long way to go in implementing these CRMPs but we've gotten off to a good start, which should help us in developing and implementing subsequent CRMPs over the next several years in the Keating Unit.

CITIZEN-BASED WATERSHED MANAGEMENT—AN EXPERIMENT IN LOCAL CONTROL OF NATURAL RESOURCES MANAGEMENT

ROBERT L. HORTON, Grande Ronde Model Watershed Program, 10901 Island Avenue, La Grande, OR 97850

Abstract: The Grande Ronde Model Watershed Program was created as an experiment in testing the viability of vesting responsibility for management of regional watersheds within local citizenry. A basin watershed management council was appointed by the county courts, representing a diverse range of affected interests. The council has created working partnerships with local, state, and federal agencies, and interest groups to restore and protect critical salmonid habitat areas and watershed health in the region. The council has been acknowledged by local, state, and federal natural resource management agencies, and has assumed an active role in proposing watershed restoration actions within the basin.

Key words: habitat protection, partnerships, natural resources, sensitive species, watershed management.

There are several different philosophies and methods natural resource managers can select in managing a watershed. A watershed can be managed to maintain and enhance natural aquatic biological diversity within a region, to enhance or protect threatened fish and wildlife populations, to maximize natural resource yield in wildlife, water, commodities, or human uses, or to support the economic and social livelihood of a community or region. The Grande Ronde Model Watershed Program has formulated a mission statement that incorporates elements of each of the above by striving to develop and oversee the implementation, maintenance, and monitoring of coordinated resource management that will enhance the natural resources of the Grande Ronde River Basin. Trying to address multiple elements in watershed restoration is perhaps more difficult than pursuing a single purpose, but the Board felt that all elements were essential to the people and ecology of northeastern Oregon.

The Model Watershed Program has developed a planning strategy that provides for local control of natural resource management within the Grande Ronde Basin. The first step is to identify the aquatic biodiversity areas within the basin. There are 33 aquatic biodiversity areas in the 9 subbasins in the Grande Ronde Basin, 25 of which contain salmon, steelhead (*Oncorhynchus mykiss*), bull trout (*Salvelinus confluentus*), or other sensitive species whose abundance and distribution have been reduced from their historical condition. The program then seeks to maintain the high-quality aquatic biodiversity areas, while focusing restoration actions on those needing improvement or restoration. The areas critical for salmon spawning or rearing have been selected as the highest priority to maintain or restore.

Aquatic biodiversity areas are specific geographical areas within a basin that possess distinctive and diverse plant and wildlife populations. Wilderness areas often provide the highest quality biodiversity environments because of the natural diversity of the native plant and animal communities, whereas cities or agricultural communities often possess less natural biodiversity because the landscape has been

converted to other uses. Some of the ways an aquatic biodiversity area can be enhanced are through the development of riparian and wetland areas, managing timber stands to encourage diversity, and building wildlife habitat areas.

Grande Ronde Model Watershed Program planners have accumulated all available stream survey data from the subwatersheds containing critical salmonid tributaries in the Grande Ronde Basin, identified the environmental problems, and are developing comprehensive subwatershed management plans to identify and aid in preparation of project proposals for the restoration of critical salmonid habitat areas. The natural resource management agencies within the basin are being encouraged to coordinate restoration actions on both public and private lands so as to restore complete subwatersheds on a holistic basis.

The program seeks to work closely with local landowners, resource managers, and key interests within the area to coordinate planning, formulate goals, and initiate activities to restore and improve the quality of our local watershed, and foster community development within the region. The program recognizes, in these efforts, that restoration actions on private lands must be acceptable and beneficial to private landowners. Key partners are local citizenry, local industry, the Soil and Water Conservation Districts, U.S. Natural Resources Conservation Service, U.S. Forest Service, and the Governor's Strategic Water Management Group (13 state natural resources agencies). Other partners include the Bonneville Power Administration, Northwest Power Planning Council, Bureau of Reclamation, and Bureau of Land Management.

The solution to watershed restoration is contained within the planning approach, in that the Grande Ronde Model Watershed is undertaking the actions today that will make a difference in the quality of our environment 25–50 years from now. It is to be found in coordinating agency actions to restore complete subwatersheds as a unit, and in seeking to maintain and enhance the aquatic biodiversity of the watershed. We believe watershed health is achieved through restoring and maintaining subwatersheds one by one to produce a cumulative effect basinwide.

WALLOWA COUNTY-NEZ PERCE TRIBE SALMON HABITAT RECOVERY PLAN

PAT WORTMAN, 101 S. River Street #202, Enterprise, OR 97828

Abstract: The goal of the Wallowa County-Nez Perce Tribe Salmon Habitat Recovery Plan is to develop a management plan to assure that watershed conditions in Wallowa County, Oregon, provide the spawning, rearing, and migration habitat required to assist in the recovery of Snake River salmonids by protecting and enhancing conditions as needed. To identify desired instream Chinook salmon (*Oncorhynchus tshawytscha*) habitat conditions, the Wallowa County Salmon Recovery Strategy Committee reviewed and adopted the General Habitat Requirements for Salmon and Related Oregon State Standards (OAR 340-41-722 & OAR 340-41-725). Acceptable ranges of habitat conditions were determined, then each reach of major streams in Wallowa County was analyzed for instream conditions. Problems were identified as characteristics of the entire watershed that created instream conditions outside the acceptable ranges. Adaptive management prescriptions were identified as potential solutions to problems. Implementation will involve identifying watersheds as stewardship management units and analyzing the existing conditions to establish baseline data. The data will be made available to land managers with recommendations for projects. The project results will be monitored to determine as positive results those that move instream conditions inside desired limits.

Key words: adaptive management, anadromous fish, habitat recovery, instream habitat, *Oncorhynchus tshawytscha*, salmonids, Snake River, Wallowa County, watershed analysis.

The circumstance in Wallowa County, Oregon, that motivated the initiation of the project was the decrease in the number of anadromous fish returning to the county. Fish runs had dropped to 10–15 % of historical numbers. This situation caused concern to the citizens of Wallowa County because of their desire to have viable fish runs return to the county and their realization that natural resource extraction activities on public land might be curtailed, causing a negative impact on the socio-economic health of the community. The Nez Perce Tribe was concerned about continuing access to historical fish runs granted by treaty rights and about the continuing multiple uses of national forest lands. The project was begun before the 22 May 1992 listing of the Snake River Chinook salmon (*Oncorhynchus tshawytscha*) as threatened under the Endangered Species Act.

I would like to thank Wallowa County-Nez Perce Tribe Salmon Habitat Recovery Plan Committee members Jack Albright, Mack Birkmaier, Cassandra Botts, Don Bryson, Bruce Dunn, Leo Goebel, Patti Goebel, Arleigh Isley, Bill Knox, Duncan Lagoe, Jack McClaran, Paul Morehead, Pat O'Connor, John Roberts, Brad Smith, Larry Snook, Lloyd Swanger, Bob Weinberger, and Si Whitman for their participation.

MISSION STATEMENT

“To develop a management plan to assure that watershed conditions in Wallowa County provide the spawning, rearing, and migration habitat required to assist in the recovery of Snake River salmonids by protecting and enhancing conditions as needed. The plan will provide the best watershed conditions available consistent with the needs of the people of Wallowa County, the Nez Perce Tribe, and the rest of the United States, and

will be submitted to the National Marine Fisheries Service for inclusion in the Snake River Salmon Recovery Plan.”

PARTICIPANTS

A committee of Wallowa County citizens, representatives and members of the Nez Perce Tribe, and Oregon State and U.S. agency professionals was established to prepare the plan. The members of the Wallowa County Salmon Recovery Strategy Committee represented the following interests: agriculture-grazing, agriculture-timber, business-community, environmental, land owner, Oregon Department of Fish and Wildlife, U.S. Bureau of Land Management, and U.S. Forest Service.

METHODS

Adopt Desired Instream Habitat Conditions

Desired instream habitat conditions for Chinook salmon were identified and adopted. These include stream substrate and structure, water quality and quantity, food availability, and protection from predation. In the county, salmon adults migrate upstream and spawn, eggs incubate and hatch, fry emerge and feed, and juveniles overwinter before migrating downstream. The acceptable ranges of desired instream habitat conditions are based on limits within which salmon can survive and function. It was recognized that the entire watershed needs to be considered to maintain desired instream habitat within those ranges.

Conduct Stream Analysis

Major streams in Wallowa County were selected for analysis. Each stream was subdivided into segments (reaches) for analysis based on channel characteristics such as gradient and structure, and on ownership and management patterns. Each reach was analyzed for instream problems and watershed conditions that contributed to instream problems. The analysis factors included water quantity, water quality, stream structure, stream substrate, and habitat requirements.

Problems and Solutions Identified

Problems were identified as those characteristics that did not fall within desired habitat conditions or which contributed to conditions outside the acceptable range. Examples of problems include compaction of soils, low flow, elevated water temperature, excess fine sediments, channelization, fuel loading, and predation.

Management prescriptions were identified as potential solutions to each problem. Management approaches have been developed to facilitate options for land managers in implementing the solutions. These include management of

- ◆ water
- ◆ forest
- ◆ livestock
- ◆ weeds
- ◆ roads
- ◆ campgrounds

Examples of solutions include upstream impoundments, commercial timber thinning, exclusion fencing, weed control, woody material removal, grazing rotation, surfacing roads, and relocating campgrounds.

Implementation of Management Recommendations

Wallowa County will be divided into stewardship management units based on watersheds. A consensus group will conduct area analyses that will result in a database of existing conditions. The data will be made available to land managers with recommendations for improvements. Encouragement and assistance will be offered in project implementation. It is intended that the projects be adaptive and that they be monitored. Project results will be incorporated in the area analyses so that implementation moves ahead in a positive manner. The specific end goal should be maintaining and enhancing salmon habitat and providing an overall healthy ecosystem and economy.

RESULTS

The tangible results of the project have already been partially evident in having the plan considered by the National Marine Fisheries Service for inclusion in the Snake River Salmon Recovery Plan and by the Eastside Ecosystem Management Project Environmental Impact Statement. If

the plan is included in these documents it would serve to enhance all natural resources, including salmon habitat in tributaries of the Snake River. Additionally, it would result in the continuation of the traditional uses on the public lands in Wallowa County. Several federal agencies, including the U.S. Forest Service, Bureau of Reclamation, Bonneville Power Administration, and others have responded to the plan by allocating funds for salmon habitat enhancement projects.

Of course, one of the intangible results of the project was enhanced understanding among the members of the Nez Perce Tribe and citizens of Wallowa County. The Nez Perce no longer live in the county but return often for hunting, fishing, berry and root gathering, and for festivals such as Chief Joseph Days. The current residents of the county, along with the descendants of the former residents, have gained an increased understanding of each others' cultures by working together on this project.

DISCUSSION

Cost of the Project

The cost of planning and facilitating the project amounted to about \$5,000, which included writing and printing the planning document. Committee members volunteered time and expenses to the project. The cost of promoting the plan amounted to about \$2,100, which included travel expenses for team members to go to Washington D.C. to present the plan to Congress and the federal agencies. Total cost of implementing the recommendations of the plan will be about \$19 million.

Sources of Funding

The sources of funding included contributions from the participating individuals and agencies to cover the costs of printing. It is estimated that about \$6,000 worth of in-kind contributions were donated by committee members. This included voluntary time and travel expenses for all planning team personnel to attend meetings in Enterprise, Oregon. In order to fund the implementation of the plan's recommendations, 35 potential funding sources have been identified.

Innovation

The innovative nature of the project is expressed in both the product and the process of the plan. No other fisheries habitat management plan has been prepared that considered fisheries habitat from ridgetop to ridgetop as this one does. The team felt that only by addressing the habitat with a holistic approach could all environmental elements be adequately considered. Another unique feature is that each stream was analyzed reach by reach. Never before has such a comprehensive plan undergone such small-scale analysis.

The process by which the Wallowa County Court and the Nez Perce Tribe initiated the project is innovative in that it seemed natural that those who love the Wallowa country should band together to solve its problems. It is especially appropriate that it was salmon that brought the groups to-

gether, because the name Wallowa comes from the Nez Perce word for the wooden fish traps that were used to capture salmon in earlier days. As the groups worked together it became obvious that the goals of each were the same when it came to using the resources of the earth with respect. It also has been discovered that the voice of a local government and that of a Native American tribe are stronger when joined together than when either one is used alone.

Sustainability

The sustained leadership demonstrated by Wallowa County officials and Nez Perce Tribal leadership to the goals of the program is evidenced by the forward to the plan:

“This document is intended to be dynamic, designed to change rapidly with new knowledge and changing conditions in a manner that will promote understanding and cooperation among all parties involved.”

Success of the plan is directly related to the commitment of the members of the communities involved in continually updating the plan.

Transferability

The transferability of this project to other counties is dependent on one factor: the dedication to the process by the volunteer participants. It is estimated that such a project conducted at actual cost by a state or federal agency would require >\$50,000, and would probably not be funded. After review by several professionals in natural resource management, the plan received as much positive comment for the process as for the product.

COMMENTS OF REVIEWERS

“In our opinion, the work of the drafting committee is commendable, and we look forward to working with you to implement a new level of coordinated and cooperative resource stewardship.” *Lloyd Swanger, Ranger, Eagle Cap District, Wallowa-Whitman National Forest, U.S. Forest Service.*

“Also beneficial is the direct involvement of Wallowa County citizens and members of the Nez Perce Tribe that provides unique insights not available from agency personnel and provides an excellent opportunity for them to become involved in shaping the management of their

community and most importantly implementing solutions.” *Susan Broderick, Fisheries Biologist, Denver Office, U.S. Bureau of Reclamation.*

“To my knowledge, [the plan] is the first county effort in the state in comprehensive eco-system management. The plan’s interdisciplinary approach and multi-jurisdictional recommended actions should serve as a model for creating a framework to address complex habitat protection problems.” *Greg Wolf, Program Development Manager, Oregon Department of Land Conservation and Development.*

“We applaud your ecosystem (holistic, and/or whole watershed) view. You frequently refer to upland forestry, fire, and other management practices. We agree. We would recommend that as you put these proposed practices into effect that you be ever-mindful of this ‘big picture’ approach, of the connectedness of the uplands to the riparian zones, and of vegetation’s role in encouraging development of soil resources which are able to capture, store, and beneficially release precipitation.” *W. C. Krueger and Dr. J. C. Buckhouse, Department of Rangeland Resources, Oregon State University.*

“The WCSRP is a major step forward in the attempt to plan and implement practical, landscape-level management practices focused on salmon recovery. The plan has combined technical quality and thoroughness with inclusive planning by basin users. We applaud this effort and encourage final development and acceptance of the plan to ensure its timely implementation.” *Forrest Olson, Fisheries Biologist; Dr. Tim White, Forest Ecologist; Kevin Neilsen, Watershed Hydrologist; CH2M-HILL Consulting Engineers.*

THE OREGON CATTLEMEN'S ECOSYSTEM MANAGEMENT PROGRAM

FRED I. OTLEY, Oregon Cattlemen's Association, HC 72, Box 30, Diamond, OR 97722

Abstract: Ecosystem management is the primary emphasis of many efforts to improve watersheds, and fish and endangered species habitat. Most of these initiatives fail to consider both the dynamic ecological components and people as important parts of these systems. Cattlemen and local communities have asserted their leadership by developing the Oregon Ecosystem Management Program, which is a community and site-specified initiated process that recognizes the dynamic nature and the multiple resources aspects of forest and rangeland systems. The program provides ecosystem and ecosystem management definitions for local groups to work from in both technical and practical terms, along with a number of management tools that may be used in planning and implementing ecosystem management.

Key words: ecosystem management, endangered species, fish, habitat, watershed.

The Oregon Cattlemen's Association has initiated a progressive natural resource management program called the Oregon Ecosystem Management Program (OEMP). This voluntary program includes both a public land and a private land component but neither is necessarily exclusive of the other. The primary emphasis of both programs includes community-based dynamic planning systems, integrated adaptive management strategies, periodic risk assessment, and adaptive monitoring systems.

Diverse interest involvement in developing goals, measurable objectives, and conflict resolution alternatives are primary parts of the public land program. Education receives the central focus of the private land program, which is conducted with the assistance and in partnership with Oregon Department of Environmental Quality and Oregon State University Rangeland Resources Department.

The OEMP is relatively straightforward but unique to each area and that uniqueness is one of the main strengths of the program. Workshops are established and developed by the community with assistance from the Association and specialists from various disciplines. Typically, one of the strengths of the program is the full involvement by most family members and the community with a lot of hands-on and how-to involved.

Subjects such as the basic functions, values, and structure of streams and riparian areas are discussed and analyzed while looking at the stream and resource conditions first hand. Existing conditions are documented and monitoring data of site-specific areas are evaluated in relation to various known biological and ecological relationships. What we do not know is also discussed as a part of analyzing alternatives and selected management actions.

Adaptive strategies are developed to identify management needs if unusual conditions and changes occur. Other informational needs are identified and methodology developed to gather that data in a systematic format. Follow-up plans are made to revisit the area as a group.

Developing adaptive and dynamic programs that meet the many diverse resource and economic needs of the community are basic to proper environmental management. Everyone needs to remember that people in poverty are not

good stewards of the land. Economic viability allows us to make rational and intellectual choices that reflect changing environmental and ecological conditions and needs. No matter how positive the objectives of a program seem to be, successful implementation is necessary to meet site-specific biological and community needs.

BACKGROUND

Current interpretation of laws like the Clean Water Act, the Endangered Species Act, the Wild and Scenic River Act, and various lawsuits associated with these laws have made it virtually impossible for resource management professionals to develop and implement programs. Site-specific plans that fully meet the intent of these laws, developed by field-level people in the private and public sector, receive little support from upper level agency administrators or the courts.

Dynamic and ecologically based programs or plans receive very little support because many times these programs are not as definable and restrictive on paper. Land-use and management plans must reflect the systems we are working with. With or without human land use, ecological succession of plants and animals continually changes with no climax or end point.

In addition to the continual ecological changes, most riparian and upland ecosystems are disturbance driven with physical or climatic events playing a major role in conditions at any one point in time. Fire, drought, precipitation, insects, beavers, etc. all have a substantial impact on both the ecological seral stage and watershed condition of an area.

Therein lies the problem because the portrayal of biodiversity and ecosystems, although given lip service relative to being extremely dynamic, is not understood by upper level agency hierarchy, nor does it fit static or linear models very well. In addition, very few administrators or specialists know very much about range management or progressive grazing systems.

This situation has become extremely serious because it is occurring at a time when umbrella top-down planning efforts like Eastside Assessment, Pac-fish, and salmon recovery efforts are superseding site-specific and integrated plan-

ning. Grazing exclusion or arbitrary grazing reductions become the focal management emphasis even if they are not relevant to the problem, and in many instances increase the risk of catastrophic fire, which will seriously impact structure and function of these systems.

ECOSYSTEM MANAGEMENT

Communities dependent on natural resource availability and management in many areas are getting involved in the issues affecting the future of their community. The Oregon Cattlemen's Association feels that communities are key elements in successfully initiating, developing, and implementing ecosystem management programs. The best way to define and integrate truly beneficial and reality-based ecosystem and biodiversity goals and objectives on private and public lands is to work together at the community level.

Stated simply, ecosystem management is the big picture, ridgetop to ridgetop, with the watershed managed for the needs of the total ecosystem, not for single species or single commodities. Ecosystem management includes multiple use, sustainable land use, rural economies, and social opportunities.

A working technical definition of an ecosystem is "the result of accumulation of interactions between all physical and biological entities including people within a prescribed area, usually a watershed. An ecosystem has dynamic, measurable structure and function."

Ecosystem management is defined as

"man's directed influence on either ecosystem structure or function to yield a specific outcome in time and space. Successful ecosystem management will result in dynamic structure and function in the context of specific landscape and social objectives."

Obviously, ecosystems are site specific. Our success in meeting biodiversity and ecosystem objectives on a community and landscape level depends on the development and implementation of site-specific and ecologically based programs initiated and developed at the local level.

INTEGRATED MANAGEMENT SYSTEMS

Integration of the many different resource issues and requirements needed to meet diverse perspectives and develop successful site-specific programs will always be a challenge. The realization that planning is ongoing and that annual adjustments and change are a part of the process actually makes the job easier.

Practical monitoring and documentation systems using measurable and objective criteria are critically important for ecosystem management. Measuring progress towards and re-evaluating what we are monitoring will provide the basis of blending biological, social, and economic needs.

The Oregon Watershed Improvement Coalition (OWIC) and various working groups represent successful efforts to integrate resource needs while diligently keeping a watchful eye on the big picture. The commonality of these efforts has to do with diverse interests working together, not broad brushing the issues. Integrating site-specific planning efforts and developing educational forums is a successful outcome of OWIC and working groups.

ADAPTIVE MANAGEMENT PROGRAM

The OEMP is an integrated program and beneficial spin-off of OWIC. The program provides the framework for a dynamic planning process reflecting the dynamic systems we are working with. Developing measurable objectives, monitoring systems, conflict resolution alternatives, and risk assessment with the help of others provides a broad and strong foundation.

Adaptive management strategies as a formal part of the formulation of management alternatives are key elements of the OEMP. Integrated secondary adaptive strategies identify management actions that will be undertaken if various biological, ecological, and climatic changes or natural disturbances occur. Therefore, management will be able to respond promptly to major events such as drought, extreme hot or dry periods, floods, ice events, insect infestations, fire, or other natural disturbances. For instance, grazing may be delayed by a month or so in some circumstances if an extremely wet period occurs, whereas in another circumstance grazing entry may be accelerated depending on site-specific needs and monitoring. Wet soil conditions and stream bank stability may make late grazing preferable in the one circumstance whereas earlier grazing may be preferable in another system to shift use to upland areas. The 2 different adaptive management responses would be initiated for specific reasons and they would be identified in the management plan itself as a secondary adaptive strategy and monitored appropriately.

COOPERATIVE GOALS AND OBJECTIVES

Another important part of the OEMP is to cooperatively develop goals and measurable objectives. Involvement of diverse interests is a key element to help define management objectives and the objective criteria necessary to measure our success in making progress towards those objectives.

A management objective of "managing and enhancing aspen [*Populus tremuloides*] stands" can have a very different short-term impact on neotropical migratory birds than "managing for a diverse age-class structure of aspen stands" if lack of older aspen is the limiting factor in the short-term needs of these migratory birds in a critical area of their migration. At the same time, not addressing the long-term loss

of aspen caused by fire suppression and the resultant encroachment of juniper (*Juniperus occidentalis*) would seriously impact these birds.

In addition, you can measure age-class structure, but by itself it fails to adequately capture or measure the ecological component. Managing and enhancing is a goal and is unmeasurable unless the goal states "manage and enhance aspen stands towards documented potential." Involvement of people who knew a lot about neotropical migrants greatly helped balance the effort to rejuvenate aspen ecosystems through the reintroduction of fire into the system, by managing and protecting an adequate number of older aspen through mechanical treatment and fuel reduction.

MONITORING SYSTEMS

A third and closely related component of the program is to cooperatively develop systematic but dynamic monitoring programs to measure our progress towards meeting management objectives. This fundamental part of the program cannot be based on subjective determinations and must measure both ecological and land-use components. The monitoring program would be an integral part of management's annual review, risk assessment, and adaptive management determinations.

Some components of monitoring need to be done the same way every year whereas others should adapt to the "type of year" and specific climatic or natural disturbance events. For example, if beavers (*Castor canadensis*) move into an old-growth aspen area or any area where the vegetative structure will be substantially altered, photo points or other monitoring techniques should be initiated. Another example could be to increase the intensity and frequency of grazing use monitoring if a lot of new cattle are put on an allotment because of drift back to the point of entry by new cattle.

CONFLICT RESOLUTION

A fourth area of the program is to find new ways to work together to solve problems. Conflict resolution alternatives would provide problem solving and mediation options for reducing the reliance on litigation to solve conflicts. Diverse interest forums and involvement out on the ground would be one important part of this process. Interdisciplinary, applied, and technical teams of various types would be other examples of ways to get past planning or implementation impasses but would not supersede local planning.

RISK ASSESSMENT

A fifth and extremely important program area would be a formal risk assessment to regularly and formally identify major risks that might severely impact the management goals, public safety, or integrity of the system. Major risks might include a massive wild fire event or an insect devastation. Risk assessment is not being adequately used in planning when impending risk of catastrophic fire will likely burn up most of our remaining old growth of our eastside forests and impact salmon habitat. Strategies would be identified to reduce the risk, mediate the impact of a major event, or prioritize available resources.

CONCLUSION

One of the strong points of the OEMP is in its dynamics, the expectation and realization of ongoing change, the adaptation to new knowledge, and the testing of information used in decisions. Continually testing the decisions and the monitoring systems used to measure "progress towards objectives" provides for both adaptability and progressive change. At the same time, the short-term economic and ecological needs are being met, which is central towards effective implementation.

MANAGING RANGELANDS FOR MULTIPLE OBJECTIVES

MULTIPLE LAND USE MANAGEMENT IN THE BIG QUILL LAKE AREA OF SASKATCHEWAN, CANADA

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Abstract: On behalf of the North American Waterfowl Management Plan, the Saskatchewan Wetland Conservation Corporation (SWCC) is acquiring >30,000 acres of native vegetation in a contiguous block around the Big Quill Lake in east-central Saskatchewan. This lake is of international importance to waterfowl and nesting and migrating shorebirds. SWCC goals for this area are to improve the condition and vigor of the range to provide habitat for wildlife such as Baird's sparrow (*Ammodramus bairdii*), improve forage resources for livestock, and protect the shoreline for breeding piping plovers (*Charadrius melodus*). Big Quill Lake is a shallow, saline lake whose waters and mud flats cover approximately 90 square miles. It is a major migratory stopover for shorebirds and recently was dedicated as a Western Hemisphere Shorebird Reserve Network site. Its shorelines provide prime nesting habitat for up to 5% of the world's population of piping plovers, an endangered species. Quill Lakes area is also within the range of the Baird's sparrow, a threatened species known to prefer lightly or ungrazed native grasslands. A history of land use was obtained, a range evaluation performed, and management plans were developed and implemented. Before SWCC involvement, approximately half of the 30,000-acre area was accessible to cattle for season-long grazing whereas the other half was vacant but had received some grazing in the past from unauthorized free-ranging cattle. Under management plans developed by SWCC, cattle access was removed from approximately 20 miles of shoreline and 7,000 acres with poor forage resources. Water development and fence construction on 8,400 acres on 4 separate pastures will allow the implementation of deferred and rest-rotation grazing systems. Grazing will be deferred on another 870 acres of riparian habitat. Improved cattle distribution and better use of forage resources should allow local livestock producers to maintain a similar number of cattle now as in the past and should improve vegetative cover for grassland-nesting birds. Continued monitoring of range, wildlife, and livestock will continue in the future.

Key words: grazing, habitat, wetlands, wildlife.

The corporate mission of the Saskatchewan Wetland Conservation Corporation (SWCC) is to lead and coordinate the province's wetland conservation initiatives to ensure the sustainability and biodiversity of the prairie environment for people and wildlife.

The SWCC was created in 1990 to coordinate provincial activities on behalf of Saskatchewan North American Waterfowl Management Plan (NAWMP) partners. The NAWMP, a continental partnership among Canada, the United States, and Mexico seeks to restore waterfowl and other wetland-dependent wildlife through sound land-use programs that contribute to soil, water, and wildlife conservation. For more detail on the NAWMP see the Appendix.

Within this context, SWCC is making a significant contribution to achieving objectives of Saskatchewan's Environmental Strategy by maintaining and improving biological diversity, soil conservation, and water quality and quantity. Saskatchewan is home to one-quarter of the continent's nesting ducks and is an essential breeding ground and stopover for many other migratory birds.

By protecting the province's wetlands and encouraging wildlife-friendly agricultural practices, the corporation is making impressive strides toward achieving its NAWMP objectives. This is being accomplished through innovative partnerships at local, regional, and international levels.

SWCC is guided by a Board of Directors with representation from provincial and national organizations that affect land use in the province. Board membership spans both private and public organizations in the agricultural, wildlife, and environmental sectors. This mix brings diversity and broad insight to the activities of the corporation. SWCC represents a partnership of provincial and national wildlife habitat conservation and land-use agencies. Through this partnership, the corporation uses an integrated land-use approach by linking agricultural and wildlife interests to NAWMP programming in Saskatchewan.

In the past the corporation has expanded its focus on improving wildlife habitat in general, and waterfowl, shorebird, and grassland songbird habitat in particular. The net result will be an umbrella of protection for wildlife species

that rely on wetlands and the enhancement of a resource that greatly benefits our province's agricultural and wildlife-related industries.

SWCC activities include agricultural services, biological services, communications and marketing, financial and human resource management, and program development and delivery. SWCC acquires and manages Crown lands and helps shape agricultural policy in Saskatchewan to meet the requirements of the NAWMP.

Sponsorship of the project is provided by the Prairie Farm Rehabilitation Administration, which funded the riparian fencing on the Wimmer Pasture; Ducks Unlimited, which funded the construction of 4 miles of cattle-exclusion fencing along the shorelines; the Saskatchewan Power Corporation, which constructed the solar water pumping systems and drafted the plans used in this paper; the Canadian Wildlife Service, through work plan funding of SWCC's land programs; and the NAWMP, through its funding of the Prairie SHORES Project. The authors wish to thank Mr. Garfield MacGillivray, Wilderness Images, Box 386, Quill Lake, Saskatchewan for providing many of the wildlife and pasture slides used in the presentation.

LAND ACQUISITION AT BIG QUILL LAKE

Before the signing of the NAWMP, a pilot project was set up by the major partners of the still unnamed NAWMP to look at broad-based landscape management to aid waterfowl nesting. Waterfowl biologists had earlier determined that the critical loss to waterfowl habitat that was lowering populations was upland nesting cover, which throughout most of the prairies was being converted to annual crop land. The place chosen for the original pilot project was the Quill Lakes area. Its landscape contains a large saline lake, a large freshwater lake, and thousands of small wetlands. Although adversely impacted by cultivation and overgrazing, the area was a very important staging area and migration stop for approximately half a million geese and cranes (with 1-day counts in October 1993 of >300,000 geese), 150,000 arctic shorebirds, and a small number of whooping cranes (*Grus americana*). The saline shoreline of Big Quill Lake is the nesting habitat of 300, or 5%, of the worlds remaining population of piping plovers (*Charadris melodus*). The grassland complexes around the Quill lakes are important to many ground-nesting shorebirds as well as Baird's sparrow (*Ammodramus bairdii*), which is considered threatened.

In the 1980s the worldwide RAMSAR Convention designated the Quill Lakes as one of only a few wetland complexes of international significance. Recently in cooperation with the Canadian Wildlife Service of Environment Canada and Saskatchewan Environment and Resource Management, SWCC nominated the Quill Lakes as a Western Hemisphere Shorebird Reserve Network site of international significance. When complete in early 1994-95, this design-

ation will provide international recognition of the value of this site for migrating birds, as well as increase opportunities for development of the province's ecotourism industry.

Changes made to The Wildlife Habitat Protection Act and new regulations added to both it and The Provincial Lands Act in 1993-94 permitted the transfer of Crown land from the Saskatchewan Department of Agriculture and Food to the SWCC. These wetlands and adjacent uplands will help meet provincial commitments to the NAWMP. Transfer on the first holding, a 3,758-acre parcel at the northern end of Big Quill Lake, was completed in the winter of 1994. This transfer was the first of almost 20,000 acres of vacant land and 12,400 acres of leased pastures.

Two other acquisitions helped consolidate wildlife habitat around Big Quill Lake. The Saskatchewan Wildlife Federation made a gift of 480 acres to SWCC, and the corporation purchased a quarter-section of key habitat along the south shore.

The land in the Quill Lakes region was initially surveyed in the 1890s. At that time the lake was much larger and the surveys stopped at the existing shoreline. In subsequent decades the lake level dropped and never fully recovered. This created >30,000 acres of unsurveyed land, in essence a "no man's land". Approximately 40 years ago, permanent vegetation had become established and grazing had started with the blessing of the provincial land authorities. To acquire this land SWCC had to have it surveyed. Arrangements were made with the Department of Justice to survey the parcel in large continuous blocks and not in the familiar British mile-square sections comprising 160-acre quarter-sections. This arrangement will create a contiguous block of land with restricted access as there are no road allowances.

MANAGEMENT OBJECTIVES

The land-use goals of SWCC are to:

- ◆ preserve habitat for nesting shorebirds, particularly the piping plover and arctic-nesting shorebirds that are migrating;
- ◆ preserve habitat for grassland birds, such as the Baird's sparrow and western meadowlark (*Sturnella neglecta*), and;
- ◆ improve range condition and pasture production for local cattle producers.

RANGE ASSESSMENT AND MANAGEMENT PLANS

A range assessment (Abouguendia 1990, Wroe et al. 1988) was performed on approximately 32,000 acres adjacent to Big Quill Lake. The area is located in the black soil zone and mostly was classified as a saline lowland range site. Range condition ranged from poor to low good with the dominant plant species of the area being northern reed

grass (*Calamagrostis inexplansa*), slender wheatgrass (*Agropyron trachycaulum*), saltgrass (*Distichlis stricta*), fox-tail barley (*Hordeum jubatum*), Nuttall alkaligrass (*Puccinellia nuttalliana*), bluegrasses (*Poa* spp.), many-flowered aster (*Aster* spp.), sowthistle (*Sonchus* sp.), gumweed (*Grindelia squarrosa*), goldenrods (*Solidago* spp.) and red samphire (*Salicornia rubra*).

In many areas, cattle had access to shorelines, beaches, and mud flats with poor vegetative cover, and uneven cattle distribution resulted in increased grazing pressure along a major creek flowing into Big Quill Lake, near water sources and along higher ridges. The saline environment also seemed to be responsible for patchy vegetative cover in several locations.

Management plans recommended stocking rates of 0.24–0.44 animal unit months/acre and employing fencing and water development to (1) eliminate grazing on 16 miles of shoreline and 12,000 acres of mud flats and beaches, (2) eliminate grazing on 7,000 acres of vacant lands with patchy vegetation, (3) allow the implementation of rest-rotational and deferred grazing systems on 8,400 acres, and (4) defer grazing on 870 acres of riparian habitat. Two reports, "Range Evaluation and Grazing Management Plans for Leased Pastures in the Big Quill Area" (Harrison 1993a) and "Range Evaluation and Grazing Feasibility for Vacant Lands in the Big Quill Lake Area" (Harrison 1993b), are currently available from the SWCC.

EXPECTED BENEFITS

Once management plans have been fully implemented and the systems are operational, several benefits are anticipated.

- ◆ There will be a reduction in conflict between cattle and nesting shorebirds, particularly on the beaches where the piping plovers nest.
- ◆ There will be large areas adjacent to pastures that will be set aside for wildlife only. In addition, a portion of the paddocks within the pastures will not be grazed until the nesting season is over and at least 1 paddock per pasture will not be grazed each year.
- ◆ There should be an improvement in the range condition and vegetative cover resulting from improved grazing management.
- ◆ Improved range condition and better cover should improve nesting habitat for grassland nesting birds.
- ◆ There will be a sustainable supply of forage for cattle for local livestock producers.
- ◆ Opportunities will be created for naturalists, outdoor recreation, and the ecotourism business.

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APPENDIX

The North American Waterfowl Management Plan (NAWMP) is an agreement among Canada, the United States, and Mexico to cooperate in restoring waterfowl populations to the levels of the 1970s and to improve habitat for other wetland-dependent wildlife.

The NAWMP encourages and helps focus investment by wildlife conservation organizations from across the continent to critical habitat areas for migratory birds. Through the NAWMP, key waterfowl habitat in Saskatchewan, Alberta, and Manitoba comprise the Prairie Habitat Joint Venture (PHJV), 1 of 12 habitat joint ventures in North America. The PHJV is the NAWMP's top priority because it provides breeding habitat for almost 40% of the continent's duck population, including 50% of mallards (*Anas platyrhynchos*) and >55% of pintails (*A. acuta*).

In Saskatchewan, NAWMP activities are coordinated by the Saskatchewan Wetland Conservation Corporation (SWCC). SWCC also represents provincial interests on the PHJV advisory board. Provincial NAWMP partners guide the corporation's activities through their representation on SWCC's board of directors. Programs contributing to provincial NAWMP objectives include Large Marsh, Nest Baskets, Prairie CARE, Prairie Shores, and Waterfowl Crop Damage Prevention and Compensation. Delivery agencies and mechanisms vary with each program.

BLUE AND WALLOWA MOUNTAINS GRASSLANDS: INTEGRAL COMPONENTS OF THE LANDSCAPE

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Abstract: The health of the Blue Mountain national forests has been of concern in recent years because of outbreaks by insects and wildfires encompassing large areas of the landscape. A large segment of the federal landscape in northeastern Oregon and southeastern Washington is dominated by grassland vegetation. These grasslands provide an invaluable addition to the biological diversity inherent in the overall mosaic of mountainous and canyonland topography. Within the grassland communities, vital processes important to the maintenance and functioning of the ecosystem have been modified by land management activities. The health of important bunchgrass communities has declined because of severe overgrazing, fire retardation, and other management-induced disturbances too severe or too frequent for the system to sustain. Examples portraying degraded bunchgrass communities compared with similar communities in healthier ecologic condition will be provided for green fescue (*Festuca viridula*), Idaho fescue (*F. idahoensis*), and bluebunch wheatgrass (*Agropyron spicatum*) plant associations. Areas excluded from ungulate use for long periods of time also will be compared using data and camera points taken during the protected period. The management emphasis to promote mid- and late-seral successional stages within landscape segments will be promoted using prescribed burning or ungulate grazing to stimulate desired conditions.

Key words: Blue Mountains, ecosystem, fire, grasslands, grazing, landscape, Wallowa Mountains.

Oregon's eastside landscape has been modified by disturbing agents and activities. Some of these modifications are natural to the ecosystems and are part of the process of ecosystem maintenance. Other modifications have been induced by human activities on the landscape, with Euro-Americans having had the greatest influence during the past century. I would like to touch on several themes. First of all, grasslands are a major component of the landscape administered by the 3 national forests of northeastern Oregon and southeastern Washington. Nonforested land constitutes approximately 31% of the total landscape administered by the Umatilla, Malheur, and Wallowa-Whitman national forests. Then I will discuss the diversity that native grasslands provide to the canyonlands of this area. I propose that principal disturbance events play a role in the formation of varying grassland communities, how the severity of the disturbances impact and influence the vitality of those communities, and consequently the composition and abundance of other organisms. Last but not least, I will summarize the overall contributions of grasslands to the enhancement of biological diversity across this varied landscape.

The northern Blue Mountains were basically formed during the Miocene when lavas extruded from fissures of local volcanoes and flooded the landscape. These formations today are collectively known as the Columbia River basalts. Then during the Pleistocene, only 2-3 million years ago, a period of erosion began that shaped the Blue Mountains and provided the especially productive grasslands and shrublands in the northern Blues.

In contrast to the northern Blues, the southern portion of the range located near the Great Basin contains large expanses where shrublands and grasslands form a mosaic and provide heterogeneity to the landscape.

However, the grasslands of northeastern Oregon and southeastern Washington are perhaps best exemplified by the landscape occurring in deeply dissected canyons of the Imnaha, Snake, and Grande Ronde river systems. It was during the Pliocene, only 10 million years ago, that the Snake River succeeded in cutting its northerly path through the Seven Devils and Wallowa Mountain uplifts. Then the spilling of Lake Bonneville's waters into the Snake River system undoubtedly doubled the erosive power of the Snake as it carved an impressive gorge through to the Columbia River. Tributary rivers, like the Grande Ronde and Imnaha, with their associated streams, transported great amounts of sediments through mass wasting. This resulted in the exposure of the basaltic layers, benches, and oversteepened slopes so common to the Snake-Imnaha canyonlands that we know today.

The grasslands that cloak the canyon slopes and ridges provide a mosaic on a contorted landscape that is highly variable. Composition of the bunchgrass communities can vary dramatically based on whether they are located immediately below the eroding rims or if they are distant from the flow edges. One of the more productive grasslands is found in the Idaho fescue (*Festuca idahoensis*)-prairie junegrass (*Koeleria cristata*) plant association. These communities are found on deep, relatively stone-free soils that contain a high percentage of windblown loess.

In contrast, on the same slope where colluvial materials increase because of gravity feed, and where the soil is incapable of retaining moisture sufficient enough to carry the fescue during the summer drought period, bluebunch wheatgrass (*Agropyron spicatum*)-dominated plant communities are found.

The aspect of bunchgrass sites also influences the kind of vegetation that can establish on them based on orientation to solar radiation and desiccating temperatures. The elevation of bunchgrass sites also determines temperature and moisture available to the plants. The fescue-dominated vegetation occurs on loess soils and northerly or easterly aspects. Droughtier sites often occur on southerly aspects that are dominated by bluebunch wheatgrass and an absence of fescue.

In the canyonlands, the ridgetops and upper slopes are capable of supporting fescue-dominated grasslands because of the lower diurnal temperatures and higher soil moisture lasting well into the summer season. The moisture-sensitive fescue is able to compete and persist on these slopes until the moisture becomes limiting and temperatures become too hot to support it. At this point, bluebunch wheatgrass and other drought-tolerant species become more dominant. Between major rims, there is also a relationship that provides diversity to the grassland mosaic on the canyon landscape. As distance increases away from the ridgetop downslope, fescue becomes less pronounced, usually merging into bluebunch wheatgrass communities until the sites are dominated finally by the more drought-tolerant bluebunch wheatgrass. Early season surface flow and subsurface moisture availability, resulting from the proximity to a basalt rim or a submerged basalt layer, can create the necessary growth conditions for domination by fescue communities at lower elevation sites. For example, at midslope levels, the inter rim slope, just above a major flow layer, often has lost the seepage water from the rim above to the extent that the fescue can no longer persist, and a bluebunch wheatgrass-dominated community is the result. Thus aspect, elevation, and basaltic flow locations all play an integral role in providing variation in overall bunchgrass community diversity.

I would now like to discuss natural disturbances as modifying events to plant community structure, composition, and distribution as it relates to bunchgrass communities. As with all vegetation in the canyonlands, the bunchgrass communities rely on periodic disturbance to rejuvenate and maintain vigor and vitality of the associated plant composition. There are key events that occur naturally, and in a cyclic way, to provide ongoing disturbances to bunchgrass communities and help to add to the overall diversity provided by the landforms.

Soil and slope movements are constant on most of the steepened canyonland slopes. These grasslands occur on colluvial slopes as well as gentle ridgetops, but perhaps most of the landscape is on slopes that are gravity fed and provide opportunities for periodic rotational slumping. Often these slumps heal with an annual vegetation occupying the slipface and deposited material as an early stage of upward succession. Over time these areas add to the diversity of the canyon landscape by providing patterns with varying successional stages of plant communities to the overall matrix.

There are very erosive basaltic layers in various portions of the Blue and Wallowa mountain canyonlands that have provided an abundant array of stone stripes as features

of the landscape. These were formed in the Pleistocene, about 10,000 years ago, when other pattern ground of the eastside landscape was created by freezing and thawing. The increase in moisture availability and soil depth associated with the deposition at the base of some stone stripes permits the establishment of highly valued shrubland communities as talus garlands across the canyon walls.

Another important periodic disturbance, which influences the structure, composition, and distribution of grasslands, is fire. Fire ignitions provided by late summer and early fall thunderstorms historically burned across these bunchgrass slopes with a haphazard, interfingering extension based on daily temperatures, wind velocity, and the microrelief of the slope. Fire was certainly not uniform its effects on the vegetation. Some areas burned intensively where standing biomass was dense and grass crowns were dry; others were burned lightly or missed altogether.

Bunchgrass communities can rebound dramatically following a fairly continuous removal of the standing vegetation by wildfire. I have noted a positive stimulus to the bunchgrass community as a result of increased plant vigor and increased seed head production on bunchgrasses immediately following the wildfires of 1986–89. Most of the late summer fire events in grassland communities in northeastern Oregon and southeastern Washington did not significantly alter the composition of the bunchgrass communities and usually did not damage them.

A summary regarding the bunchgrass-dominated plant communities, which have been burned with varying fire intensities in northeastern Oregon from the fires of the last 5 years, shows a consistent pattern of renovation and rejuvenation to these bunchgrass-dominated plant communities when fire has visited them in late summer.

Next I will discuss grazing as a natural event in the grasslands. Grazing, like fire, can be a stimulus to the bunchgrass plants in providing a natural, beneficial role to plant vitality and community stability. The key to maintaining and enhancing bunchgrass communities through grazing management lies in timely grazing of the plants and in the moderate use of the plant community. Different classes of ungulates tend to graze the bunchgrass community preferentially seeking different plant species within the community, which can benefit the vigor and vitality of the overall vegetation.

Unfortunately, our native grasslands were unable to sustain some of the heavy use by domestic sheep operations that grazed the canyon and subalpine grasslands earlier in this century. Estimates for the period before national forest establishment range from 200,000 to 380,000 sheep using the grasses of the canyonlands and the high Wallowa Mountains.

Gentle ridgetops and basins were particularly vulnerable and heavily used. The modification of bunchgrass communities was the greatest where the grazing animal had the easiest access to the range. Perhaps the greatest detrimental grazing practice, which severely decreased the vigor of bunchgrass plants, has been the use by domestic ungulates too early in the season and for too many seasons over time.

As an example of another bunchgrass ecosystem, green fescue (*F. viridula*) communities occurring in the subalpine elevations of the Wallowa Mountains provide valuable lessons to the investigator studying plant succession. Communities of the green fescue-spurred lupine (*Lupinus laxiflorus*) plant association provide examples of how disturbances influence the structure, composition, and vitality of this vegetation.

Green fescue communities occur at high elevations in the Wallowa Mountains where a cold, moist climate permits the green fescue to out-compete Idaho fescue. In late seral stands, green fescue forms dense mats with relatively few breaks in the continuous sod.

Soils for this green fescue plant association are deep, averaging 40 inches, with a fine silt loam surface soil, and a loamy or sandy clay loam subsoil. These deep soils have a high water holding capacity enabling the green fescue plant to persist in what would otherwise be a very harsh environment. The fescue is able to develop a dense sod mat that helps retain moisture throughout the summer season and a normal month-long droughty period.

Mid-seral stands are characterized by a codominance between the fescue and spurred lupine and a greater composition of needlegrasses (*Stipa* spp.) and sedges (*Carex* spp.). The late seral fescue community can contain 65% coverage by fescue with $\leq 1\%$ by spurred lupine. A mid-seral stand may be exemplified with the following coverages: green fescue, 30%; spurred lupine, 40%; needlegrass, 10%; and Hood's sedge (*C. hoodii*), 10% of the composition.

Unfortunately, green fescue grasslands were unable to sustain some of the heavy use by domestic sheep operations that grazed these subalpine grasslands during the summer months earlier in this century. Gentle ridgetops and basins were particularly vulnerable and heavily used. As a result, many sites were degraded and succession retrogressed, with the resulting vegetation exemplifying an early seral stage. This stage can be characterized by a dominance of lupine over the fescue.

In addition to a retrogressive pathway with increased lupine, this plant association can also degenerate from its highly continuous cover by fescue to a dominance by needlegrasses.

In 1937, Pickford and Reid selected Tenderfoot Basin in the subalpine zone of the Wallowa Mountains for a location to study plant succession and the effects of over-use on green fescue grasslands. They then selected a second study location known as the Nebo Range. This was to be a comparative area where green fescue communities were in good ecological condition. Here sheep use had been much lighter as a result of shepherders avoiding the ridge because of a historical poisoning and dieoff of sheep.

At Nebo, green fescue coverage was approximately 85% with little else associated vegetatively. Needlegrass accounted for $\leq 5\%$ of the cover with only a trace of sedges. A noticeable hummocky appearance to the site provided a good indication that this grassland had received some abuse in its past.

But the accounts of the fescue grassland in Tenderfoot Basin were dramatically different. Degradation caused by domestic overgrazing left deep depressions caused by subsequent soil loss due to wind and water erosion. These depressions resulted in an erosion pavement caused by exposure and accelerated surface soil removal by winds, melt waters from receding snowbanks, and high intensity summer storms.

The primary degrading of these grasslands occurred as a result of too many domestic sheep grazing for too long a period of time, too early in the season, season after season. The result was an inability of the plants to retain their vigor and maintain occupancy of the site.

The ending to the green fescue story is one of optimism in the sense that many degraded sites in the Wallowa Mountains are rebounding from their depleted condition during the earlier part of this century. Highly eroded ridgetop sites are being recolonized with perennial plants such as 2 species of pussytoes (*Antennaria* spp.), sedges, and Parry's rush (*Juncus parryi*).

To depict successional stages of yet another important bunchgrass plant association, I would like to discuss the Idaho fescue-bluebunch wheatgrass plant association. Communities of this association are very widespread through the Blue and Wallowa mountains and associated canyonlands.

Typically a late seral Idaho fescue-bluebunch wheatgrass community contains bunchgrasses dominating with a coverage exceeding 50%, with forbs and annual grasses subordinate. A mid-seral stand is also dominated by the bunchgrasses, but at coverages closer to 40%, with forbs increasing compositionally.

An early seral stage of this plant association would be characterized as having the 2 primary bunchgrasses with a combined cover of only 25%. Dominance might be by arrowleaf balsamroot (*Balsamorhiza sagittata*), creamy buckwheat (*Eriogonum heracleoides*), yarrow (*Achillea millefolium*), and various annual forbs and grasses. The other part of this story involves the interspaces between the caespitose grasses. The late seral bunchgrass site might have a nonvegetative surface comprised of bare ground and rock of approximately 30%. In contrast, the more degraded, early seral site typically has a nonvegetative surface of $\geq 60\%$.

In the Blue Mountains of northeastern Oregon and southwestern Washington, grazing animals have had a long relationship on the montane grasslands. These grasslands evolved with light grazing and periodic fire as stimuli to renovation and reinvigoration of the perennial grass-dominated plant community. With increasing pressure by herbivores, plant composition was modified, resulting in an increase in plant species diversity. This increase in diversity decreases the capacity of the dominant bluebunch wheatgrass and Idaho fescue to exclude other species and creates gaps available for occupation by other plants. As grazing frequency and intensity continues to increase, the level of disturbance will reach a threshold where diversity is lowered.

The landscape of the Blue and Wallowa mountains and associated canyonlands exhibits very spectacular relief, varied geologic formations, differing soil fertility, and a resultant assemblage of grassland vegetation, shrubland vegetation, and forest vegetation that gives the area a tremendous natural biological diversity. When disturbances are periodic and moderate, the results have been an accentuation of varied plant communities providing habitat for an equally high variety of fauna. However, when disturbances are too severe, too frequent, or out of sequence phenologically, grassland health deteriorates, and with it, depending on magnitude, the ability of the overall ecosystem to rebound.

The native grasslands form a mosaic created by topographic landform undulations that in turn produce microclimates and promote different grassland structures and compositions. Added to this diverse landscape are the superimposed modifications by past fires and by grazing pressures that have combined to form various seral stages across the land. These are certainly not undesirable from an ecological perspective.

Undisturbed late seral grasslands dominated by bunchgrasses to the virtual exclusion of other plants may provide the best forage for grass-eating ruminants. But, the greater diversity in plant species composition found in mid-seral stages of bunchgrass plant associations may provide the most balanced offering for all users of the grasslands. Certainly the increased plant species richness found in mid-seral successional stages provides a level of overall stability to the community.

Early and very early seral stages of grasslands may be a cause of concern for land managers today. Many of these have been so thoroughly degraded that they no longer contain bunchgrass vegetation capable of establishing on the site. Alien vegetation, such as cheatgrass (*Bromus tectorum*), has naturalized in many of the degraded bunchgrass communities to the point that its invasion can become permanent and complete unless degrading influences to the site are moderated.

The native bunchgrasses of northeastern Oregon have diminished on gentle bottoms, benches, and ridgetops. These sites have been severely affected by the plow, as well as the grazing animal. Alien plants often have become firmly established, with little chance for natural succession to return native bunchgrass vegetation to those sites without intervention by land managers.

Perhaps the most degraded bunchgrass sites are found on the structural benches of the Snake, Imnaha, and Grande Ronde river canyons. Homesteaders, early ranchers, sheepherders, and wild ungulates all converged on these benches for the lush vegetation and ease of movement in an otherwise vertical world. Today the bunchgrasses are absent or nearly so. Kentucky bluegrass (*Poa pratensis*) has become the primary invasive species to dominate these benches whereas red threeawn (*Aristida longiseta*), annual bromes, and goatweed (*Hypericum perforatum*) all may be found in large patches throughout these bench lands.

Perhaps the most virulent of all aliens to overtake bunchgrass sites has been cluster tarweed (*Madia glomerata*) on ridgetops and interforest clearings in the Blue and Wallowa mountains. This opportunistic plant entered these communities when grazing animals, in numbers that exceeded carrying capacity, were depleting the native bunchgrass vegetation from these ridgetops. Herbivore use was often too early in the season and sustained for too long throughout the grazing period. In subsequent growing seasons, native perennial plants were incapable of naturally rehabilitating these sites because the pressure was once again applied by too many animals too soon and for too long in the season. As a result, the tarweed, with its superior competitive capability, was able to totally occupy the site, resulting in a very simplistic plant community. Biological diversity had consequently been diminished.

With the almost total occupation of highly productive sites by the cluster tarweed plant community, there was little palatable vegetation for domestic or wild ungulates. The task of rebuilding biological diversity through diversification of the plant community using earlier seral forbs and bunchgrasses should be a priority on those sites that still retain their inherent productive potential.

In the canyonland ecosystem, undulating ridgelets with their intervening drainages provide a vertical and horizontal array of plant communities. Relatively small patches are nested within a larger forest expanse up the drainage toward contiguous forest whereas a larger nonforested expanse occurs down the drainage away from the forest. These patchy canyon segments represent perhaps the greatest area of biological diversity within this highly varied landscape. As we consider the value of edge, as well as the importance of corridors for genetic and biotic transport, we can appreciate the value of retaining the inherent diversity of landscapes such as these.

It seems to me that many of us look across a grassy slope or a grassy ridgetop and overlook the variation that is played out before our eyes. For here in that landscape view is captured a natural diversity provided by soil depth, slope position, and aspect in providing a varied mosaic of plant communities. The occurrence of fire passing through this landscape, perhaps not as frequently as in the historical past, has influenced the composition and vigor of the included plants. And lastly, the slope has been a constant provider of forage and browse for large ungulates, as well as home to many other mammals, birds, reptiles, and insects. They too have a role to play in the evolutionary change brought on by their habitation, just as strongly as climatically induced modifications.

In conclusion, the eastside landscape, and its vegetation, has been modified by disturbing agents and activities for a millennia. Some of these modifications are natural to the ecosystems and are part of the process of ecosystem maintenance. They have enhanced the grasslands, shrublands, wetlands, and forests that have given us the biological diversity that compliments the overall diversity of the mountains and canyons.

Soil fertility, moisture, temperature variation, and the presence of disseminules are the key factors influencing plant community development. As a modification occurs on a site, any one, or all, of these factors may be negatively affected if that disturbance is too severe, or too frequent, or as in the case of fire, too long removed from participating in a regular way as a change agent for the plant communities and their included biota. Regarding the restoration of these ecosystems, it is imperative that we understand the interactions of the component parts. That is easy to say but is harder to do. It takes the collective wisdom of scientists from various functional persuasions mixing with land managers and techni-

cians. They must employ the science and technology that they collectively can muster to do what is right for all of the parts of the included ecosystems within a given landscape.

The time to act is now. The way to act is to focus on the landscape, to emulate the disturbances that have created and shaped its plant communities, to initiate projects on a large scale that use modifying events to enhance the combined plant communities of the included ecosystems, and to cease those destructive activities that do not replace elements required by the ecosystem for its maintenance and enhancement.



SUBSOILING AND GRAZING EFFECTS ON GROWTH OF NITROGEN-FIXING SPECIES

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Abstract: Compaction on logging roads is equated with lost forest productivity. Three methods of mitigating existing compaction were attempted: a subsoiling (ripping) treatment, grazing exclusion, and broadcast seeding of nitrogen-fixing species. Three legume species and Sitka alder (*Alnus sinuata*) were broadcast seeded after ripping forest roadbeds. Grazing exclusion cages were used within plantings to measure compaction effects by large animals. Soil compaction was not increased or decreased by any treatment. Ripping allowed deeper penetration of roots, and no ripping increased root numbers. There were no differences in rooting depth or numbers of roots within versus outside grazing exclusions. Alsike clover (*Trifolium hybridum*) grew the most roots and they extended deeper into the soil profile than other species. Mountain lupine (*Lupinus albicaulis*) varied the most in all growth parameters. Seeded alder did not germinate and begin growing until the second year and black medic (*Medicago lupulina*) did not seem to be suited to this northern high elevation area.

Key words: *Alnus sinuata*, alsike clover, black medic, compaction, *Lupinus albicaulis*, *Medicago lupulina*, mountain lupine, roads, roots, Sitka alder, subsoiling, *Trifolium hybridum*.

Ground-based timber harvesting activities require extensive road systems in northwestern forests. The use of heavy equipment to move timber from felling areas to spur roads and on to primary roads has been estimated to impact 10% of the ground area of a sale unit (Garland 1983). Heavy equipment weight, season of activity, soil type, and number of vehicular passes all affect the relative degree of compaction in these areas (Glinski and Lipiec 1990, Jarmer et al. 1992). Surface (top 5 cm) compaction changes with time and is generally a self-healing process, often occurring over the course of 18 months (Glinski and Lipiec 1990), but subsoils stay compacted to a greater degree and for a much longer period of time. The vertical distribution of roots is restricted to surface layers in highly compacted soils (Russell 1988, Glinski and Lipiec 1990). Classic examples in forested areas are of tree roots that grow to the hard pan and begin lateral branching at a shallower level than normal for the species (Heilman 1981). This condition causes premature windthrows or drought-related mortality caused by unnatural growth morphology of the roots and reduced rooting depth. Livestock and large wild ungulate use of these roads also creates a potential for additional surface and subsoil compaction.

The nature of compaction problems on logging spurs has not been extensively examined in north-central Washington, nor have the benefits of subsoiling (hereafter called ripping) compacted road areas. Vegetative restoration of compacted logging spurs is often practiced to decrease erosion by increasing infiltration rates (Everett et al. 1990), but to what degree vegetation is able to decrease compaction in

this area is unknown. In this study we examined the relationships of ripping, restricted use by large herbivores, and the use of leguminous plant species to decrease compaction and revegetate logging spurs.

METHODS

One site on the Okanogan National Forest in northeastern Washington was selected for this study. Elevation at this site on the Tonasket Ranger District (SE 1/4, Sec. 2, T. 38 N., R. 29 E.) is 1,707 m (5,600 ft). Rainfall averages 64–76 cm (25–30 inches) per year. The soil is classified as a loamy-skeletal, mixed, Andic Cryochrepts (ash over till parent material). The bedrock is medisedimentary and includes mesozoic granitic rock. There was moderate rill erosion potential on the roadbeds, and they were mostly well drained, with the exception of 1 area where there was seepage from a nearby creek.

Two short roads, 1 near the bottom (slope approximately 15%) and 1 midway through a shelterwood harvest site, were each divided into 3 areas for a total of 6 blocks. Ripping to 46 cm (18 inches) was accomplished by dragging tines behind a Caterpillar tractor and was done in alternate blocks. Preliminary bulk densities to measure soil compaction were taken after ripping but before other treatments. Bulk densities were taken again after 3 years.

Leguminous plants were broadcast seeded on the roads in an attempt to increase soil nitrogen while alleviating compaction. Based on prior research (Java-Sharpe et al. 1995) alsike clover (*Trifolium hybridum*), black medic (*Medicago*

lupulina), and mountain lupine (*Lupinus albicaulis*) were the 3 herbaceous species chosen for planting in this study. Mountain lupine seeds were scarified before planting; alsike clover and black medic seeds were not scarified because hard-seed values were only 3 and 1%, respectively. The 3 herbaceous legumes were inoculated with compatible rhizobium mixed with 2% milk immediately before seeding.

We chose Sitka alder (*Alnus sinuata*), a woody species, because of its known ability to revegetate disturbed areas (Tarrant and Trappe 1971). Alder seed was collected at 1,067 m (3500 ft) in elevation, from an area approximately 161 km (100 miles) southwest of the study plots. The seed was broadcast without stratification or inoculation with rhizobium. The alder seed was not inoculated; the soil in the vicinity was expected to contain adequate amounts of rhizobium because of the native population of Sitka alder.

Each block was divided into 5 44-m² (12 x 40 ft) plots and each plot was randomly chosen for broadcast seeding with a single leguminous species in May 1991. One randomly located control plot was left unplanted in each block. Alsike clover, black medic, and Sitka alder were all seeded at a rate of 344 seeds/m² (32 seeds/ft²). Because of its larger seed size, mountain lupine was seeded at 172 seeds/m² (16 seeds/ft²). Two sets of nested subplots were established in each block. Each set contained a 0.45-m² (4.8-ft²) grazing exclusion cage and an uncaged area of the same size adjacent to the grazing exclusion.

Cover values, measured as percent cover/area, were determined for each species 1 and 3 years after seeding. In the third year, cover values of indigenous (native) species also were recorded. Aboveground biomass of seeded species also was determined for each nested subplot by clipping to 1 cm above the soil surface. Biomass was calculated for leguminous species on a dry-weight basis for the second and third years after seeding. In the second year pits were dug at the base of 1 plant in each of the nested plots to a depth of 70 cm (27 inches) or to solid rock, whichever came first. Bulk densities were collected at the surface and at every 20 cm (8 inches) thereafter to the bottom of the pit. The profile wall method was used to determine root distribution of planted species (Mackie-Dawson and Atkinson 1991). The number of roots in 50-cm² (7.8-in²) rectangles were counted at 5-cm (2-inch) intervals down the soil profile, beginning at the base of individual plants.

Collected data were first analyzed by ANOVA to determine if there were significant differences ($P = 0.05$) between mechanical treatments and among individual legume species. Further analyses were conducted using averages and confidence intervals ($P = 0.05$).

RESULTS

No significant differences in bulk density were detected for any treatment or species over time, among, or between any treatments (Fig. 1). There was, however, a trend toward higher bulk densities in ripped plots compared to unripped

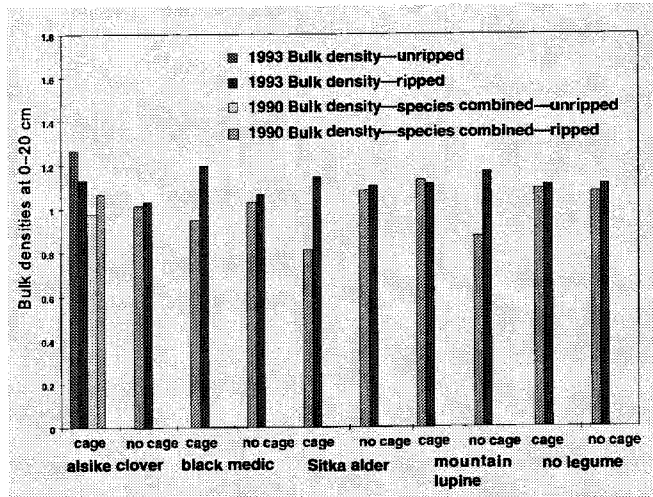


Fig. 1. Average bulk densities before seeding and grazing exclusion and 2 years later.

plots. The significant differences detected concerned the performance of plant species compared to each other and their responses to ripping and grazing exclusion.

Species were first combined and summarized by mechanical treatment. The number of roots and rooting depths seemed to exhibit dissimilar responses, tending to have the deepest roots in ripped plots and the most roots in unripped plots (Figs. 2 and 3). There were no differences inside versus outside cages. Root growth data were then combined by species without regard for mechanical treatment; alsike clover had deeper roots than all species except black medic and more roots than all other species at the end of 2 years (Fig. 4). When species were compared based on mechanical treatment, uncaged alsike clover in ripped plots had deeper roots than Sitka alder and mountain lupine, and had deeper roots than black medic growing in unripped plots (Fig. 5). Mountain lupine produced more roots in unripped than in ripped plots (Fig. 6). Sitka alder, in both caged and uncaged areas, and black medic in caged areas also tended to have more roots in unripped blocks than in ripped blocks but not significantly so.

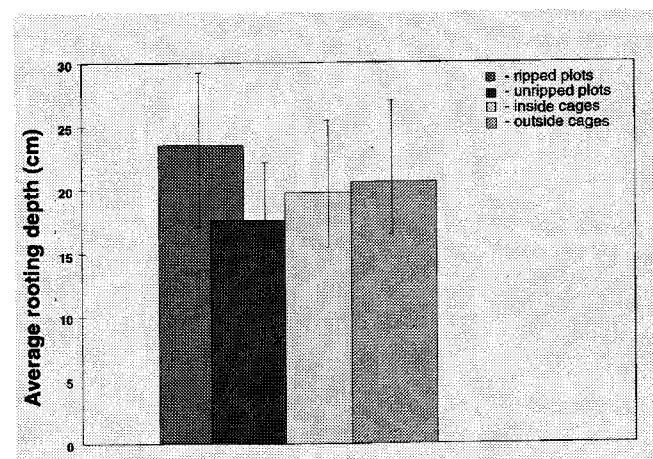


Fig. 2. Average rooting depth for all species combined in ripped and unripped plots, and inside and outside cages, 1993.

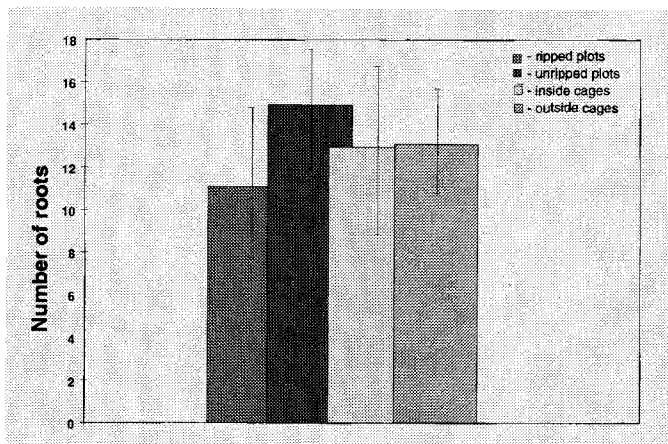


Fig. 3. Average number of roots for all species combined in ripped and unripped plots, inside and outside cages, 1993.

In the first year after seeding, alsike clover in unripped plots had higher cover values than all other species, except black medic seeded into ripped plots (Fig. 7). In the third year after seeding, alsike clover had significantly more cover than all other seeded species and more alsike clover cover occurred in unripped than in ripped plots.

In the second year, alsike clover in ripped plots produced more biomass than Sitka alder in mechanical treatments and more than black medic seeded into unripped areas (Fig. 8). Alsike clover also produced more third-year biomass than all other species in all treatments but unripped plots had values comparable to third-year Sitka alder. Mountain lupine produced the most biomass in year 2 after planting but variation between subplots was high. By the third year there was little or no mountain lupine in any of the plots. No germinated Sitka alder was observed in the first year after planting but by the third year it was second in biomass production after alsike clover.

Native plant cover responded negatively to ripping in control plots (Fig. 7) and black medic plots had less native cover in ripped than in unripped areas. Alsike clover also suppressed native cover when compared to unseeded control plots.

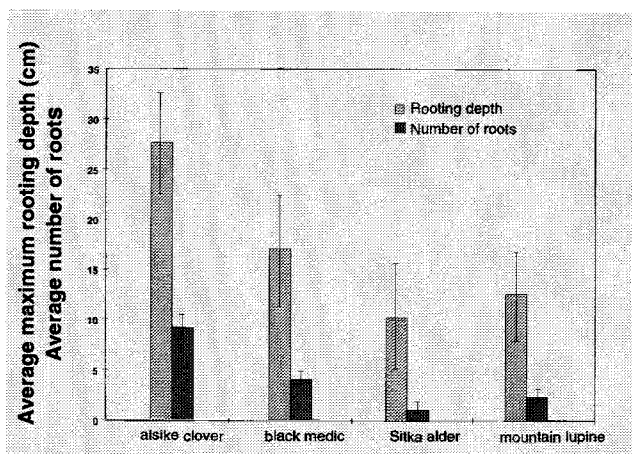


Fig. 4. Rooting depth and number of roots of legume species, regardless of mechanical treatment, 1993.

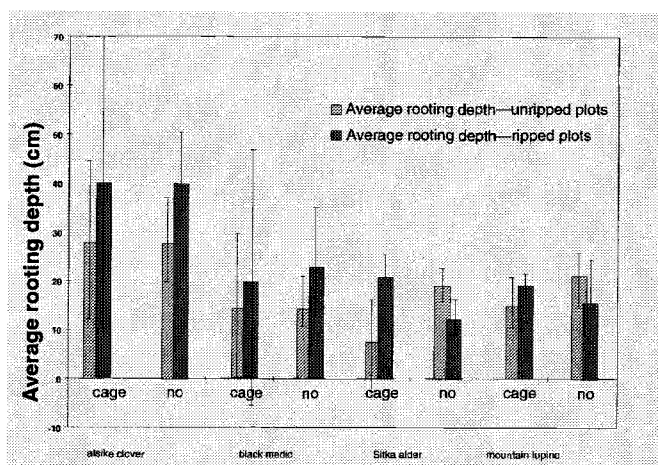


Fig. 5. Average rooting depth of planted legumes for ripped and unripped plots, inside and outside cages, 1993.

DISCUSSION

Efforts to ameliorate soil compaction on this site were unsuccessful using the chosen techniques during the 3-year time frame of this study. Ripping was expected to decrease compaction but actually may have increased it slightly. Meek et al. (1992) found similar results in an agronomic study involving tillage and traffic in cropping systems. It is possible that the timing of the ripping treatment may have influenced the results because of the amount of moisture in the soil when ripping occurred (Glinski and Lipiec 1990). Grazing effects are also known to increase compaction, dependent on soil type and number of passes (Orodho et al. 1990, Scholand et al. 1991). Number of passes by cattle were not measured but heavy grazing was observed on alsike clover and black medic plots, light browsing occurred on Sitka alder and lupine plots, and cattle trails were evident on all plots.

Soil bulk densities on this site were not affected by the root growth of seeded species; however, establishment of seeded species on this site guarantees a certain amount of increased soil fertility (Schmidt and Brübach 1993). Alsike clover was the most successful legume species on this site. It is expected that over time Sitka alder will overtake alsike clover in biomass production and eventually dominate the sites where it was planted if the seed has not been moved too far from its source. How far Sitka alder seed can be moved is unknown.

Mountain lupine's population collapse after 2 years was not surprising. Its behavior in more Mediterranean climates is that of a biennial although it is sometimes listed as a short-lived perennial (U.S. Dep. Agric. 1980). Others have experienced similar patterns of growth associated with these lupines (Schmidt and Brübach 1993). This type of growth can be beneficial where short-lived nonnative species are desired for a quick pulse of nitrogen input to a site. One unknown factor in the use of this species is its possible allelopathic effects on soil and neighboring vegetation. No toxic symptoms were detected in livestock when tests were conducted using mountain lupine (U.S. Dep. Agric. 1980). Black

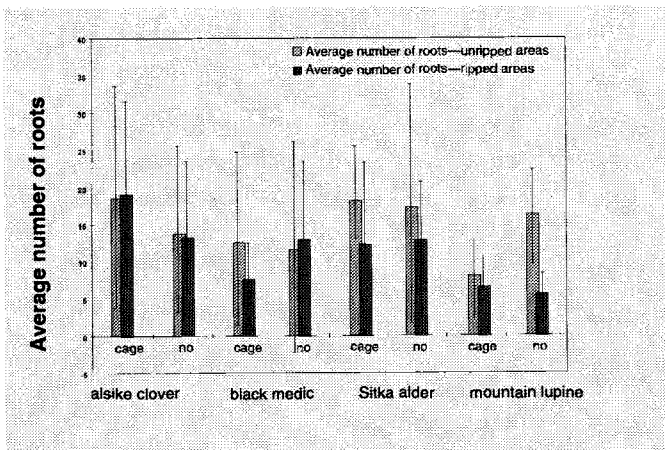


Fig. 6. Average root numbers in ripped and unripped plots, inside and outside cages, 1993.

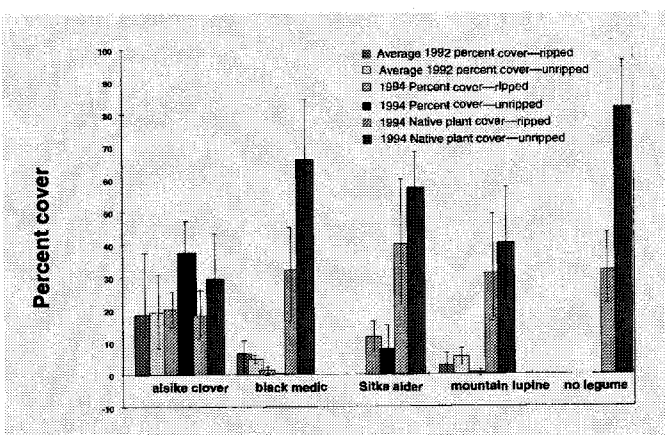


Fig. 7. Legume and native plant cover, 1992 and 1994.

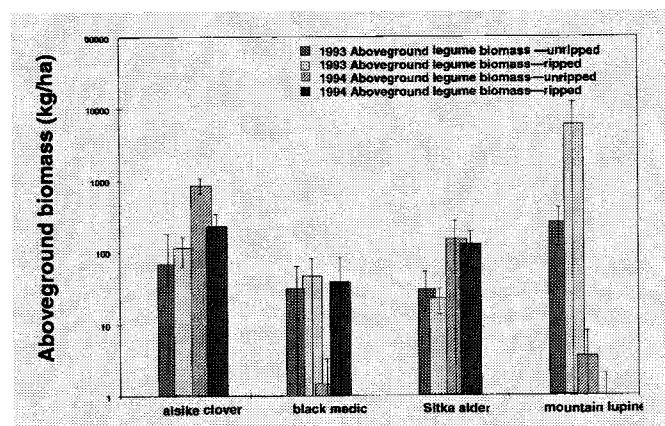


Fig. 8. Aboveground biomass of planted legumes, 1993 and 1994.

medic's performance in terms of root growth was second only to alsike clover. It seems to have the potential to grow in compacted soils, but at this site, establishment was less than needed for site amelioration. Cover values were low and few seed-producing adults survived through the end of the third year. This species can be expected to inhabit little if any of the site over extended time periods.

Overall, the vegetation sampled tended to have deeper roots in ripped versus unripped plots. It can be hypothesized from this result that whereas ripping treatments did not change compaction, they did open opportunities for root elongation by the displacement of soil as ripping tines went through the roadbed. Because there tended to be fewer roots and less aboveground biomass and cover in ripped areas, it could be further postulated that the plants compensated for added effort in root elongation by decreased shoot:root ratios (Wilson 1975, Glinski and Lipiec 1990, Rundel and Nobel 1991). The fact that native plant cover was significantly lower in ripped control plots compared to unripped control plots is cause for concern. Further work is needed to determine the validity of these theories. Additional subjects for study on this issue include testing of other species for survival and root growth, and extending the length of this study to observe long-term changes in compaction.

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REDUCTION OF BIG SAGEBRUSH CANOPY COVER USING REDUCED RATES OF SPIKE® 20P

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Abstract: Big sagebrush (*Artemisia tridentata*) management can be accomplished by using reduced rates of Spike® 20P herbicide to thin the density of this native brush species. Plant and small mammal community diversity is increased in areas treated with low rates of Spike® 20P. Grass production also is increased allowing for better management for wildlife habitat or livestock grazing. Spike® 20P is registered by the U.S. Environmental Protection Agency for use on range, rights-of-way, and other sites. Rates of 3.7–5.0 lb/acre will control sagebrush, but rates of 1.0–2.5 lb/acre will effectively thin the sagebrush density.

Key words: *Artemisia tridentata*, biodiversity, sagebrush, Spike® 20P, tebuthiuron.

Big sagebrush (*Artemisia tridentata*) is the dominant shrub on almost 100 million acres of rangeland in the western United States (Vale 1974). Although it is a native plant in this ecosystem, its density has increased on many acres because of past management practices. This increase in big sagebrush density decreases the ecosystem's plant diversity and negatively impacts livestock grazing and wildlife habitat (Pieper 1991). The vast root system and competitive ability of big sagebrush causes not only a reduction in herbaceous plant diversity, but also a reduction in soil moisture resulting in lowered water tables, decreased water volume in creeks and springs, and degraded riparian areas.

Controlling dense stands of big sagebrush has been recognized as a positive range management practice for many years. Traditionally, sagebrush control programs included mechanical or selective chemical treatments aimed at total control of sagebrush. The most common herbicide used in this program was 2,4-D, which was erratic in controlling big sagebrush; the sagebrush completely reestablished in treated areas within 5–10 years after treatment. Mechanical treatments were not selective and destroyed wildlife habitat along with the sagebrush (Swenson et al. 1987).

Spike® 20P (Trademark of DowElanco), a pelleted clay formulation with 20% active ingredient (tebuthiuron), was introduced for brush control in 1974. The efficacy of Spike® 20P on big sagebrush was first reported by Klauzer and Arnold (1975). Additional studies (Whitson and Alley 1982, McDaniel et al. 1992) showed that 5 lb/acre Spike® 20P would effectively control sagebrush from 95 to 99% of the original population densities. In areas where sagebrush was controlled, grass production was increased 2.5–5.5 times (McDaniel et al. 1992).

In 1989–90, Whitson conducted follow-up evaluations on big sagebrush research with Spike® 20P established in 1980 and 1982. Results demonstrated that reestablishment of big sagebrush did not occur and forage growth increased on plots that had partial control (thinning to $\leq 70\%$ of the original plant density) 10 years after treatment. Whitson suggested that thinning the sagebrush density would fit many

current land managers' program objectives of providing a diverse, mixed sagebrush ecosystem for improved wildlife habitat.

Further research was conducted to assess diversity in both plant and small mammal communities at various sagebrush density levels resulting from treatment with Spike® 20P. Johnson et al. (1993) found that the plant community diversity was greatest when sagebrush was reduced by 48 and 66%. Big sagebrush reduction of 85% and the untreated control were the least diverse. Small mammal community diversity increased significantly with increased plant community diversity.

These results stimulated additional interest in evaluating the concept of thinning sagebrush with Spike® 20P. In 1993, sites treated up to 10 years earlier were selected for further evaluation based on Spike® 20P rates and site characteristics.

MATERIALS AND METHODS

Treatment method and herbicide rates varied between the research locations. Treatments were applied by air at Rexburg, Idaho, and Tres Piedras, New Mexico, to plots measuring 250 ft x 1,700 ft separated by a 250-ft buffer. One replication of 1.0 lb/acre Spike® 20P was applied on 10 October 1983 at Rexburg and 1 replication of 1.5 lb/acre Spike® 20P was applied on 12 April 1983 at Tres Piedras. At Littlefield, Arizona, and Vernon, Utah, treatments were applied by ground to 100-ft x 125-ft plots arranged in a randomized complete block with 2 replications/treatment. Treatments at Littlefield included 1.5 lb/acre Spike® 20P applied on 27 January 1983. Rates at Vernon included 1.0 and 1.5 lb/acre Spike® 20P applied on 18 May 1983.

Site characteristics varied by location (Table 1). Soil types ranged from loamy sand to loam with organic matter from 1.7 to 4.9%.

Evaluations were made at the locations in 1985 by counting live and dead plants in 4 random areas across the plot and calculating percent kill. These data are not reported here.

Table 1. Site Characteristics in Spike® 20P research trials.

Location	Soil type	Sand (%)	Silt (%)	Clay (%)	Organic matter		Mean precip. (in)
					(%)	Ph	
Rexburg, Id.	loamy sand	87	7	6	1.9	7.1	13
Vernon, Ut.	loam	34	37	29	2.7	8.1	11
Littlefield, Ariz.	loam	39	49	12	2.6	8.4	11
Tres Piedras, N. M.	loam	17	49	34	2.9	6.9	15

Evaluations in 1993 were taken by randomly placing 8 100-ft tapes in each treated and untreated area and recording the portions of the tape covered by big sagebrush live canopy. Percent canopy cover and percent canopy cover reduction were calculated from these numbers (Table 2).

RESULTS AND DISCUSSION

The effectiveness of tebuthiuron on big sagebrush is dependent on the availability for root uptake. Tebuthiuron is more available for root uptake in a coarse soil with low organic matter. Conversely, on fine textured soils with high organic matter and clay content, a greater portion of the tebuthiuron will be absorbed in the soil material and less is available for uptake.

At 10 years after treatment the big sagebrush canopy cover was reduced at all sites. The amount of reduction depended on the initial sagebrush canopy cover, the rate of

coarse soil and lower percentage of organic matter. Sagebrush canopy cover reduction at Rexburg was greater than for the same rate applied on heavier soils with a higher percentage of organic matter at Vernon (Table 2). Sagebrush canopy cover reduction was similar (68–73%) at Vernon, Littlefield, and Tres Piedras with the same rate of Spike® 20P and similar soil characteristics. These data show that big sagebrush did not reestablish in treated areas up to 10 years after treatment.

Forage data from Vernon show that there was an increase in forage production on treated versus untreated plots. Untreated plots averaged 115 lb/acre grass production, whereas the 1.0- and 2.5-lb Spike® 20P treated areas averaged 566 and 1,000 lb/acre grass production, respectively.

CONCLUSION

These studies indicate that reduction of big sagebrush canopy cover can be accomplished by using reduced rates of Spike® 20P. These lower rates have been shown to improve ecosystem diversity of both plants and small mammals. Results from these locations are similar to those of Whitson and Alley (1982) that show the sagebrush did not reestablish to original levels after treatment with Spike® 20P at up to 10 years after treatment. New research has been initiated by Whitson and Olson in Wyoming to document effects of thinning sagebrush on sage grouse (*Centrocercus urophasianus*) and pronghorn antelope (*Antilocapra americana*) habitat.

Spike® 20P is registered by the U.S. Environmental Protection Agency for use on rangeland, rights-of-way, and other sites. Labeled rates for control of sagebrush are 3.7–5 lb/acre. Rates to thin sagebrush are much lower (1.0–2.5 lb/acre) and can be used to improve wildlife habitat or for a compromise management objective for wildlife/livestock areas.

Spike® 20P offers the unique opportunity to design a big sagebrush management program to improve wildlife habitat by thinning the density of a native species (big sagebrush) or to control the sagebrush and increase forage production for livestock management

Table 2. Percent sagebrush canopy cover and reduction from Spike® 20P treatments at 10 years after treatment.

Location	Soil type	Rate (lb/acre)	Canopy cover (%)	Canopy cover reduction (%)
Rexburg, Id.	loamy sand	1.0	4	76
		untreated	17	0
Vernon, Ut.	loam	1.0	11	56
		untreated	25	0
Vernon, Ut.	loam	1.5	7	72
		untreated	25	0
Littlefield, Ariz.	loam	1.5	6	65
		untreated	17	0
Tres Piedras, N. M.	loam	1.5	6	75
		untreated	24	0

Spike® 20P used, and the soil type. Lighter soils had greater canopy reduction than heavier soils or those with a higher percentage of organic matter. The Rexburg location could be considered an optimal site for tebuthiuron because of the

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USE OF SEWAGE SLUDGE BIOSOLIDS TO IMPROVE DEGRADED RANGELANDS

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Abstract: Heavy livestock pressure on southwestern rangelands has decreased vegetation production and cover while concurrently degrading soil properties, including organic matter content. Many degraded areas may not recover merely by removing or reducing livestock grazing. Treatment of degraded areas with municipal sewage sludge application may be an excellent means of improving rangeland conditions because of the sludge's high fertility and soil conditioning attributes. For nearly a decade, the U.S. Forest Service has conducted research on land application of municipal sewage sludge as an organic amendment to degraded rangelands. A preliminary study investigated the effects of different quantities of sludge biosolids on vegetative growth and plant and soil chemistry. A one-time surface application of sludge biosolids at either 22.5 or 45 Mg/ha¹ (10–20 tons/acre) significantly increased plant production and ground cover without producing undesirable levels of potentially hazardous elements, including heavy metals, in either soils or plant tissues. A second study investigated the effects of biosolids application on surface runoff and runoff water quality. Both natural and simulated rainfall showed that a surface application of sludge biosolids greatly reduced runoff by increasing ground surface roughness, thereby significantly increasing infiltration. Surface water quality was not affected by potential contaminants in the biosolids. Our current research includes the establishment of a demonstration project (50 ha) to investigate the effects of sludge biosolids on southwestern rangelands at the landscape ecological scale.

Key words: grassland restoration, New Mexico, organic amendments, plant nutrient increases, plant response, runoff control, semiarid soils.

Overgrazing by livestock is responsible for the desertification of more land than any other factor in the U.S. (Sheridan 1981). Desertification results in a substantial reduction in plant cover and density and soil organic matter accompanied by increased erosion and sediment problems (Dortignac and Hickey 1963, Sheridan 1981). These once productive grasslands may deteriorate to a point where they may never recover if the current degradation is not reversed. Successful grassland restoration in degraded areas will require an increase in plant production, a reduction in soil erosion, and ultimately, the replenishment of soil organic matter. Removal of livestock grazing pressure would likely increase vegetative cover and plant litter additions over time, but this "passive approach" to rangeland restoration would be slow and the replenishment of diminished soil organic matter could take decades. The preferred alternative is the employment of an "active" management practice that directly replenishes depleted organic matter and plant nutrients and thus more rapidly increases vegetative growth and ground cover.

Municipal sewage sludge is an excellent choice as an organic soil amendment because it is readily available, contains comparably high levels of plant nutrients (particularly nitrogen and phosphorus), and has excellent soil conditioning capabilities (Catroux et al. 1981, Glaub and Golueke 1989). The U.S. Environmental Protection Agency strongly encourages municipalities to explore new and innovative means of beneficially using sewage sludge biosolids rather

than disposal modes such as land-filling and below-ground injection (U.S. Environ. Prot. Agency 1984). Potential benefits and environmental problems associated with land application of sewage sludge biosolids have been studied extensively for many years in mine-land reclamation (Sopper and Kerr 1979, Kerr and Sopper 1982, Suhr 1982, Seaker and Sopper 1988) and in agricultural systems where sludge biosolids have been used as a soil amendment and fertilizer source (Kelling et al. 1977, Sommers 1977, Williams et al. 1980, Berry 1982, Sposito et al. 1982, Coker 1983, Berglund et al. 1984). However, in-depth studies of the beneficial and potentially detrimental effects of sludge biosolids application to arid and semiarid rangelands have occurred only within the past 10 years (Gallier et al. 1993).

The research summarized in this paper consists of a series of studies in New Mexico using sewage sludge biosolids as a soil organic matter and nutrient amendment in an attempt to increase rangeland production and decrease runoff and sediment yields. Specific research objectives were to (1) determine the effects of different rates of sewage sludge application on soils and vegetation in a semiarid grassland environment; (2) determine how subsequent changes in vegetation following biosolids application influence runoff and surface water quality; (3) assess the fate of potential sludge-borne contaminants in the soils, vegetation, and runoff water; and (4) evaluate the benefits of biosolids as an amendment for degraded semiarid rangeland on a demonstration project scale.

RESEARCH STUDIES

Rio Puerco Watershed Resource Area

In 1985, a study was initiated to test the effects of varying rates of biosolids application on degraded rangeland within the Rio Puerco Watershed Resource Area in north-central New Mexico. The Rio Puerco Basin, a degraded watershed with a long history of heavy livestock grazing, is one of the most eroded and overgrazed river basins in the Southwest (Sheridan 1981). The sludge biosolids were provided by the City of Albuquerque's Public Works Department. Approximately 70% of Albuquerque's biosolids currently are applied over large areas of rangeland set aside specifically for disposal purposes. Safe, economically feasible disposal of the biosolids, not rangeland rehabilitation, is the city's primary objective. Unlike the city's disposal operation, the plots at the Rio Puerco study area were not disked or tilled, thus minimizing disturbance to the existing grassland vegetation.

The Rio Puerco Watershed study showed that degraded rangeland responds favorably to the application of biosolids as a fertilizer and organic matter amendment (Fresquez et al. 1990a,b; Fresquez et al. 1991). The results of this preliminary study also showed that a one-time surface application of 22.5–45.0 Mg/ha⁻¹ (10–20 tons/acre) dry-weight equivalent of biosolids did not lead to contamination of soils or plant tissues (Fresquez et al. 1991).

Plant nutrients in the soil, including total nitrogen, available phosphorus, and potassium, increased linearly with increasing biosolids application during the first year of the study (Fresquez et al. 1990a). Organic matter in soil below the biosolids layer did not increase until after the fifth year because of a lag between increased nutrient availability and subsequent below-ground plant and microbial productivity (Fresquez et al. 1991). Total plant density, species richness, and species diversity decreased while cover and yield of blue grama grass (*Bouteloua gracilis*) significantly increased on treated plots during the 5-year study. Blue grama production was significantly greater for all of the biosolids treatments during the first and second growing seasons with yields 1.5–2.7 times greater in the treated plots than in the control plots. Although the benefits of the biosolids treatment had greatly diminished for the lowest amendment (22.5 Mg/ha⁻¹) by the end of the fifth growing season, blue grama production remained higher in the 45 and 90 Mg/ha⁻¹ sludge-amended plots than in the control plots throughout the study. We recently sampled the soils and vegetation at the Rio Puerco Watershed study site and found that the benefits of the 45 Mg/ha⁻¹ biosolids application continue to persist 8 growing seasons since the initial one-time surface application.

The biosolids also significantly increased the nutritional value of blue grama. Heavy metals in blue grama did not increase significantly during the study, thereby alleviating concerns that these toxic elements could be transferred to grazing animals (Fresquez et al. 1990b). Based on these results, it was concluded that a one-time biosolids treatment

of 22.5–45.0 Mg/ha⁻¹ (10–20 tons/acre) would yield the best vegetation response without potential harm to the environment. An unexpected benefit of biosolids application was a decrease in broom snakeweed (*Gutierrezia sarothrae*), a toxic, nonpalatable shrub. Following the addition of the various biosolids treatments, the density of broom snakeweed plants in the sludge-amended plots decreased during the course of the study (Fresquez et al. 1990b). The cause of the decline of broom snakeweed remains unclear, but its decline was concurrent with an increase in forage production and we suspect the snakeweed was essentially "choked-out" by blue grama and other forage species. The reduction in broom snakeweed may represent a significant finding in rangeland restoration research because this undesirable species has increased in number tremendously over much of the Southwest. In New Mexico alone, broom snakeweed occupies >16 million ha (Budd 1989).

Sevilleta National Wildlife Refuge

A second study was established in 1991 to determine if and how changes in vegetation following biosolids application influence runoff and sediment yields and to assess the fate of potential sludge-borne contaminants. This study was conducted on the Sevilleta National Wildlife Refuge, managed by the U.S. Fish and Wildlife Service. Six pairs of runoff plots (3 x 10 m), each pair consisting of a treated (sludge-amended) and a control (no sludge) plot, were established within 2 hillslope segments. Albuquerque biosolids were surface-applied at 45 Mg/ha⁻¹ (dry-weight basis) to the treated runoff plots in spring of 1991. Runoff after high-intensity thunderstorms was significantly less from sludge-amended plots than from control plots (Aguilar and Loftin 1992; Aguilar et al. 1994a,b). Runoff yields from control plots ranged 3.4–37.0 times greater than yields from treated plots. The plots also were subjected to simulated rainfall equivalent to a high-intensity summer thunderstorm (6–8 cm/hr⁻¹ for 30 min.). The rainfall simulation experiments also demonstrated that the biosolids significantly reduced runoff from the treated rangeland. Runoff yields from our control plots were comparable to runoff yields from studies conducted in rangeland elsewhere in New Mexico and Arizona (Ward and Bolton 1991). Therefore, the hydrologic differences observed between our treated and control plots can be directly attributed to the treatment. The 2 factors we considered responsible for the reduced runoff on treated plots were enhanced infiltration because of increased ground surface roughness and water absorption by the dry sludge. Eventually, the biosolids should decompose and have a less direct effect on surface runoff, but increases in vegetation cover in response to the biosolids fertilizer effect should further improve the surface hydrology of the treated rangeland. Potential pollution of surface water by sludge-borne contaminants in Albuquerque sewage sludge biosolids does not seem to be a problem with a one-time application of 22.5–45 Mg/ha⁻¹. Nitrate, copper, and cadmium concentrations in the runoff water, during both natural and simulated rainfall, were well below New Mexico limits for ground water and live-

stock and wildlife watering. Similar results could be expected using comparable biosolids from other municipalities.

Large-scale Restoration Project

In a partnership with the City of Albuquerque, Bureau of Land Management (BLM), and the U.S. Environmental Protection Agency, we recently initiated a larger scale restoration study to test our research results on an operational scale. The principal objectives of this study are to promote public acceptance of the use of biosolids for rangeland restoration and evaluate the economic and logistical constraints of large-scale application projects in the Southwest. Albuquerque biosolids are being surface-applied at a rate of 45 Mg/ha⁻¹ to a 50-ha (120-acre) parcel of BLM-administered rangeland in the Rio Puerco Watershed Resource Area. The demonstration project area is a small watershed in the upper reaches of a well-defined ephemeral drainage. The biosolids are being applied to one half of the watershed with the other half left undisturbed to serve as a control. As in the 2 previous studies, disturbance to the existing fragile rangeland vegetation is minimized as much as possible. The biosolids are being surface-applied using a tractor-pulled manure spreader with a 15-m (50-ft) side distribution pattern. Thus, the area of rangeland subjected to tire compaction and other disturbance during the spreading operation constitutes <10% of the total area being treated with biosolids. As in the previous studies, we will be assessing vegetative response to the biosolids amendment, changes in soil chemistry, biosolids effects on surface water quality, and leaching (or lack thereof) of potential contaminants including heavy metals and nitrate.

Only 1 watershed is being treated because of project cost limitations and the time required to apply the biosolids. Consequently, there is no treatment replication and the research results will have to be limited (statistically) to the study area. We hope this research will stimulate more interest and continued research on the use of municipal biosolids for the restoration of degraded rangeland. As more research is conducted, results of additional studies can be combined to yield a comprehensive understanding of the spatial and temporal response(s) of semiarid rangelands to surface-applied biosolids.

CONCLUSIONS

Our research has shown that a one-time surface application of municipal biosolids can significantly increase semiarid rangeland vegetation cover and total forage production and will not produce undesirable levels of sludge-borne contaminants in either soils or vegetation when applied at rates of 45 Mg/ha⁻¹. Furthermore, the potential for runoff and soil erosion is greatly diminished in treated rangeland because of increased ground surface roughness and increased soil water-holding capacity. Subsequent increases in ground cover resulting from improved vegetative growth should further improve the surface hydrology of treated areas. Poten-

tial contamination of surface water by Albuquerque biosolids does not seem to pose a problem and similar results could be expected using comparable biosolids from other municipalities. Rangeland restoration using sludge biosolids has the potential for being environmentally and economically beneficial if these practices are based on sound guidelines developed through continuing research.

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THE RESILIENCE AND RECOVERY OF WILLOWS, BLACK COTTONWOOD, AND THIN-LEAF ALDER IN NORTHEASTERN OREGON

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Abstract: Willows (*Salix* spp.), thin-leaf alder (*Alnus incana*), and black cottonwood (*Populus trichocarpa*) are keystone species in Northeastern Oregon riparian ecosystems. They play major roles in maintaining biodiversity, fish and wildlife habitat, and water quality. In addition, they are very palatable to livestock and native herbivores. The recovery of riparian shrubs is of paramount importance to the restoration of degraded stream ecosystems. To quantify recovery following livestock removal, this initial phase of a long-term study examined shrub dynamics along Meadow Creek. Elk exclosures separated the effects of elk (*Cervus elaphus*) and deer (*Odocoileus hemionus*) browsing. In late June 1991, the first season without livestock, the initial mean height of 6 of the 9 species was less than their mean width. Willow mean heights were 60 cm, black cottonwood was 34 cm, and thin-leaf alder 77 cm. After 3 seasons of nonuse, mean crown volumes of willows increased 550% inside of the elk exclosures and 155% outside. In contrast, cottonwood increased 790% and alder 200%, whether inside or outside of the exclosures. These data indicate that willows, cottonwood, and alder retain high levels of resilience following decades of grazing pressure. Cottonwood exhibited the strongest regrowth response, whereas willows were impeded by deer and elk.

Key words: black cottonwood, deer, elk, livestock, riparian ecosystems, thin-leaf alder, willow.

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