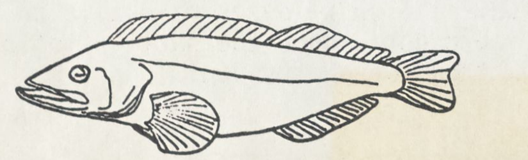
Washington's Lingcod Culture Program Beginning

The Washington State Department of Fisheries Marine Fish Enhancement Unit under the Direction of Ray Buckley, Unit Leader, and Jim Walton, fisheries biologist, is developing a program for the enhancement of lingcod (Ophiodon elongatus) in the waters of Puget Sound and Hood Canal. This project was necessitated by recent declines in commercial and recreational harvest in inshore waters and a significant decline in egg mass sitings on lingcod spawning surveys.

To facilitate the enhancement efforts and ensure stock preservation at present levels, the Washington Department of Fisheries has instituted a complete moratorium on the harvest of lingcod in inside waters beginning April 1, 1978 for a period of 2 years. Permanent closures have been adopted for the spawning season from December through March in the Strait of Juan de Fuca and all inside waters.

The lingcod enhancement program is being designed to ensure adequate stocks through the development of mass propagation techniques. Preliminary studies by the Enhancement Unit and the Seattle Aquarium have indicated a potential for success by rearing lingcod from eggs. These techniques, however, are still in the experimental stages and any advice or suggestions from anyone who has attempted to raise this species would be appreciated.

Juveniles will also be captured in the wild and raised in salt water rearing pens. After a short period of intensive feeding and rearing, these fish will be tagged and transplanted to depleted areas.



The Lingcod is not related to the cod family (Gadidae) at all; its closest relatives are the sculpins. The ling (probably named by early Pacific fishermen from Europe who were familiar with the ling of the North Sea) occurs in the northeast Pacific. It reaches 1.5 m and 45 kg.

The propagation of marine species of fish in the Pacific Northwest is still in the first developmental stages. A crisis such as the abrupt decline in an economically and recreationally valuable fish such as the lingcod can and should be used to promote the research necessary to cope with problems such as this in the future.

MITIGATION SYMPOSIUM UPDATE

A year or so ago, the Western Division began to plan a regional workshop on strategies for fish and wildlife mitigation. The idea was so good that a national rather than regional Symposium is now being planned. A Steering Committee met at the Vancouver meeting and has met several times since. A Symposium Director, Dr. Gustav Swanson, has been recruited, a time and place, July 1979, Colorado State Univ., has been set, and funds are being solicited. The Symposium is still in the early planning stages but should you desire additional information, contact Gustav Swanson, Dept. of Fish and Wildlife Biology, Colorado State Univ., Ft. Collins, CO. 80523.

ENDANGERED SPECIES: SOME HISTORY

U. S. endangered species legislation began in 1966 with the Endangered Species Preservation Act. The act authorized the listing of endangered species, research on their needs, and protection of them and their habitat. In 1969, the law was broadened to prohibit the importation of endangered species into the U.S. In 1973, the Endangered Species Act, put new teeth into early legislation by charging federal agencies to ensure that actions authorized, funded, or carried out by them does not jeopardize the existance of endangered or threatened species or destroy critical habitat. States are responsible for the protection and management of endangered and threatened species. Some important definitions are: 1) critical habitat is the water, land or air required for normal needs and survival of the species, 2) endangered means that a species is in danger of extinction throughout all or a significant portion of its range, and 3) threatened means that a species is likely to become endangered within the foreseeable future.

(See Endangered Species, Page 6)

(Endangered Species continued)

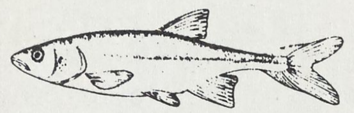
Some recent action on Western endangered fish is as follows:

Cui-ui sucker (Chasmistes cujus) - This sucker is found only in Pyramid Lake, Nevada and is endangered due to water diversion from the Truckee River. A recovery plan has been approved which includes determination of critical habitat, restoration of Truckee River habitat, artificial propagation and establishment of subpopulations at suitable sites.

Greenback cutthroat (Salmo clarki stomias) - This Colorado native has been removed from the endangered list. New populations have been located and certain former habitat areas have been restocked after elimination of stocked rainbow trout. The remaining habitat is on public land which is safe from habitat alteration.

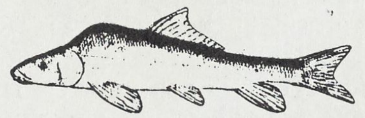
California golden trout (Salmo aguabonito) - This brilliantly colored trout indigenous to the Little Kern River watershed, was recently listed as threatened (Federal Registar, April 13). Hybridization with introduced rainbows and habitat modifications have made inroads into the population.

Bonytail chub (Gila elegans) - This Colorado River watershed native was recently listed as endangered (Federal Register, April 24). It has become extinct in the lower basin and is now rare in the upper Colorado. The largest



fish collected recently was just over 400 g. Dams have changed the habitat of the bonytail in the Colorado and competition from over 100 introduced species has probably caused further reductions in population size.

Razorback sucker (Xyrauchen texanus) - This Colorado River watershed native was recently listed as endangered (Federal Register, April



24). This large (5 kg maximum weight) fish is characterized by its prominant dorsal ridge, an adaptation which may promote stability in turbulent waters.

WESTERN DIVISION NEWSLETTER
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Fishery & Wildlife Bio.

American Fisheries Society
WESTERN DIVISION NEWSLETTER

Volume 3 June, 1978 Number 3

San Diego Meeting Promises Fireworks

The time is here to plan your trip to San Diego. And if you haven't seen the schedule, a warning is called for. Beware! Some sensitive issues will be aired. For example, a session on the current energy dilemma is entitled "Energy and the Environment - Are they Compatable?" Other sessions will handle the pros and cons of environmental protection, the social value of fish and wildlife, resource allocation and other topics. In one general session, the media will conduct a no-holds-barred critique of current management of fish and wildlife in the West. Setting the theme of the conference will be the Keynote Address by Charles Warren, a member of the President's Council on Environmental Quality.

If anyone is left standing after the General and Technical Sessions, they will enjoy the planned entertainment. There will be cruises of San Diego Harbor, a Cioppino Dinner, a special Sea World program, and a Banquet finale featuring Bob Crosby and the Bobcats, one of only four big dance bands still on tour. A half-day deep sea fishing trip is $10.00 per person. Pools, tennis courts and beaches are at the Conference hotel. The San Diego Zoo is world famous. Tijuana, Mexico is only 15 miles from downtown San Diego.

The registration desk will be open on Sunday, July 16 for those attending Committee meetings. The AFS Executive Committee (elected officers, Chapter presidents, Committee Chairman) will be meeting at 1:00 on Monday, July 17. EXCOM meetings are open to anyone. Arrive early and take part. The Annual meeting of the Division will be held Thursday, July 20 at 1:00 PM. Arrange your departure to allow attendance at this meeting.

Students. Lodging is available in dorms at San Diego State University (5300 Companile Drive, San Diego, Calif. 92115), 8 miles from the conference hotel. Contact the University to reserve a dorm room on a guest basis. Rates are $10.00 per night for a room with two beds. Reservations at the Conference hotel, the Sheraton Harbor Island (1380 Harbor Island Drive, San Diego, Calif. 97101) should be made as soon as possible for accomodations in San Diego will be difficult to find in July.

Do it in San Diego ! !

Western Division Voting Conducted By Mail Ballot Again This Year

This is the second year in which the Western Division has elected officers by mail ballot. But, this year, a new wrinkle has been added. You don't have to buy a stamp or address an envelope. Just mark the enclosed ballot card and drop it in the mail. Find the list of candidates inside the Newsletter (Page 2). With this quick and easy method of voting, there should be 90% + participation this year. A first for any Division of the Society. VOTE!!!

Candidates For Division Offices 1978-1979

The Nominations Committee has presented the 1978-79 slate of candidates for Division offices. A brief biographical sketch of each candidate is included below. Vote by marking an "X" in the appropriate box on the enclosed, stamped and addressed post card. Simply drop the card in the mail. VOTE!!!

For President-Elect:

Ron Marcoux

Mr. Marcoux is presently Regional Fisheries Manager with Montana Fish and Game after being with the organization since 1969. He received BS and MS degrees from Univ. of Montana and Montana State Univ. respectively. He has served the Society at the Chapter level (Sec-Treas. and Pres., Montana Chapt.), the Division level (Time and Place Comm.), and the National level (Arrangements Comm.).

Robert Wiley

Mr. Wiley is Supervisor of Fishery Research with Wyoming Game and Fish Dept. after being with the organization since 1963. He received BS and MS degrees from Humbodt State Univ. and Univ. of Wyoming respectively. He has served the Society at the Chapter level (Pres., Bonneville Chapt.; Sec-Treas., Vice Pres. and Pres., Colorado-Wyoming Chapter), the Division level (Newsletter Editor, Sec-Treas., Nominations, Time and Place, Resolutions Committees), and the National level (Resolutions, Membership Concerns Comm.).

For Secretary-Treasurer:

Clare Carlson

Dr. Carlson is presently Professor of Fishery Biology at Colorado State Univ. He has attended Augustana College and Iowa State and has been a faculty member at Augustana and Cornell Univ. where he was Assistant Leader of the New York Cooperative Fishery Research Unit. He has served the Society at the Chapt. level (Sec-Treas., Vice Pres., Colorado-Wyoming Chapt.), the Division level (co-chaired the International Symposium on River Ecology, Northeast Division), and the National level (Student Affairs Comm.).

Bernie Leman

Mr. Leman is presently a Fish and Wildlife Biologist for Public Utility District No. 1 of Chelan County, Washington after being with the organization for 20 years. He has also worked for fish and game agencies in Nebraska, Oregon and Idaho. He received BS and MS degrees from Oregon State Univ. He is a member of the Wildlife Society, Society for Range Management, Pacific Fishery Biologists, American Fisheries Society, and Association of Power Biologists.

For National Nominating Committee:

John Peters

Dr. Peters has been an Environmental Specialist with the Bureau of Reclamation since 1971. He administers Bureau environmental plans and programs in 17 Western States. He worked for Montana Game and Fish Dept. for 12 years. He attended Michigan State and Colorado State Universities. He has served the Division as chairman of the Membership Committee.

Robert White

Dr. White has been Assistant Leader of the Idaho Cooperative Fishery Unit, University of Idaho since 1974. He attended Northeast Missouri State and Utah State University. He has served the Society at the Chapter level (Sec-Treas. and Pres., Idaho Chapt.), the Division level (Executive Committee), and the National level (Student Affairs, Membership and Best Student Paper Committees).

WHY YOU SAY IT

Sardine - waters off the island of Sardinia are thick with this fish.

Trout - ancient Greeks dubbed this fish a "gnawer"; gnawer is trutta or tructa in latin.

Menhaden - Algonquin Indians planted one with each corn seed; munnohquohteau means "he enriches the land", shortened by English settlers.

Gar - body shaped like the gar or spear of the fifteenth century English.

Halibut - butt or large pan fish was eaten by early Dutch and German christians on holy days; Holy butt = holibut = halibut.

1978

COWS & FISH

Western rangeland has traditionally been exploited for livestock production. Recently public actions and legislation have required that other uses of public lands be considered in range management plans. The need to consider fish and wildlife habitat in range management has presented problems and incited controversy. For example, based on "widespread experience", one group of authors has written the following: "Livestock grazing is being managed and integrated with other uses of federal lands. There is no evidence to indicate that well managed grazing of domestic livestock is incompatable with a high quality environment" (Heady et al 1974). Another author, based on "long years of observation" has written: "Fish and wildlife habitat in Western rangeland is undergoing steady, chronic deterioration under exhisting patterns of multiple use. Livestock grazing in particular may be having cumulative ecological ill effects on productivity of both lands and water" (Leopold 1974). One reason for the lack of uninimity is the lack of data in the hands of the range scientists on management goals and methods for the aquatic and riparian zones of the range. Fishery biologists have also been at a loss to provide information on range management impacts on aquatic resources when asked. They found that they had little data to substantiate their suspicions that present grazing practices were having a deleterious impact on fishery resources. They also found that their methods for measuring the impact were not very precise. Fishery biologists began to discuss the situation and no less than 3 workshops or symposia were held on the topic of livestock interactions with fish, aquatic environment and riparian zones in 1977. These were:

1. Symposium on the Importance, Preservation and Management of Riparian Habitat. USDA Forest Service, Gen. Tech. Rept. RM-43, Research Support Services, 240 W. Prospect Street, Fort Collins, Colorado 80521.
2. Livestock Interactions with Wildlife, Fish and Their Environments, USDA Forest Service, Berkley, California (in press). Pac. SW Station, Research Support Services, 1960 Addison Street, Box 245, Berkley, CA 94701.
3. Improving Fish and Wildlife Benefits in Range Management. Fish and Wildlife Service, Pub. FWS/OBS-77-1. U.S. Fish & Wildlife Service, Office of Biologial Services, Washington, D.C. 20240.

EPA:

T.U. Denver

Information on ecology and management on one of the most important rangeland plants, sagebrush, was summarized in a recent Sagebrush Symposium (Range Science Dept., Utah State University, Logan, Utah 84322). The Symposium included several papers on the impact of sagebrush management and grazing on fish and wildlife resources. Now in the planning stages is a Symposium on the impacts of grazing on riparian and stream biota to be held in the fall. The Symposium is being planned by Federal, State, private and public groups representing the interests of wildlife, range, and livestock (more about this meeting as plans develop).

Although progress in range rehabilitation has been made, grazing is still thought to be a major deleterious impact on aquatic resources in the West. At a recent symposium the condition of riparian and aquatic habitat in areas under eight different grazing systems was summarized (Platts 1978). A poor aquatic habitat was usually found in areas of yearlong or season long grazing. Deferred, rotation, deferred-rotation, rest-rotation, and short duration-high intensity grazing systems resulted in poor to fair ratings of the aquatic system, depending on location, topography and other land features. Only in areas where there was no grazing were aquatic resources found in good to excellent condition. The main impacts of grazing appear to be a reduction of upland and riparian vegetation cover which cause increased soil erosion, bank instability, stream temperature, stream bottom siltation and water turbidity. Each of these changes has potential secondary effects on a fishery by reducing cover and decreasing primary and secondary productivity. Minor potential impacts of grazing are bacterial contamination and organic enrichment of water, increased peak flows, physical disturbance of spawning areas and fish behavioral alterations.

Consumer demand for beef is increasing. It is projected that an additional 70 million acres of forage producing range will be needed in the next 24 years. In the West, mining, agriculture and other developments are reducing grazing land at a rate of 1.4 million acres per year. The increased demand for recreation areas and protection of watersheds for water quality may be yet another drain on the rangeland available for red meet produc-

(See Cows & Fish, Page 4)

(Cows & Fish continued)

tion. Hopefully, this drain can be minimized through an interdisciplinary approach to management. The grazing issue is definately one all Western Division members should keep abrest of for the opinions and data of western fishery biologists will certainly by called for in the future.

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Heady, H. et al. 1974. J. Range Manage 27:174.

Leopold, S. 1974. Proc. Wild Trout Manage. Symp. pp. 96-98.

Platts, W. 1978. Trans. Cal-Neva Chapt. (in press).

STREAM CHANNELIZATION GUIDELINES

The Soil Conservation Service and the Fish and Wildlife Service have issued guidelines that are intended to minimize the impacts of small watershed projects on fish and wildlife. The guidelines will affect federally assisted watershed protection and flood prevention projects. They are aimed at helping personnel of the SCS and FWS determine when and where to channelize. The guidelines consider potential effects on wetlands, streamside vegetation and wildlife habitat, they consider alternatives to channelization and establish an appeal procedure to resolve disputes between field personnel of the two agencies. Copies are available from the National Stream Alteration Team, Federal Bldg., Room 200, 608 East Cherry Street, Columbia, MISS. 65201.

The Fish and Wildlife Service, in cooperation with Colorado, Nevada, Utah and Wyoming, will soon publish an atlas of stream values in each state. The four criteria used in the study for determining the value of a stream were 1) the status of endangered species in the stream reach, 2) the status of threatened species in the stream reach, 3) the importance of the stream to species of high interest to a State, and 4) a stream's potential for restoration and reclamation following a development activity. The information in the atlas is intended to optimize State, local and Federal decisions about how and where development programs will be carried out. The knowledge of the location of highly valued stream reaches will be very useful early in any planning process. The series of maps will soon be available at FWS Area Offices or State Government Offices.

In-stream Flows: A Current Study

A study of in-stream flows has recently been completed in Montana. The entire paper will appear in Transactions later, but due to the timely nature of this topic, the author Fred Nelson, Fishery Biologist, Montana Fish and Game, has permitted the Newsletter to publish a summary of the work.

The Montana Department of Fish and Game completed a 10-year study of trout-flow relationships in a 6455 foot section of the Beaverhead River below Clark Canyon Reservoir. The numbers and biomass of brown and rainbow trout were estimated by age groups in the fall and spring of each year using electrofishing techniques. Average daily flows were obtained at a U.S.G.S. gage. The survival of age III and older rainbow trout was directly related to the magnitude of flow releases during the nonirrigation season (approximately October 15 - April 15). During this period, Clark Canyon Reservoir stores water for irrigation and releases into the Beaverhead River are minimal. Results of the study suggest that flow releases greater than approximately 200 cfs are needed to maintain a high quality, trophy rainbow trout fishery in the upper river. Flows were not sufficiently reduced during the study to adversely affect the survival of brown trout. Reproductive success, which was inadequate for providing sufficient numbers of trout to fill all available living space, was the major factor limiting the total numbers and biomass of trout throughout much of the study. Violent fluctuations of the flow releases at Clark Canyon Dam during the brown and rainbow trout spawning periods appear to be the major factor hindering reproduction. The upper Beaverhead River would support greater numbers and biomass of trout of all age groups than those which existed throughout much of the study if flow releases favorable to both trout reproduction and the survival of older rainbow trout were provided.

The in-stream flow issue is creeping into the popular literature. An article recently appeared in the June-July issue of National Wildlife (16:4-11).

RESEARCH DEFINITIONS: "It has long been known" Translation - I haven't bothered to look up the original reference. "of great importance" Translation - interesting to me. "typical results are shown" Translation - best results are shown.

GENERAL TECHNICAL REPORT PNW-84
1979

WILDLIFE HABITATS IN MANAGED RANGELANDS-- THE GREAT BASIN OF SOUTHEASTERN OREGON

NATIVE TROUT

WAYNE BOWERS
BILL HOSFORD
ART OAKLEY
CARL BOND

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
FOREST SERVICE U. S. DEPARTMENT OF AGRICULTURE

ABSTRACT

All land management activities on managed rangelands will have some impact(s) on fish habitat; those in the riparian zone will have the greatest impact(s). Native trout populations in the Great Basin of southeastern Oregon exhibit predictable responses to alterations in their habitats; optimum production of native trout is therefore achievable through careful habitat management.

KEYWORDS: Fish habitat, trout, range management.

THE AUTHORS

WAYNE BOWERS is Fish Biologist and BILL HOSFORD is District Fish Biologist, Oregon Department of Fish and Wildlife. ART OAKLEY is Fisheries Biologist, U. S. Department of the Interior, Bureau of Land Management. CARL BOND is Professor of Fisheries, Department of Fisheries and Wildlife, Oregon State University.

Audubon January 1979

ENVIRONMENTALIST AT LARGE

The eating of the West

PHILIP L. FRADKIN

IN 1977, AMERICANS ate 25 billion pounds of beef, which averaged out to about 126 pounds per person. By the year 2000 the per capita consumption of beef is expected to rise to 151 pounds, which approaches one-half pound a day. While other less fortunate countries have sought their protein in grains and fish, from hamburgers to filets mignons America has historically been a nation of beef-eaters.

What is little known, though, is the high environmental cost attached to this indulgence, particularly on the public lands of the western states.

Simply put, no other activity covers so much land area in this country as cows eating grass. Nor, with particular reference to the eleven western states where more land is grazed than in any other region, has any single activity or combination of activities contributed more toward altering the shape and texture of the land and the wildlife that is dependent upon it.

Approximately 1.2 billion acres, or 63 percent of the total land area in the continental United States, has been or is being grazed. More than one-half this amount—622 million acres—is in the eleven western states. The 622 million grazeable acres represent 83 percent of the land areas of Washington, Oregon, California, Idaho, Nevada, Arizona, Utah, Montana, Wyoming, Colorado, and New Mexico. And of the 622 million acres in the West, 504 million were being grazed in 1970, the base year the Department of Agriculture used in a study. Of this amount, about half were private lands and the other half those public lands containing the vast majority of the nation's national resource lands, national forests, national parks and monuments, national recreation areas, Indian and military reservations, fish and wildlife refuges, and wilderness areas where cattle and sheep have been nibbling away, in some cases, for four hundred years.

Almost no area in the West has been left undisturbed by livestock. The ubiquitous cow can be seen grazing from below sea level to the 12,000-foot heights of mountain peaks. As biologist Carl B. Koford of the Museum of Vertebrate Zoology at Berkeley wrote, "Natural grasslands are so rare that rangemen are forced to search the corners of old cemeteries for pieces of protected ground." The impact of countless hooves and mouths over the years has done more to alter the type of vegetation and landforms of the West than all the water projects, strip-mines, powerplants, freeways, and subdivision developments combined. The changes, in most cases, are irrevocable.

Overgrazing by livestock and remedial programs like fencing, chaining, plowing, and dumping of herbicides on millions of acres in the name of range "improvements" have had a greater effect on wildlife in the West than any other factor except the climate. Speaking at a symposium in 1974, zoologist A. Starker Leopold said, "I am increasingly convinced that fish and wildlife habitat in our western forests and rangelands, both public and private, is undergoing a steady, chronic deterioration under existing patterns of multiple use. Livestock grazing in particular may be having cumulative ecological ill effects on the productivity of both lands and waters." A 1977 Department of the Interior seminar entitled "Improving Fish and Wildlife Benefits in Range Management" concluded, "Livestock grazing is the single most important factor limiting wildlife production in the West. It has been and continues to be administered without adequate consideration for wildlife, especially on federal lands."

Vegetative cover can be changed by overgrazing in the following manner: Cattle move onto an undisturbed range and first select those plants which are most accessible and palatable. Such species, called "dessert" or "ice cream plants," tend to have the highest nutritional values and are the sweetest. With prolonged grazing, these prime grasses and weeds—mostly perennials—are replaced by less desirable annuals. Shrubs such as sagebrush and piñon-juniper now invade and take over the weakened area. Less nutritious and even such poisonous species as larkspur and locoweed which literally drive cattle crazy, appear. Exotic plant species—perhaps from Mediterranean Europe or the steppes of Asia—proliferate and crowd out the native species. The composition of vegetation has changed, and along with it the small mammals and invertebrates and their prey that are dependent upon it.

Where there is heavy use over a number of years in an arid climate, the grassland yields to a desert in a process called desertification. In a paper for the 1977 United Nations Conference on Desertification, the Worldwatch Institute warned, "Where land abuse is severe and prolonged, and especially where extended drought intensifies its effects, grasslands and fields can be reduced to stony, eroded wastelands—or even to heaps of drifting sands. More commonly, the quality of rangeland vegetation declines as the more palatable and productive plants are nudged out by less desirable species. On croplands, yields may gradually fall as soil nutrients are dissipated and the topsoil is eroded by wind and water." Overgrazing is the prime cause of desertification, and much of the West is arid or semi-arid.

CONSIDER HOW THE landscape can be altered by overgrazing: Livestock trampling compacts the soil. There is greater runoff, and the sediment load of nearby streams and rivers increases. Downstream water users and public works erected to dam or divert rivers can be harmed. With the lessening of grass cover and subsequent invasion of

GENERAL TECHNICAL REPORT PNW-80

WILDLIFE HABITATS IN MANAGED RANGELANDS-- THE GREAT BASIN OF SOUTHEASTERN OREGON

RIPARIAN ZONES

JACK WARD THOMAS
CHRIS MASER
JON E. RODIEK

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
FOREST SERVICE U. S. DEPARTMENT OF AGRICULTURE

ABSTRACT

Riparian zones are the most critical wildlife habitats in managed rangelands. More wildlife species depend entirely on or spend disproportionately more time in this habitat than any other. The zone is also disproportionately important for grazing, recreation, timber production, fisheries production, road location and water quality and quantity. The importance to wildlife is examined and guidance given for management.

KEYWORDS: Riparian habitat, wildlife habitat.

THE AUTHORS

JACK WARD THOMAS is Principal Research Wildlife Biologist, U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, La Grande, Oregon. CHRIS MASER is Wildlife Biologist, U.S. Department of the Interior, Bureau of Land Management, La Grande, Oregon. JON E. RODIEK is Associate Professor, Environmental Design, University of Arizona, Tucson.

STREAM MORPHOLOGY IN TWO ADJACENT GRAZING SYSTEMS

J.L. Robinson and M.A. Smith

ABSTRACT

This report presents the results of studies conducted on Pole Mountain, in the Medicine Bow National Forest, East of Laramie, Wyoming. This study evaluated stream morphology in continuous and deferred rotation grazing allotments.

Results indicate an increase in bank stability following implementation of deferred rotation grazing. Improvements in stream morphology also included greater stream channel with water ratio and different overhead cover. Fish population surveys provided by the Wyoming Game and Fish Department indicate population increases in brook trout (Salvelinus fontinalis) in the deferred rotation streams.

INTRODUCTION

Meehan and Platts (1978) state that until recently the effects of use on aquatic resources in cold water streams have not been identified or quantified. As a result livestock grazing and fisheries management were carried out without an understanding of their inter-relationship. This study was designed to evaluate the effects of riparian stream morphology of continuous grazing compared to deferred rotation grazing. The two grazing systems studied were adjoining with the continuous grazing located above the deferred-rotation allotment on two drainages. The deferred-rotation grazing was initiated in 1957. Cattle stocking rates were roughly equivalent. Geologic materials and stream gradients were similar between treatments.

METHODS

A total of 23 study sites were included in this study with 11 sites on the deferred-allotment and 12 within the continuous allotment. Each study site was a 100 foot section of stream located 50 feet on either side of the center of a randomly selected vegetative site. Vegetative sites were divided into 3 types: (1) willow bog, (2) wet meadows, (3) moist meadows. From a 100 foot tape placed along the stream bank data was collected at 20 feet intervals starting at zero and perpendicular to the center line of the stream. Data collected were as follows: (1) channel width and depth, (2) bank slope, (3) water width and depth, (4) overhead cover, (5) undercut banks, (6) bottom type and (7) length and dispersion of pools, riffles, and runs.

Techniques utilized for data gathering (WRRI, 1978) were evaluated and modified to meet the requirments of this study. A taut perpendicular tape across the stream at each point utilizing heavy wire tent stakes to fasten the steel tape facilitated measurement. Channel and stream depths were taken with an aluminum measuring stick at 4-6 points across the stream. Bank slope measurements on both sides of the channel were also taken from this tape. Overhead cover consisted of shadows cast by trees or herbs on the tape and vegetation or debris below the tape.

Bottom material was evaluated at sample points and given a numerical value of 1 through 4 defined as follows: (1) silt, less than .04" diameter, (2) sand and fine gravel, .04"-1.25" diameter, (3) coarse gravel, 1.26"-3.0" diameter, (4) rubble, 3.0"-12.0" diameter. This evaluation of bottom material was made of material comprising more than fifty percent of bottom material.

Length and dispersion of pools, riffles, and runs were taken from the 100 ft. site area and recorded to the nearest one half foot. Measurements were taken by walking the 100 ft. tape and recording segments, thus giving both length and number of each category per site. For this study pools, riffles and runs were identified by the following criteria:

> Pools--Sections of stream irregardless of length with water depths generally in excess of 5 inches, low velocity and smooth surface.
> Runs--Sections of stream irregardless of length with water depths varying generally between 2 and 5 inches but not limited to exactly 5 inches with visibly higher velocity and choppy surface.
> Riffles--Sections of stream irregardless of length with water depths averaging 1 to 3 inches in depth with visible high velocity and choppy surface.

To properly utilize data from length and dispersion of pools, riffles, and runs the data was divided into two categories: (1) dispersion is the percent of total stream segments composed of pools, riffles, and runs, (2) length is the actual footage of site by allotment each category comprises.

The site data were compiled by treatment to evaluate the stream morphology in each allotment. This combined data indicates the effect of deferred rotation and the continuous grazing systems.

RESULTS AND DISCUSSION

Study results indicate an increase of 32% in bank stability in the deferred allotment. Comparison shows 74% of the points in the deferred allotment compared to 42% in the continuous allotment were undercut. Undercut banks indicate both bank stability and valuable trout habitat. Stream width/channel width also indicated an improvement in bank stability with 14% more stream/channel in the deferred allotment. Noticeable signs of bank sloughing were also apparent in the continuous allotment. Sloughed material seldom remains where it initially falls and will contribute to stream sedimentation. Bottom material score improved 1.8 to 2.1 showing an improvement towards gravel in the deferred sites.

Little variation was noted between allotments in bank slope. The deferred allotment averaged 1.8 compared to 1.7 in the continuous system. This may be attributed to annual livestock use and lack of recovery time between grazing cycles.

Data compiled from water depth/channel depth show an increase in the percent of channel with water in the deferred allotment. The deferred allotment averaged 40% channel with water compared to 29% in the continuous allotment.

The deferred allotment is more uniform in both length and dispersion of pools, riffles and runs, as noted in Table I.

TABLE I

Grazing	Total (ft.)	Avg. Total (ft.)	% of Total Length	Total Number	Average Number	% of Total
			Pools			
deferred	433.5	15.5	40	28	2.5	33
continuous	550.5	13.1	46	42	3.5	40
			Riffles			
deferred	227.5	7.8	20	29	2.6	29
continuous	141.0	6.1	11	23	1.9	22
			Runs			
deferred	436.5	12.5	40	35	3.2	38
continuous	513.5	11.7	43	44	3.7	38

Overhead cover data indicated the continuous allotment had 46% overhead cover compared to 31% on the deferred sites. While this indicates an improvement through continuous grazing, on site inspection shows washed-in debris being the major contributing factor. There is a definite lack of live woody species and overhanging herbaceous vegetation. Thus, the continuous allotment has less renewable overhead cover needed for bank stabilization and to maintain water temperatures.

SUMMARY AND CONCLUSION

In evaluating data from this study many improvements are evident under the deferred rotation system. It is doubtful that the allotment will show as dramatic additional improvements in the future except for over-head cover. With the transitory nature of washed-in debris, its value to the continuous grazing system should continue to decline. That annual use of riparian vegetation by grazing livestock will not allow recovery time between grazing cycles (Behnke et al., 1977) is not supported by this study.

The improvements indicated by this study to both the riparian stream morphology and the trout population show the value of the deferred rotation system. Through implementation of deferred rotation grazing the 8800 useable acres support 3.9 acres/AUM. This is compared to 3.5 acres/AUM on 8600 useable acres in the continuous allotment. Wyoming Game and Fish Department data indicates brook trout biomass and numbers are 225 and 400 percent greater in the deferred grazing area. The result is a stable, more productive riparian stream system while continuing to provide livestock grazing. Deferred rotation grazing works to benefit both livestock grazing and fisheries management.

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Sheep and Streams

William S. Platts

Recent trends toward protecting riparian-fisheries habitat have focused attention on grazing management in riparian zones. Although some of the effects of cattle grazing on streamside areas have been documented, information describing the effects of sheep grazing on streams is limited. Sheep have generally been assumed to exert little influence on riparian and stream environments as they usually are herded onto and graze slopes and upland areas. In the Pole Creek meadows, however, past heavy grazing, plus additional use by driveway sheep for forage and bedding while awaiting shipment, was probably harmful to the riparian and stream environment.

Area Description

The Salmon River drainage, which includes Pole Creek and the study meadows, supports the major chinook salmon and steelhead rainbow trout spawning runs entering Idaho from the ocean. Pole Creek, which flows through meadows (6,200 feet elevation) formed by glacier-transported sediment, receives water from a small tributary stream on which the study site is situated. The tributary stream channel is composed of gravel with smaller amounts of rubble and fine sediments. The stream supports sculpin and brook trout.

The area has been heavily grazed since the late 19th century. Shortly after the settlement of the Snake River Plains by European man, the upper Salmon River drainage became increasingly important for sheep summer forage. Because the Pole Creek meadows were located on the Ketchum-Stanley sheep driveway, the meadows received unusually heavy use; 200,000 sheep used the area in 1910, according to a report by William Horton, District Ranger at the Pole Creek Station. Ketchum, Idaho, was the largest shipping center for sheep in the United States.

A 30-acre enclosure was fenced in the Pole Creek meadows in 1910 to encircle a Forest Service Guard Station. The enclosure was used to pasture 10 horses and mules from 1964 to 1974 for about 1 month each year. The adjacent unfenced meadow, immediately upstream from the enclosure, continued to receive heavy sheep and bedding use and, by 1934, 150 acres had to be reseeded because of overgrazing. The sheep driveway from Ketchum to Stanely was closed in 1964 by the USDA, Forest Service to spring travel, which resulted in reduced grazing pressure on the meadows.

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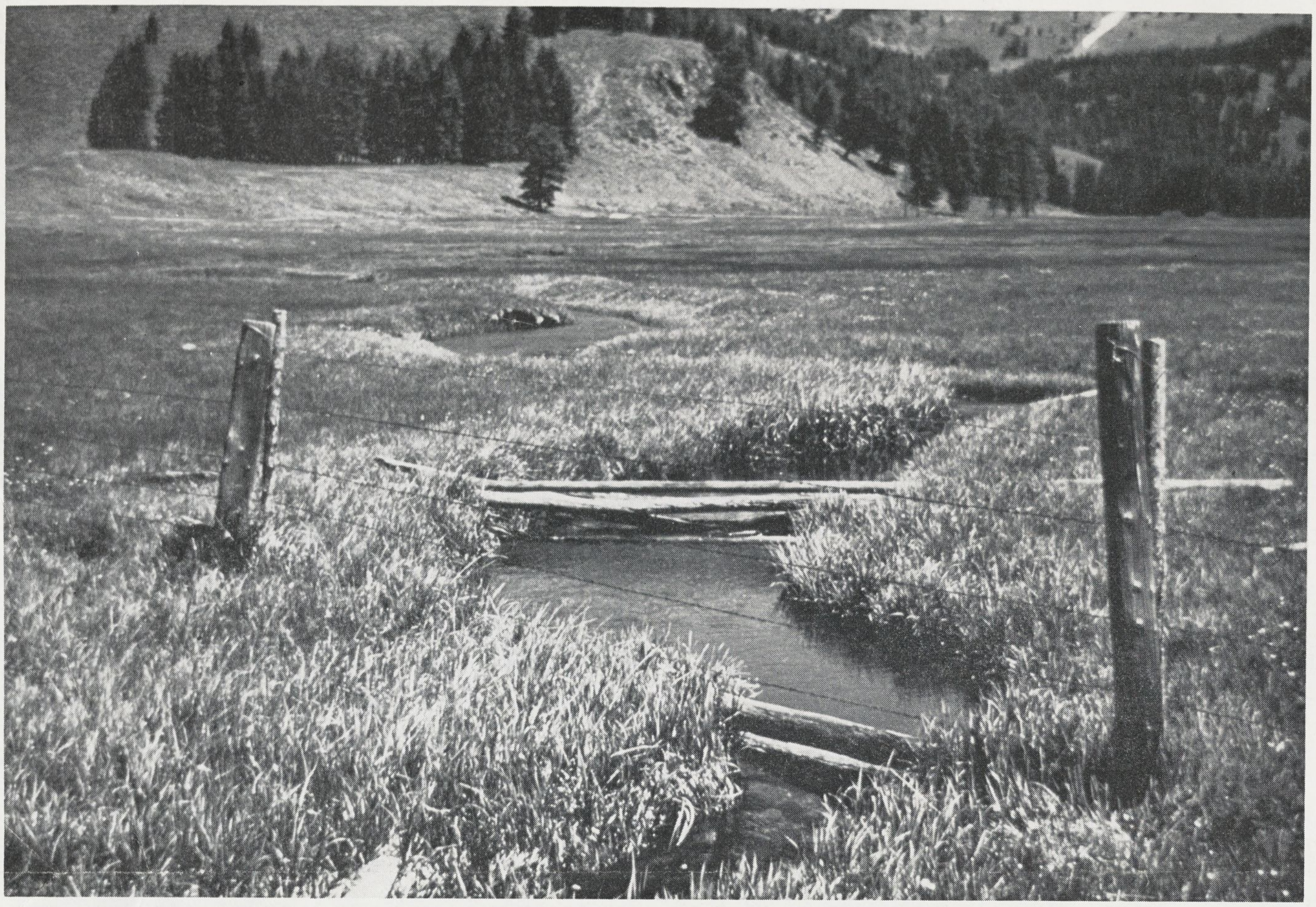


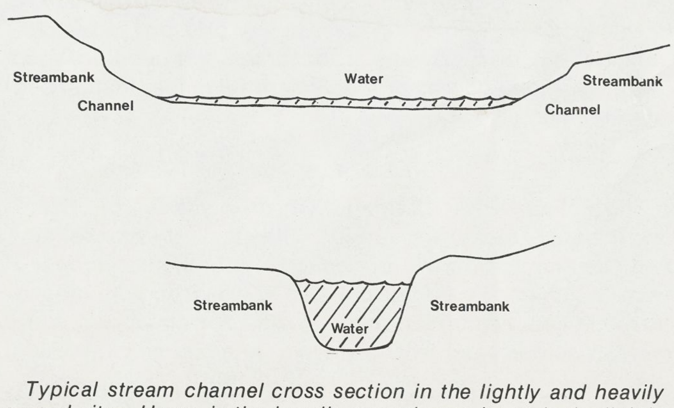
The fence separates the heavily grazed area (background) from the lightly grazed area (foreground). Note the wide, shallow stream in the heavily grazed area narrowing as it enters the fenced area.

The many years of heavy sheep grazing on the unfenced meadows and the light or nonexistent grazing within the Guard Station enclosure provides an ideal case history for studying riparian and stream reactions to heavy sheep grazing.

Methods

Methods evaluating the riparian and aquatic habitats consist of measurements taken at each of 121 channel cross sections that run from bank to bank, perpendicular to the main flow of the stream. These cross sections are situated at 10-foot intervals covering 600 feet of stream in the fenced area and 600 feet of stream in the unfenced area. The two sites are adjacent to each other. Aquatic habitat measurement were taken in July, August, and September of 1978, and riparian measurements were taken in October after the grazing season ended.

Aquatic habitat measurements include those documenting water column conditions (stream width, depth, depth of water at the bank, and water velocity); those documenting channel conditions (channel gradient and percent gravel, fines, and rubble); and those documenting streambank conditions (bank angle, bank undercut, and bank alteration). Stream width was the width of the channel covered by water at each cross section. Stream depth was the average of four water depths taken at equal intervals across each cross section. Water depth was also measured at the point where the streambank meets the edge of the water (called bank water depth). Water velocities were taken at selected intervals across the transect. The percent of gravel (0.19 to 2.9 inches in diameter) and fine sediment (less than 0.19 inches in diameter) in the stream channel surface was obtained by using measuring tapes. Channel gradient was taken using an engineer's level and sighting rod. Channel cross sections were developed using an engineer's level, sag tape, measuring rod, and a sighting rod. Streambank angle was measured with a clinometer, which determined the downward slope of the streambank to the water. Streambank undercut was measured from the greatest protrusion of the bank that goes over or into the stream to the furthest undercut of the bank.



Typical stream channel cross section in the lightly and heavily grazed sites. Upper is the heavily grazed area, lower is the lightly grazed area.

Table 1. Comparison of variable averages between the lightly grazed and heavily grazed sites.

Variable	Lightly grazed	Heavily grazed
Stream width (feet)	1.8	7.8
Stream depth (inches)	6.2	1.3
Bank water depth (inches)	5.1	0.4
Water velocity (fps)	1.3	0.8
Gravel (percent)	69.3	98.2
Fine sediment (percent)	28.2	2.9
Channel gradient (percent)	0.7	1.2
Bank angle (degrees)	82.0	132.0
Bank undercut (inches)	1.7	0.6
Artificial streambank alteration (units)	5.7	86.1
Habitat type rating (units)	17.7	14.0
Vegetative use (percent)	2.3	37.3

Alteration of the streambank was rated visually using a defined rating system.

The riparian habitat measurements include rating the streambank habitat type. The rating is based on the dominant and subdominant plant or soil composing the streamside environment as it would affect the fishery. A streamside habitat of sand (dominant)/sand (subdominant) is considered to have the least value to salmonids and is rated 1. A brush (dominant)/sod (subdominant) habitat is considered to have the most value and is rated a 24. The other streambank habitat types range between these ratings. Use of streamside vegetation was a visual estimate of the percent of vegetation used or altered by animals within 5 feet of the streambank.

Results

The results in Table 1 and the channel profiles in the drawing show definite differences between the lightly grazed and heavily grazed sites. The stream was over four times as wide in the heavily grazed area as in the lightly grazed area. Sheep use on the streambanks in the heavily grazed meadow caused the banks to erode away, resulting in over four times as much water surface being exposed to solar radiation as was the case in the stream research in the lightly grazed meadow. Average stream depth was almost five times as great in the lightly grazed area as in the heavily grazed area. The depth of the stream at the streambank stream channel interface was almost 13 times as great in the lightly grazed meadow.

Discussion

Sheep are often classified as animals who prefer slopes and upland areas for grazing. Therefore, under proper management, they would be expected to have little on-site effect on riparian-stream environments. This study shows, however, that when sheep were forced in the past to concentrate on a riparian-stream area, which is contrary to proper management, they adversely affected the stream environment. Heavy concentrated sheep grazing can make streams wider and shallower, outslope the streambanks, eliminate undercut banks, change riparian habitat type, expose the stream to more solar radiation, and decrease water depths at the stream surface-streambank interface. Fishery biologists generally agree that the documented changes tend to decrease fish populations. Therefore, to concentrate sheep on meadows for long periods of time is probably detrimental to the riparian-stream ecosystem.

Under a grazing strategy such as deferred use combined with good herding, there should be few if any detrimental effects on the fishery. The Forest Service has reduced sheep grazing and holding time on the study site. Under this new management, it is my judgment that the stream has been constantly improving. ●

[1983]

RIPARIAN-STREAM HABITAT CONDITIONS ON TABOR CREEK, NEVADA, UNDER GRAZED AND UNGRAZED CONDITIONS

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Rodger Loren Nelson
Osborne Casey
Val Crispin

ABSTRACT

A previously grazed riparian-stream habitat improved in many environmental conditions when management was changed from continuous grazing to complete rest. The most dramatic improvements were observed in the water column, streambank, and riparian vegetation, with a trend detected toward improvement of the channel morphology. The historical continuous grazing season is considered detrimental to the riparian-stream habitat. The plan to evaluate a new grazing strategy (rest-rotation) on this same habitat is discussed.

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INTRODUCTION

As settlement of the Western United States began in the mid-1800's, the grazing of cattle and sheep on the vast open ranges quickly became an important industry. Initially, management of these herds was left to the discretion of the individual stockmen, and by the 1930's much of the western range was in poor condition. With the initiation of range management by the various managing agencies created for this purpose, such as the USDA Forest Service (USFS) and the USDI Bureau of Land Management (BLM), and with the cooperation of private permittees, the public rangelands began to improve.

Busby (1978) found that present range conditions are far superior to the denuded, deteriorated conditions prevalent in the early 1900's. Studies leading to this conclusion, however, tended to ignore the riparian-stream habitats (Platts 1981). Livestock, especially cattle, will preferentially graze riparian vegetation because of its abundance, easy accessibility of drinking water, gentler terrain, longer period of succulent vegetation, and often milder microclimate. Therefore, it is probable that much of the riparian-stream habitat has not seen the improvements that occurred in the dryer upland range.

This paper compares a presently ungrazed (rested) section of a riparian-stream system with an adjacent grazed section. Future studies will evaluate livestock effects as the rested section of riparian-stream habitat is again opened to grazing under a rest-rotation system.

STUDY AREA

Tabor Creek is a tributary of the East Fork of the Humboldt River in northeastern Nevada (fig. 1). The study area, at 6,200 feet (1890 m) elevation, lies within the Great Basin Sagebrush Province described by Bailey (1981). Tabor Creek supports a narrow streamside zone of riparian vegetation, has good water quality, and a gravel bottom with lesser amounts of rubble, boulder, and fine sediments. The summer fish community is composed largely of sculpin (*Cottus* sp) and hatchery-reared rainbow trout (*Salmo gairdneri* Richardson), with natural production of rainbow trout and minor production of brook trout (*Salvelinus fontinalis* Mitchill) adding to the population. By fall, the salmonid population is composed mainly of wild trout.[2/]

2/ Coffin, Patrick. 1981. Personal communication. Nevada Dept. of Wildlife, Elko.

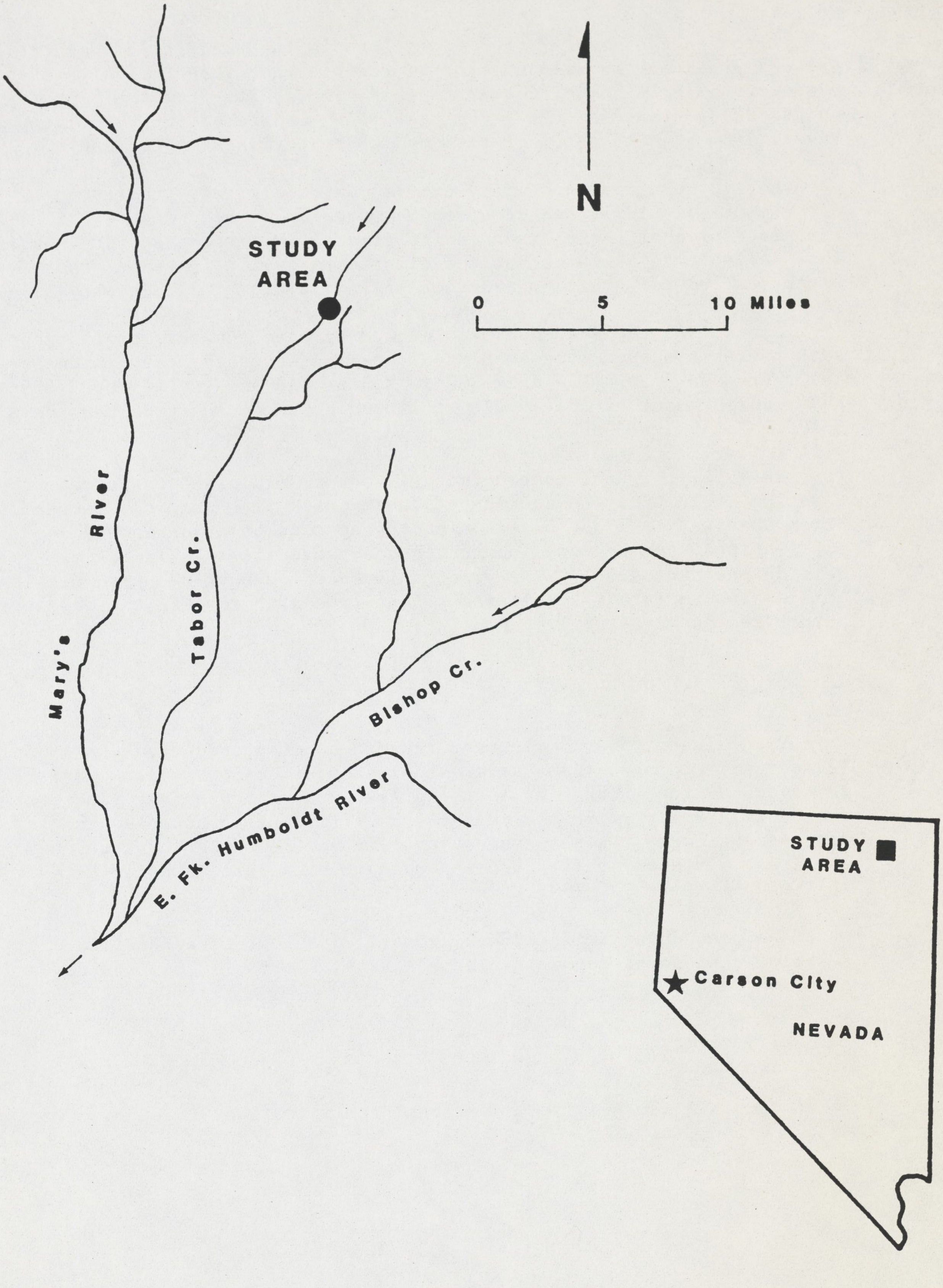

Figure 1. Study area location.

RANGE HISTORY

Prior to the arrival of European man in the study area, vegetation use was primarily by wild ungulates, rodents, and insects. With the discovery of gold in California in 1849, immigrants from the Eastern United States traveled along the meandering course of the Humboldt River, and the need for way stations led to permanent settlements.

Early, unregulated grazing use was extremely heavy and range deterioration quickly became a serious problem. Government administration of these lands let to gradual improvements, but even as late as 1957, adjudication of the allotments, which included Tabor Creek, called for grazing reduction of an additional 39 percent.

Since 1961 the area has been grazed by cattle under an allotment system with a season-long continuous grazing strategy. Use intensity has increased from 4,725 Animal Unit Months (AUM's) in 1965 to 7,639 AUM's during most of the 1970's, followed by reduction to 6,366 AUM's in 1979.

In 1968, the BLM constructed a livestock exclosure to protect the riparian habitat on one section of Tabor Creek from grazing by cattle. Stream habitat in 1968, based on photographs taken at designated photo-points, and personal communication, were the same inside as outside the exclosure.[3] No grazing is known to have occurred within this exclosure (study site) since 1976; from 1968 to 1976 there was some authorized and unauthorized grazing.

METHODS

To evaluate the riparian and aquatic habitat conditions, a group of 122 channel cross sections were established at 10-foot (3.1 m) intervals to cover 600 feet (182.9 m) in the grazed area and 600 feet (182.9 m) immediately upstream in the ungrazed area (fig. 2). Aquatic habitat measurements were taken in August of 1979 and September of 1980 during the grazing season, while riparian measurements were taken in October of 1979 and September of 1980.

The procedures employed are summarized below; more detailed descriptions can be found in Platts (1974), Platts (1976), and Ray and Megahan (1978).

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[3] Brigham, William R. 1981. Personal communication. USDI Bur. Land Mgt., Carson City, Nev.

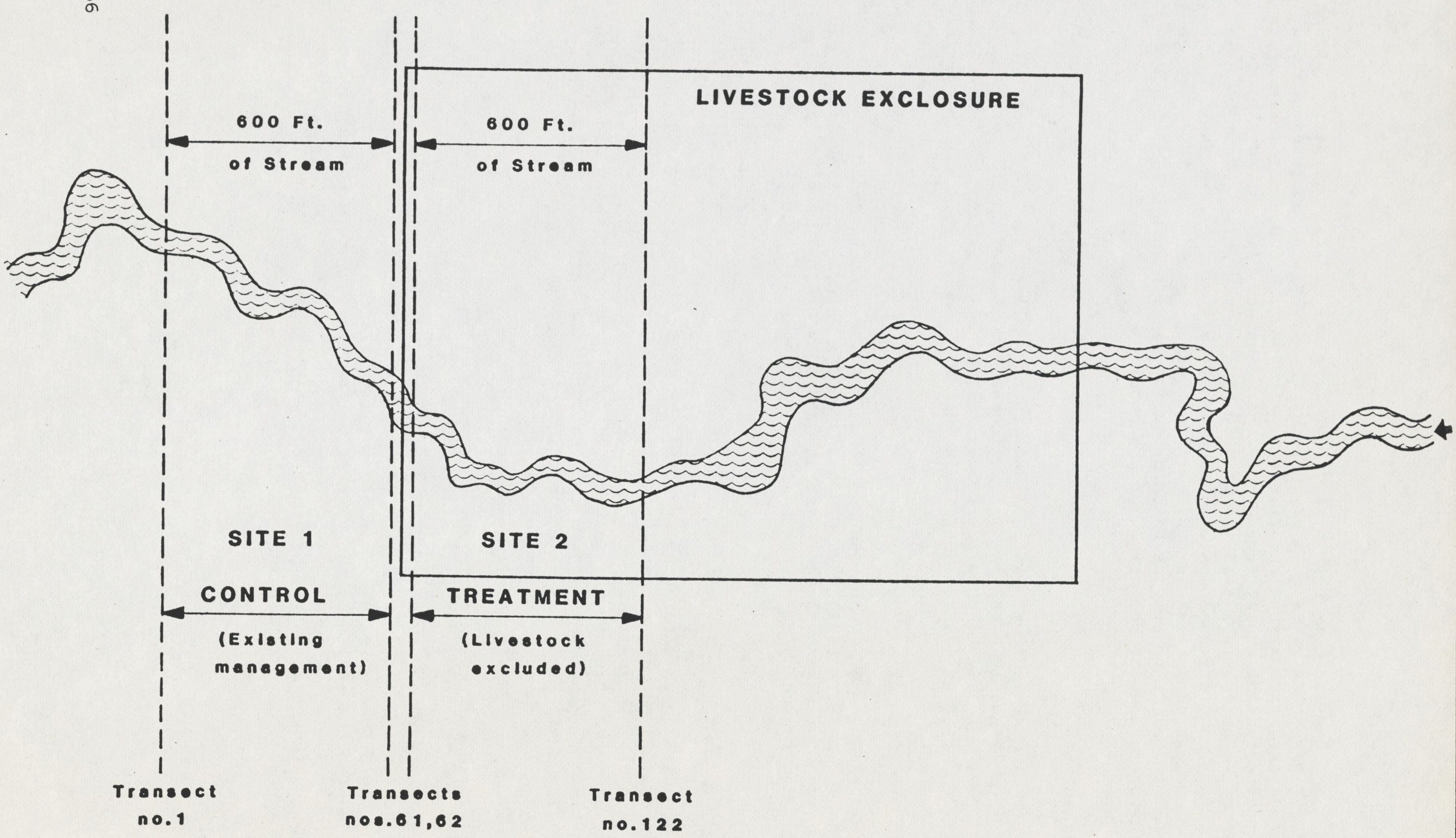

Figure 2. Schematic diagram of the Livestock-Fishery Interaction Study area on Tabor Creek, Nevada.

Water Column

Stream width is that area of the transect covered by water. Stream depth was the average of four water depths taken at four predetermined equal intervals across the transect. Streamshore depth was taken at the intersection of the streambank or stream channel with the edge of the water. Pools were classified as that area of the water column usually deeper than riffles and slower in water velocity; the remainder of the column was classified as riffle. Pool quality rating was based on the pool's ability to provide certain rearing requirements of fish. Pool feature evaluated the origin of the pool.

Steam Channel

Channel sediments were classified as small boulder, 12 inches (305 mm) or larger in particle to 23.9 inches (305 to 609 mm) diameter; rubble, 3 to 11.9 inches (76 to 305 mm); gravel, 0.19 to 2.9 inches (4.8 to 76 mm); and fine sediment, less than 0.19 inches (4.8 mm) in particle diameter.

Instream vegetative cover was a direct measurement of the vegetation cover on the channel intercepted by the transect. Stream channel substrate embeddedness measured the gasket effect of fine sediment around the larger size substrate particles. Channel gradient was determined using an engineer's level and stadia rod.

Streambanks

Streambank alteration measured the natural and artificial change (mainly livestock-induced) occurring to the streambank. The streambank angle was measured with a clinometer that determined the downward slope of the streambank to the water. Streambank undercut was a direct horizontal measurement, parallel to the stream channel. Fisheries environment rating was based on the quality of the bank-stream contact area relative to the needs of salmonids.

Riparian Vegetation

Streamside cover categorized the dominant vegetation as tree, brush, grass, or exposed. Streamside cover stability rated the ability of the streambanks to resist erosion. Vegetation overhang directly measured the length of the vegetation overhanging the water column within 12 inches (304.8 m) of the water surface. The habitat form rating ranked the streamside habitat with respect to the relative importance of its structure to fish.

Hydraulic Geometry

An engineer's level and stadia rod were used to map the stream channel cross sections. A steel measuring tape was stretched across the transect and from this tape, vertical, and respective horizontal measurements were made across the transect from the tape to the streambank, stream channel, and water level. Using a sag tape program developed by Ray and Megahan (1978), a computer was used to plot cross sections. Water velocities were taken at selected intervals across the transect with a Marsh-McBirney electronic meter.[4/]

RESULTS

Water Column

Considerable differences, significant at the 95 percent confidence level, were observed between the grazed and rested sites in some of the water column measurements, showing the beneficial effects to the stream from the prolonged rest (table 1). The rest eliminated streambank erosion from livestock trampling in the exclosure and allowed the banks to rebuild (figs. 3 and 4). This allowed the water column to narrow in width, which if it occurred over a large enough area, could reduce summer stream temperatures because of reduced insolation. Average stream depth was also greater in the rested area, as was streamside water depth and percentage of pool in 1980. Water velocities were less and pools were of higher quality (by means only). Beaver are using the rested area, where willow has regrown, but are not using the grazed area where willow has not recurred.

Stream Channel

The stream channel also showed some improvement, but not to the extent that occurred in the water column. Boulder was slightly higher and rubble was lower in the rested site versus the grazed site. Embeddedness, a function of the fine sediments, was slightly lower in the ungrazed area in 1979 but showed no significant difference in 1980.

Although stream width was narrower in the rested area, it contained about four times as much instream vegetation cover (7.0 percent) as the grazed area (2.7 percent).

[4/] The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others which may be suitable.

Table 1.--A comparison of environmental conditions between grazed and rested sites with 95 percent confidence intervals on Tabor Creek, Nevada.

Variable	1979 Study Site Ungrazed Mean	Interval	Grazed Mean	Interval	1980 Study Site Ungrazed Mean	Interval	Grazed Mean	Interval
Water Column								
Stream width (ft)	10.2*	9.2 - 11.2	13.9*	12.9 - 14.9	11.7*	10.8 - 12.7	14.6*	13.7 - 15.6
Stream depth (in)	5.3*	4.8 - 5.8	4.0*	3.5 - 4.4	5.2*	4.7 - 5.6	3.8*	3.5 - 4.3
Riffle width (percent	78.7	73.2 - 84.2	81.4	75.9 - 86.9	63.0*	56.9 - 69.2	76.5*	70.4 - 82.7
Pool width (percent)	21.3	15.8 - 26.8	18.6	13.1 - 24.1	37.0*	30.8 - 43.1	23.5*	17.3 - 29.6
Pool quality	1.8	1.5 - 2.1	1.3	1.0 - 1.6	2.0	1.6 - 2.3	1.5	1.1 - 1.8
Pool feature	1.6	1.2 - 2.0	1.0	0.7 - 1.3	1.3	1.1 - 1.5	1.0	1.0 - 1.2
Streamside water depth (in)	0.9	0.4 - 1.3	0.6	0.1 - 1.1	1.4	1.0 - 1.9	0.9	0.5 - 1.3
Stream velocity (cfs)	0.9	-	1.3	-	-	-	-	-
Instream vegetal cover (in)	8.6	5.3 - 12.0	2.3	0.0 - 5.6	8.0	5.2 - 11.0	4.7	1.8 - 7.7
Stream Channel								
Boulder (percent)	12.3	8.1 - 16.6	4.8	0.5 - 9.0	9.4*	7.1 - 11.6	2.2*	0.0 - 4.4
Rubble (percent)	20.1*	14.6 - 25.5	31.1*	25.7 - 36.5	27.7*	23.8 - 32.5	47.9	43.1 - 52.7
Gravel (percent)	45.3	38.5 - 52.2	50.2	43.4 - 57.0	52.0	46.3 - 57.7	41.0	35.3 - 46.7
Fines (percent)	22.3*	16.5 - 28.1	13.9	8.2 - 19.7	11.0	6.9 - 15.0	8.9	4.9 - 13.0
Embeddedness	2.8*	2.6 - 3.0	3.3*	3.1 - 3.5	3.2	3.0 - 3.4	3.5	3.2 - 3.7
Streambanks								
Bank angle (degrees)	110.4	102.5 -118.2	113.8	106.0 -121.6	115.9	106.9 -125.0	127.7	118.6 -136.7
Bank undercut (in)	2.0	1.3 - 2.8	1.6	0.8 - 2.2	2.2	1.6 - 2.9	1.4	0.7 - 2.0
Bank alteration natural (percent)	27.2*	23.9 - 30.5	22.4*	19.1 - 25.7	42.9	37.1 - 48.6	38.9	33.2 - 44.7
Bank alteration artificial (percent)	7.0*	5.1 - 9.0	14.1*	12.2 - 16.1	0.0*	0.0 - 3.1	17.1*	14.1 - 20.2
Cover type	2.0	1.8 - 2.2	2.0	1.8 - 2.2	2.0	1.8 - 2.1	1.9	1.7 - 2.1
Bank stability	2.3*	2.1 - 2.5	1.7*	1.5 - 1.8	2.5	2.2 - 2.7	2.2	2.0 - 2.5
Vegetative overhang (in)	5.0*	3.7 - 6.5	1.3*	0.1 - 2.6	5.5*	3.8 - 7.1	0.5*	0.0 - 2.0
Vegetative use (percent)	0.0*	0.0 - 3.6	68.3*	64.8 - 71.9	0.0*	0.0 - 5.1	72.4*	67.3 - 77.4
Habitat type	13.1	11.9 - 14.2	13.7	12.6 - 14.9	12.2	11.0 - 13.4	11.5	10.3 - 12.7
Fisheries rating	1.7	1.6 - 1.9	1.3*	1.1 - 1.5	1.5*	1.4 - 1.7	1.3*	1.1 - 1.4

*Significant ($P<0.05$)

Figure 3. Tabor Creek in May 1977 with widened stream channel.

Figure 4. Tabor Creek in July 1981 after 5 years' rest. Note narrowing of the channel.

Streambanks

Most streambank environmental measurements also demonstrated the beneficial effects of rest from grazing (figs. 5 and 6). The bank angle means were less (not significantly, however) in the rested area with higher undercut, indicating that the rested banks are beginning to redevelop their natural, undercut character. Natural streambank alteration was similar in both study sites, but the amount of artificial streambank alteration was over twice as extensive in the grazed area. During 1980, no bank alteration clearly attributable to artificial processes could be detected in the rested area.

Stream cover type and habitat forms were similar in both study sites, though arithmetic means were slightly better in the ungrazed area in 1980, whereas bank stability was consistently better in the rested area. Vegetation use was, of course, absent in the rested area, but was heavy (68 to 72 percent) in the grazed area. As a result, the vegetative cover overhanging the water column was 11 times greater in the rested site in 1980 than in the grazed site. The fisheries habitat rating was superior in the rested area, though the difference was not dramatic.

Cross Sections

The channel in the ungrazed area was narrower, steeper, and water depth was deeper (table 1 and figs. 7 and 8).[5/] The channel structural rehabilitation process in the rested area is slow, but with 4 years of nongrazing the rested area is showing improvement.

[5/] These were drawn from actual cross sections that appeared typical for the stream section in question; the occurrence of the island in figure 8 does not mean that the channel will bifurcate or form islands when rested.

Figure 5. Tabor Creek in May 1977, with unstable streambanks.

Figure 6. Tabor Creek in July 1981 after 5 year's rest. Note improvement in streambank stability.

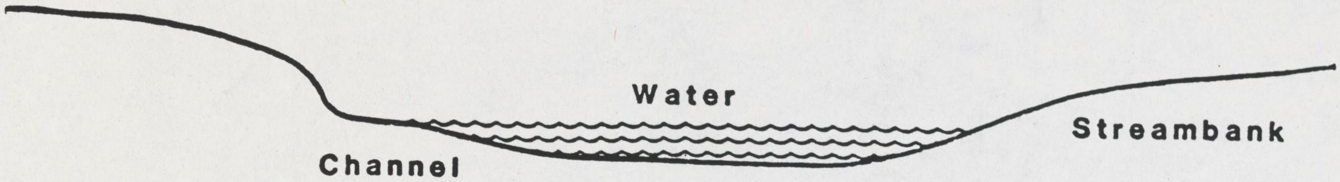

Figure 7. Typical channel cross section in the grazed area.

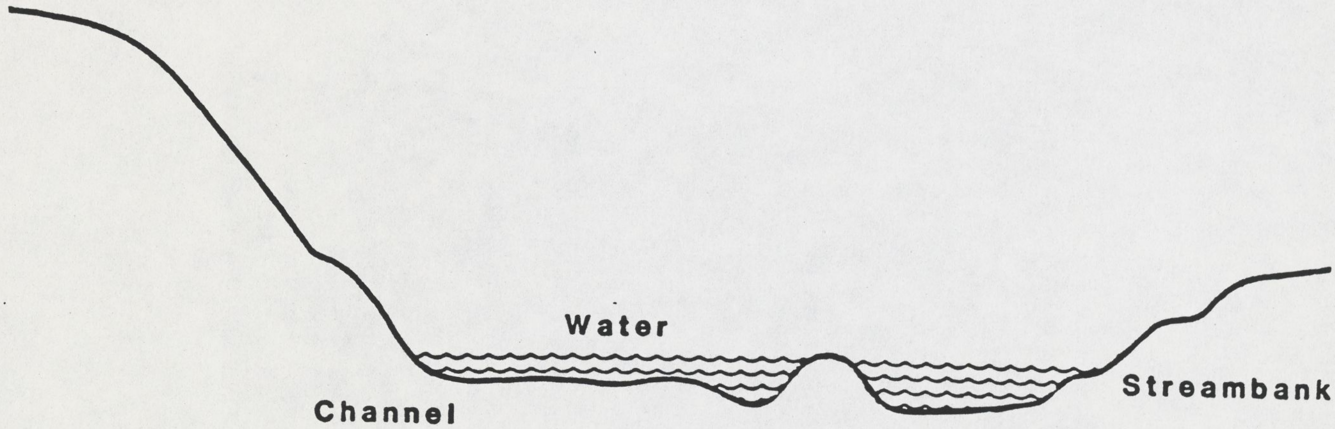

Figure 8. Typical channel cross section in rested area.

DISCUSSION

A continuous grazing strategy on riparian-stream habitat types, such as found on Tabor Creek, can cause environmental deterioration, but with 4 years of rest there can be considerable improvement in certain aquatic habitat types. The management of the study site is being modified to initiate a rest-rotation grazing strategy for the rested area. This will allow an evaluation of what the researchers hypothesize is a more compatible system, a comparison of this system with the continuous system, and an opportunity to evaluate whether the improving trend within the rested area will be slowed or reversed under rest-rotation grazing.

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1985

Stream habitat and fisheries response to livestock grazing and instream improvement structures, Big Creek, Utah

William S. Platts and Rodger Loren Nelson

ABSTRACT: Fisheries habitat and fisheries response were compared on an area protected from grazing for 11 years and on adjacent, heavily grazed areas of similar structural and riparian character. Prohibiting grazing dramatically improved riparian vegetation, streambanks, and stream channel conditions. But this improvement was countered by off-site, upstream influences and on-site, instream improvement structures that functioned as fine sediment traps. Fish populations did not respond to improving habitat conditions because the relatively small size of the livestock exclosure did not reduce incoming, limiting influences created by upstream conditions and the artificial nature of the fishery.

OF the 1.9 billion acres of land in the conterminous United States, 639 million acres are rangeland. Most of this rangeland is in the 11 western states. Early western settlers quickly recognized the value of using these vast areas for livestock grazing. Sheep and cattle were turned onto rangeland in large numbers. By the 1930s range degradation had occurred in many areas (*11*). Awareness of this general deterioration led to improved range management practices. Overall, range conditions have since improved (*3*).

A shortcoming of positive range trend assessment is that analyses have been based primarily on upland range vegetation conditions, neglecting riparian ecosystems (*7*). These verdant, often narrow strips of streamside vegetation attract domestic livestock, particularly cattle, because of the drinking water, shade, relatively gentle topography, and vegetation that may remain succulent long after upland forage begins to cure. Consequently, the degree of range improvement implemented on uplands may not have occurred in riparian ecosystems.

Livestock grazing is a worthwhile use of western public land, but not at the expense of other legally mandated uses. The Feder-

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al Land Policy and Management Act of 1976 (P.L. 94-579) and the Public Rangelands Improvement Act of 1978 (P.L. 95-517) jointly direct the Bureau of Land Management (BLM) to manage rangeland for multiple use, including but not limited to fish and wildlife needs. An obvious need exists to expand the study of livestock-fishery interactions to improve range management. Our study compared heavily grazed sections along Big Creek in Utah with an adjacent stream section that has been fenced to exclude livestock for 11 years.

Study area

Big Creek, in northeastern Utah, is a principal tributary of the Bear River (Figure 1). It originates from a spring on the eastern flank of the Wasatch Mountains and flows about 20 miles to its confluence with the Bear River. Only 5 miles of Big Creek are on BLM-administered land (*4*). Upper reaches of the creek are primarily on land administered by the Forest Service. Downstream reaches are chiefly privately owned.

The study area lies within the Middle Rocky Mountain Physiographic Province (*6*). Upland range vegetation is potentially of the sagebrush-wheatgrass section of the Wyoming Basin Province (*2*). Water in Big Creek is moderately hard and turbid, with summer temperatures as high as 70°F. Game fish include hatchery-reared rainbow trout (*Salmo gardneri* Richardson), some resident Yellowstone cutthroat trout (*Salmo clarki* Richardson, ssp. *bouveri*), and a few eastern brook trout (*Salvelinus fontinalis* Mitchell). Nongame species include mottled sculpin (*Cottus bairdi* Girard) and sucker (*Catostomus* sp.).

Plant cover and soil stability along the stream apparently were so altered by cattle concentrations (*4*) that in 1970 BLM constructed a barbed wire fenced exclosure to protect 3,300 feet of the creek from livestock grazing. To improve pool quality and pool-riffle ratio, 17 instream improvement structures—gabions and trash catchers—were constructed inside and outside the exclosure in 1970. An additional 26 such structures were constructed inside the exclosure in 1971. The exclosure has not prevented livestock use completely. Heavy unauthorized use occurred in 1974 (*4, 5*) and less extensive use occurred in 1979 and 1981 (authors' unpublished report). However, land within the exclosure received considerable rest compared with adjacent heavily grazed areas.

Grazing history

BLM established the Big Creek Allotment in 1965 following a 40% reduction in forage use. However, the historic continuous or season-long grazing system was retained. A 1978 range trend analysis found that forage use by cattle was at the 65% level; 61% of the cattle range was in static condition; 39% was deteriorating. Also, riparian habitat (Figure 2) was in poor condition (Glade Anderson, BLM, Salt Lake City, Utah, unpublished report). An environmental impact assessment identified streambank sloughing as an area of special concern. The assessment also found that stream habitat within the exclosure as the only "good" fishery habitat in the planning unit. The study proposed short-term reductions in grazing intensity and a change in grazing strategy. These proposals have not been implemented.

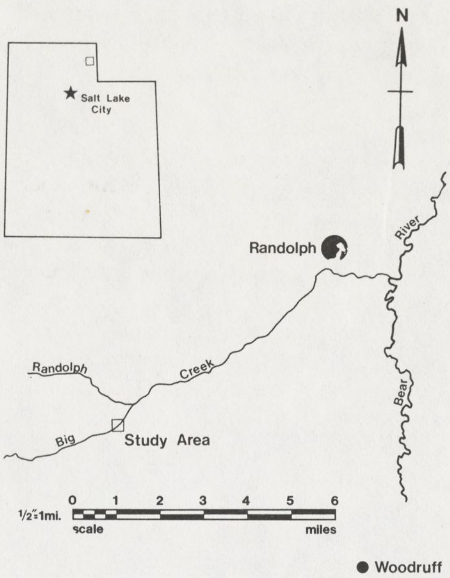

Figure 1. Location of Big Creek study area.

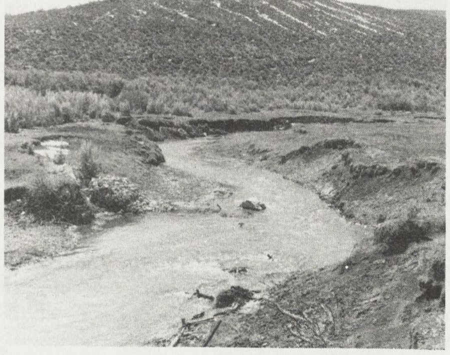

Figure 2. Riparian habitat along Big Creek.

Study methods

In 1979, as part of a coopertive study with BLM, we subdivided 1,800 feet of Big Creek (600 feet below the exclosure and continuous with 600 feet within the exclosure and 600 feet immediately above the exclosure) into 183 stream cross sections, creating three study sites of 61 transects each (Figure 3). Transects were placed at 10-foot intervals perpendicular to the principal streamflow and marked with permanent steel posts. All data collections were made along these transects.

Comparison of photographs taken in 1970 prior to exclosure and in 1982 showed the grazed and ungrazed stream sections in the study area were of a similar nature (Figures 4, 5, 6, and 7). Duff (*4*) found that percent vegetative cover (25%) on streambanks was quite similar in 1971 on the grazed and ungrazed sites even though the

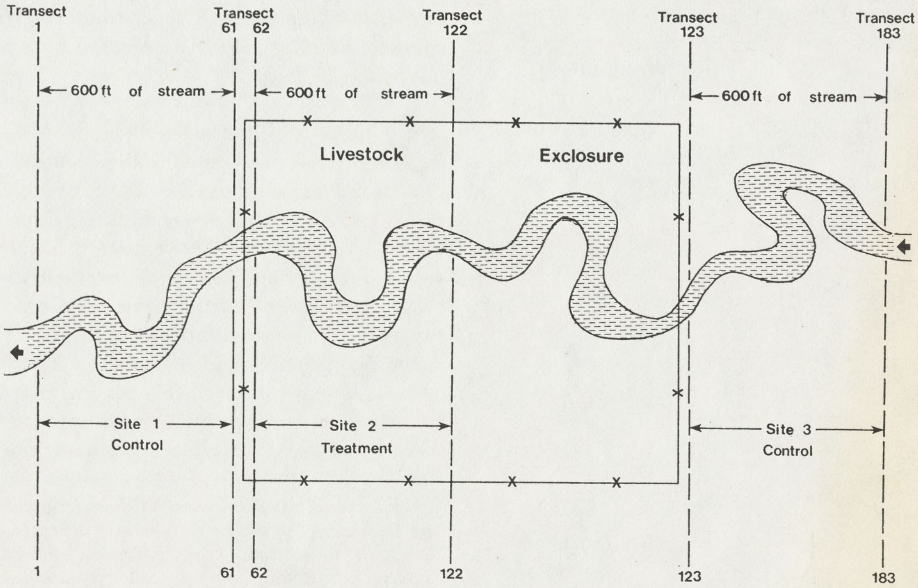

Figure 3. Schematic diagram of the study design.

ungrazed section was entering its first year of rest.

Aquatic habitat measurements were made in August 1979 and September 1980; riparian habitat measurements were taken near the end of the grazing season in October 1979 and September 1980. Fish population sampling was conducted in cooperation with the Utah Division of Wildlife Resources at the same time the aquatic habitat measurements were made.

Water column. Stream width was that area of the transect covered by water. Stream depth was the averge of four measurements taken at predetermined, equal intervals along the transect. Pools were those areas of the water column usually deeper than riffles and slower in water velocity; the remainder of the column was classified as riffle. We based quality evaluation on the pool's ability to provide trout rearing habitat. A high quality pool was rated 5 (over 3 feet deep or over 2 feet deep with abundant fish cover); a poor quality pool was rated 1 (shallow and small with little cover).

Streambanks. We measured streambank angle with a clinometer. Streambank undercut was a direct horizontal measurement, taken parallel to the bottom of the stream channel, of the amount of overhanging streambank. Streamshore water depth was a direct measurement of stream depth at the edge of the bank. The fisheries environment rating evaluated the quality of the fisheries habitat near the streambank, based largely on the streambank measurements.

Figure 4. Along this newly constructed fence in 1970, grazing intensity was the same inside the exclosure (right) as in the grazed area.

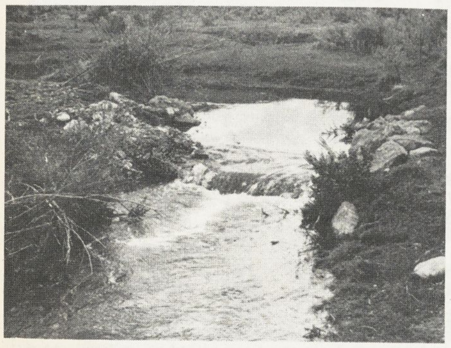

Figure 5. A gabion site, soon to be fenced inside the exclosure in 1970, shows the heavy grazed condition prior to exclosure.

Streambottom. We classified substrate materials into five groups by visually projecting each 1-foot division of a measuring tape to the streambed and assigning the major observed sediment class to each division. Substrate particles included boulder, 12 inches and larger in particle diameter; rubble, 3 to 11.9 inches; gravel, 0.19 to 2.9 inches; coarse sediment (sand), 0.033 to 0.18 inch; and fine sediment (silt), smaller than 0.033 inch. Stream channel substrate embeddedness measured the gasket effect of fine sediments around the larger substrate particles. The rating ranged from a high of 5 when fine sediment covered or contacted less than 5% of the larger substrate to a low of 1 when fine sediment covered more than 75% of the larger substrate. We measured vegetation cover directly on the channel intercepted by the transect. Channel gradient was surveyed at the hydrologic stations at each transect with an engineer's level and stadia rod.

Riparian habitat. We categorized the dominant streamside vegetation as tree, brush, grass or forbs, or exposed soil. Streamside cover stability rated the ability of the streambanks to resist erosion. Ratings ranged from 4, when vegetation in vigorous condition or large substrate particles preventing erosion covered 80% of the bank, to 1, less than 25% of the bank covered by vegetation or large substrate particles. We measured vegetation overhanging the water column within 1 foot of the water surface. Streambank alteration measured the quantity of natural and artificial change occurring along the streambank; it was ranked from 0 to 100%.

Hydraulic and channel geometry. We used an engineer's level and stadia rod to map 10 cross sections in each study site. We plotted cross sections with a sag tape computer program developed by Ray and Megahan (*10*).

Fish populations. Utah wildlife biologists collected fish with back-pack mounted, battery-powered electrofishers using 2, 3, or 4 removals as appropriate. Trout were individually weighed and measured for total length; sucker and sculpin were identified, counted, and weighed only. Population estimates were determined using a

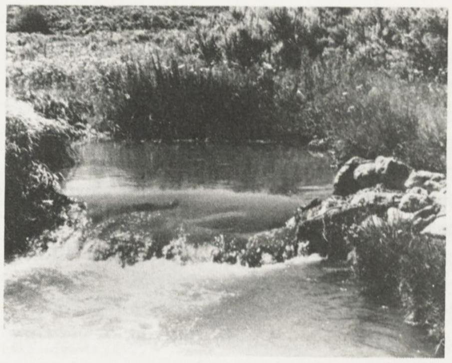

Figure 6. A gabion site in 1982 within the exclosure shows the changes that occurred since 1970.

Figure 7. The exclosed ungrazed area (top) in 1982 shows habitat improvement compared to the heavily grazed area (bottom) that exhibits conditions similar to 1970.

computerized, maximum likelihood depletion model (9).

Results

Water column. Our findings support the hypothesis that streams widen and become more shallow when cattle heavily graze the banks (Table 1). In both 1979 and 1981 the grazed stream sections were wider than the ungrazed section, though the difference was not statistically significant. The difference is especially meaningful because the instream improvement structures along the ungrazed site should increase water column width. The stream section within the ungrazed section was significantly ($P > 0.05$) deeper than the sections within the grazed controls. The relative amounts of pool and riffle also were significantly different; the ratio was nearer 1:1 in the ungrazed section in 1979. But in 1980 the relative amount of pool greater than 50% in all sections and was greatest in the ungrazed site. This apparent change probably was due to observer bias because the methodology encouraged rating intermediate areas as pool, though increased streamflow in 1980 also may have influenced the ratings.

Pool quality was consistently higher within the ungrazed section, but the differences were significant only with respect to downstream grazed sites. We partially attributed these differences to the greater number of instream improvement structures inside the exclosure. The upstream grazed area was more similar to the ungrazed exclosure, suggesting that reduction of livestock impacts was partially responsible. The upstream grazed section included some private land and received less grazing pressure.

Streambanks. In 1979 ratings of streambanks were significantly better in the ungrazed treatment site than in both grazed sites. In 1980, however, only fisheries rating and bank angle were significantly better than both grazed areas. We attributed this to improved ratings within the upstream grazed site in 1980, whereas most ratings within the ungrazed site were similar to their corresponding 1979 ratings. The cause of this is unclear, but the parallel changes in pool width, pool rating, and fisheries rating and the decline in bank angles suggest that the increased water level in 1980 was influential. Such increased streamflow can cause real changes in streambank conditions as well as making the streambank-water contact zone appear somewhat different to the observer.

Streambottom. Channel surface substrate evaluation showed significantly greater amounts of rubble and boulder and lesser amounts of gravel within the ungrazed site in both 1979 and 1980 compared with both grazed sites. However, the higher pool-feature ratings in the ungrazed area suggest that some of the boulder and possibly some of the larger rubble may have been structural material either *in situ* or eroded from the gabions. The amount of coarse sediment was low at all sites in both years. On the other hand, the amount of fine sediment was high in the ungrazed site and the upstream grazed site in both years, but significantly lower in the downstream grazed site. The gabion enhancement dams within the ungrazed site probably functioned as fine sediment traps and provided more pool; this effect extended into the upper grazed site. The embeddedness rating reflected this sedimentation effect. Fish cover provided by instream vegetation consistently was greatest within the ungrazed site; it was significant with respect to both grazed sites in 1979 and with respect to the lower grazed site in 1980. Fish cover also was relatively high in the upper grazed site.

Riparian habitat. Overall, riparian habitat conditions were significantly better within the ungrazed site than within either grazed site both years. Bank stabilization by riparian vegetation was much more extensive within the ungrazed site compared with both grazed sites. Though only significant in 1980, grass and brush contributed more to the streamside vegetation on the ungrazed site. The riparian habitat type rating was significantly better on the ungrazed site in both years compared with both grazed sites, indicating that the streamside vegetation was more favorable to game fish production in this protected area. There was also significantly more overhanging vegetation on the ungrazed site.

Vegetation use by livestock was very low on the ungrazed site although some unauthorized grazing was evident. Interestingly, vegetation use was somewhat less within the upper grazed site than within the lower grazed site, possibly because a fenceline from a private property inclusion bisects the upper grazed site. Artificial bank alteration was considerably less evident on the ungrazed site. Natural alteration was similar in all three study sites.

Hydraulic and channel geometry. The ungrazed site has been rested since 1970, with occasional occurrences of unauthorized cattle use. Despite this, stream channel geometry, which should improve more slowly than vegetative conditions, was best in the ungrazed site (Figure 8). Because of

Table 1. Summary of riparian-stream habitat variables, Big Creek, Utah, 1979 and 1980.

	Grazed								*Ungrazed*			
	Site 1				*Site 2*				*Site 3*			
	1979		*1980*		*1979*		*1980*		*1979*		*1980*	
Variable	*Mean*	*± Percent**	*Mean*	*± Percent**	*Mean*	*± Percent**	*Mean*	*± Percent**	*Mean*	*± Percent**	*Mean*	*± Percent**
Water column												
Stream width (feet)	12.5	6.2	13.3	6.1	12.8	6.0	13.8	5.9	11.7	6.6	12.3	6.6
Stream depth (inches)	6.3	13.4	7.0	14.4	7.9	10.6	8.2	12.4	10.4ab†	8.1	12.0ab	8.4
Riffle width (%)	78.5	8.5	43.7	18.2	62.7	10.6	28.6	27.8	42.1ab	17.0	14.9a	53.4
Pool width (%)	21.5	30.9	56.3	18.2	37.3	17.8	71.4	11.1	57.7ab	11.5	85.1a	9.3
Pool rating	1.6	19.0	3.1	9.9	3.1	9.3	3.9	7.9	3.6a	7.9	4.5a	6.7
Pool feature	1.5	-	1.2	-	1.0	-	1.0	-	5.7a	-	6.2ab	-
Streambanks												
Bank angle (degree)	136	5.4	134	5.8	138	5.3	124	6.3	113ab	6.5	104ab	7.5
Bank undercut (inches)	0.9	55.7	1.2	53.4	0.8	67.9	1.7	38.1	2.3ab	23.3	2.6	25.2
Bank water depth (inches)	1.1	55.6	0.9	76.1	0.6	92.6	1.7	40.7	2.9ab	20.5	2.9a	23.5
Fisheries rating	1.2	15.5	2.0	10.5	1.9	9.6	2.4	8.8	2.6ab	7.1	4.3ab	5.0
Streambottom												
Boulder (%)	1.2	97.8	3.3	62.7	0.0	‡	0.0	‡	3.7ab	31.8	6.1ab	33.7
Rubble (%)	1.9	221.0§	3.6	149.1	0.1	3,133.2§	0.0	‡	23.7ab	18.1	33.6ab	15.8
Gravel (%)	81.3	7.7	82.8	6.6	51.7	12.2	68.9	8.0	22.7ab	27.7	15.2ab	36.0
Coarse sediment (%)	0.0	‡	0.4	87.7	2.3	44.4	0.0	‡	0.9	120.2§	0.3	123.0§
Fine sediment (%)	15.5	46.6	9.9	68.8	45.8	15.8	31.1	21.9	49.0a	14.8	44.8ab	15.2
Substrate embeddedness	3.0	8.4	3.3	7.0	2.3	11.0	3.0	7.9	2.2a	11.5	2.3	10.4
Instream vegetative cover (feet)	1.2	70.7	0.8	84.5	5.1	16.5	3.2	20.9	3.3ab	25.2	3.2a	20.8
Riparian habitat												
Bank cover stability	1.7	9.7	1.6	10.2	2.0	8.4	1.7	9.5	3.4ab	4.9	3.2ab	5.0
Stream cover	1.9	5.2	1.4	8.5	1.8	5.3	1.5	7.8	2.1	4.7	2.1ab	5.6
Habitat type	12.9	6.0	10.0	8.6	11.7	6.6	13.5	6.3	15.3ab	5.1	15.3ab	5.6
Vegetation use (%)	76	3.5	87	3.7	74	3.6	77	4.1	17ab	15.4	0	‡
Ban alteration (%)												
Natural	13	12.1	6	18.9	10	15.8	5	25.9	12	12.6	7	18.9
Artifical	29	7.5	63	4.4	24	9.1	58	4.8	4ab	50.0	20ab	13.8
Vegetative overhand (inches)	0.8	90.6	2.1	46.6	1.4	54.3	2.7	36.2	6.8ab	11.0	13.1ab	7.5

*95 percent confidence limits expressed as a percentage of the mean.
†a = significantly different than site 1 mean at the 95% level; b = significantly different than site 3 mean at the 95% level.
‡Cannot be expressed as percentage of mean.
§Upper limit only, lower limit = 0.

the lack of grazing, the stream has narrowed and the banks are beginning to regain their natural high, undercut character. Meanwhile banks remain broken-down and outsloped within the adjacent grazed sites.

Fish populations. Trout populations do not reflect the apparently improved habitat conditions within the ungrazed site (Table 2). The put-and-take nature of the game fishery in Big Creek; the low numbers of trout; and the unknown impact of recreational fishing, which may be greatest in the ungrazed site because of the better looking habitat, preclude reliable speculation on trout population trends. We can say safely that trout are not abundant. Those present are almost exclusively hatchery-reared rainbow trout. A few wild cutthroat trout occasionally move into the area from upstream reaches of the adjacent Cache National Forest (Dexter Pitman, Utah Department of Wildlife Resources, personal correspondence). Furthermore, poor conditions in the water column generated upstream from the degraded watershed, such as suboptimal temperature, turbidity, and nutrients, probably move into the ungrazed area. Consequently, the generally improved channel and streambank conditions may not be sufficient to improve fish populations. Limiting factors created by upstream conditions and transported through the ungrazed area by the water column may be the principal cause why this and other riparian fencing projects fail to increase fish populations despite improved habitat conditions.

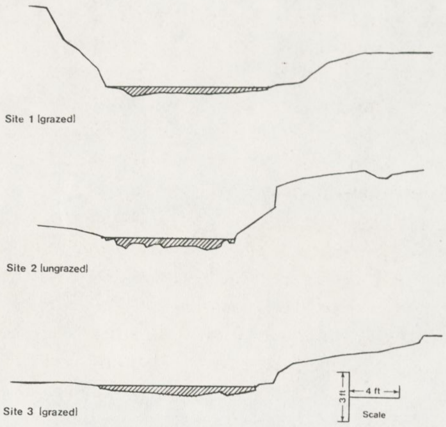

Figure 8. Representative stream channel cross sections from the 1979 hydraulic and channel geometry analysis.

Figure 9. Eroded gabion, Big Creek.

The increased embeddedness in the ungrazed site may have negatively affected sculpin populations, which were lowest in both years in this stream section. Bailey (*1*) found that mottled sculpin prefer riffles and are scarce in heavily silted areas; our study corroborated this. Conversely, suckers appear to have benefitted from sedimentation; they were most numerous in the highly embedded grazed sites.

Conclusions

Our results show that degraded riparian and fishery habitat can be rehabilitated with grazing rest. We observed similar results in Tabor Creek, Nevada (*8*). In the 11 years since construction of the livestock exclosure, riparian vegetation conditions in the ungrazed section of Big Creek improved dramatically. Channel and streambank improvement also occurred, though such structural rehabilitation was slower than vegetational improvement. Duff (*4*) also found that riparian and stream habitat improved from 1973 to 1976, attributing this to rest from grazing inside the exclosure.

Fish populations have not benefitted from the improved habitat conditions, probably because of the influence on limiting factors from upstream sources. Structures have improved the pool-riffle ratio and overall pool quality in the treatment area. But they also have trapped large amounts of fine sediments from upstream erosion. This has counteracted

Table 2. Fish population analysis, Big Creek, Utah, 1979 and 1980.

	Grazed								*Ungrazed*			
	Site 1				*Site 3*				*Site 2*			
	1979		*1980*		*1979*		*1980*		*1979*		*1980*	
Species/Variable	*Value*	*± Percent**	*Value*	*± Percent**	*Value*	*± Percent**	*Value*	*± Percent**	*Value*	*± Percent**	*Value*	*± Percent**
Rainbow Trout												
Total catch	5	-	9	-	7	-	2	-	6	-	4	-
Population estimate	5	0.0	9	0.0	7	14.3‡	2	0.0	6	0.0	4	125.0‡
Length (inches)	9.28	18.2	10.10	7.1	10.02	9.9	9.59	96.5	9.37	28.3	9.51	13.6
Weight (ounces)	4.67	56.9	6.07	21.0	5.53	34.0	5.13	266.3§	4.85	48.3	4.88	49.5
Biomass [(oz/ft²)(10⁻³)]‖	3.1	-	6.9	-	5.0	-	1.2	-	4.1	-	2.6	-
Cutthroat trout												
Total catch	0	-	0	-	3	-	23	-	0	-	3	-
Population estimate#	-	-	-	-	3	66.7‡	25	24.0‡	-	-	3	166.7
Length (inches)	-	-	-	-	5.24	166.6§	6.46	9.5	-	-	7.13	15.6
Weight (ounces)	-	-	-	-	1.42	215.0§	1.74	40.3	-	-	2.22	53.3
Biomass [(oz/ft²)(10⁻³)]‖	-	-	-	-	0.6	-	5.3	-	-	-	2.6	-
Sculpin												
Total catch	744	-	1,240	-	788	-	1,100	-	383	-	666	-
Population estimate#	946	13.2	1,240	7.3‡	1,023	47.8	1,109	1.4‡	384	1.0‡	896	17.2
Weight (ounces)	0.20	20.8	0.11	22.9	0.19	24.0	0.19	31.6	0.21	18.5	0.13	31.6
Biomass [(oz/ft²)(10⁻³)]‖	25.7	-	16.9	-	24.7	-	25.0	-	11.7	-	15.6	-
Sucker												
Total catch	16	-	2	-	21	-	22	-	34	-	6	-
Population estimate#	17	35.3‡	2	1,050.0‡	21	14.3‡	23	17.4‡	34	2.9‡	6	33.3
Weight (ounces)	0.85	12.3	1.13	0.0	1.03	7.3	0.89	29.3	1.92	59.6	1.10	18.5
Biomass [(oz/ft²)(10⁻³)]‖	1.9	-	0.3	-	2.8	-	2.5	-	9.3	-	0.9	-

*95 percent confidence limits expressed as a percentage of the mean or population estimate.
†The value of the population estimate is reduced when total catch is small and confidence intervals are wide in such cases.
‡Upper limit only; lower limit equals total catch.
§Upper limit only; lower limit = 0.
#Based on three removals only.
‖Based on population estimates; no attempt was made to pool variances and calculate confidence intervals.

other habitat improvements for trout and sculpin, while possibly making the area more suitable for suckers. Furthermore, cattle trampling has broken down most of the structures within the grazed sites; these subsequently have ceased to function (Figure 9). Structures inside the exclosure are still functioning, creating pools of good quality but also trapping large quantities of fine sediments.

If managers fence stream corridors as a rehabilitation option, they need to fence sufficient lengths of stream to reduce the influence of offsite habitat degradation and to control limiting factors inside the exclosures. Management agencies and private operators must work together more closely if such projects are to be effective.

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Anadromous Fish Law Memo

NRLI

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LIVESTOCK GRAZING IN RIPARIAN ZONES: ENSURING FISHERY PROTECTION IN FEDERAL RANGELAND MANAGEMENT

Management of riparian ecosystems on the federal rangelands recently has become a contentious subject among land managers, fisheries specialists, agriculture and livestock interests, and public interest groups. In July 1985, the Bureau of Land Management (BLM) published, but has not yet adopted a "Riparian Area Management Policy." In April 1985, the BLM, the U.S. Forest Service, the Bureau of Reclamation, the U.S. Fish and Wildlife Service, the Soil Conservation Service, and the University of Arizona co-sponsored the First North American Riparian Conference, which elicited over 100 papers and presentations. In late 1984 and early 1985, the Oregon State University Sea Grant Program held several panel discussions around the state entitled "Where Cows and Salmon Meet." And during the past year, Congress considered legislation that would set aside riparian areas on federal lands suffering from overgrazing by domestic livestock.

From about 1850 until 1934, unregulated livestock grazing on the public range destroyed much of the fish habitat and water storage capacity of riparian ecosystems in the semiarid west. Even though range use was regulated under the Taylor Grazing Act of 1934, not until some 40 years later did rehabilitation of rangeland riparian ecosystems become an issue. The change in attitude was due to: (1) scientific evidence indicating that degraded riparian ecosystems cause adverse downstream effects like increased water pollution and diminished late season flows; (2) evidence that degraded riparian zones can be rehabilitated by reduction or exclusion of livestock, upland treatment, and reestablishment of riparian vegetation; (3) changes in public land law requiring public participation in management planning; (4) new federal and state policies declaring that anadromous fish runs must be restored; and (5) judicial interpretation of the federal Clean Water Act provisions prohibiting execution of federal land management plans violating state water quality laws.

Together, these factors mean there are new constituencies the BLM must consider in managing riparian zones, and there may be substantive limits on the agency's discretion to overlook rehabilitation of degraded riparian ecosystems. The Northwest Power Planning Council's compilation of information on salmon and steelhead losses in the Columbia River Basin recently noted that grazing impacts on fish production have received "considerably less mitigation" than other detrimental influences. It appears that the knowledge, interest, and law may now be in place to prompt riparian ecosystem rehabilitation and restore the ecological benefits those systems provided 135 years ago.

This Memo, written by Richard Braun, Natural Resources Fellow at Lewis and Clark Law School during 1985-86, discusses (1) the functions of riparian ecosystems and recently acquired information about the benefits of riparian zone restoration, (2) the conflict between livestock grazing and restoration of riparian zones, (3) the evolution of range management policy from enactment of the Taylor Grazing Act through recent judicial interpretation of the Public Rangeland Improvement Act of 1978, and (4) the role of the Clean Water Act in limiting BLM discretion to forestall or scale down riparian zone restoration, including the availability of citizen suits to enforce agency compliance with water quality laws. The Memo concludes that both the political and legal context for BLM riparian management decision making have changed dramatically; consequently, the agency must give a high priority to implementing a program for rehabilitation of streamside ecosystems.

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Eventually, degraded streams can rebuild and restore conditions suitable for healthy fisheries.

The riparian zone plant community also functions to regulate streamflow, basically acting as a sponge. Porous banks absorb water during fall and spring freshets, with the greatest volume absorbed where soil has not been compacted by livestock. This retained water may recharge shallow aquifers, or it may pool as it seeps along the floodplain. During dry periods, when runoff from the uplands ceases, the streamflows are augmented by releases from the riparian sponge and nearby aquifers.[11] Thus, streams with degraded riparian vegetation and intermittent flows may flow perennially if the riparian zone is restored.[12] Several riparian zone restoration projects have demonstrated this phenomenon.[13] One such study is in progress on Camp Creek, a tributary of the Crooked River in central Oregon, near Prineville. The results of riparian restoration on Camp Creek are nothing short of remarkable.

1. The Camp Creek Story[14]

In 1875 the Oregon Surveyor General described the Camp Creek watershed as an "ungullied meadow" with several marshes and an abundance of bunchgrasses on the uplands. In 1905, a U.S. Geological Survey report stated that Camp Creek ran through a vertical walled trench about 25 feet deep. This major change in geography can be attributed to several factors. First, unregulated livestock grazing depleted the upland bunchgrass. Second, homesteaders and ranchers, competing for native livestock forage, allowed livestock to annihilate riparian vegetation. Third, fire suppression allowed western juniper to overtake the uplands. Juniper, with its extensive shallow root systems, more readily obtained water than the native bunchgrasses, thereby preventing bunchgrass recovery. The areas between juniper trees were left bare and vulnerable to erosion. A severe flood in the winter of 1889 began accelerated downcutting of Camp Creek into the valley floor. As the stream channel cut into the valley floor, the valley's water table dropped.

Without riparian vegetation to stabilize soil, Camp Creek became a conduit for enormous amounts of sediment. In 1953, a riparian landowner built a dam on Camp Creek creating a reservoir with a storage capacity of 531 acre-feet. By 1970, the reservoir had filled with sediment -- roughly 856,680 cubic yards of sediment -- about a million tons of eroded soil. Today, most of the Creek is dry in late summer; in other seasons it has a turbidity problem due to suspended clay and fine silts.

In the fall of 1965, BLM staff and Oregon Department of Fish and Wildlife biologist Harold Winegar experimentally fenced about one mile of Camp Creek's eroded gully to exclude livestock and seeded that section with tall wheatgrass and sweet clover. Later, willow cuttings and Russian olive seedlings were planted. Reestablishment of native plant species and silt catchment was so successful that by 1974 the BLM had installed an additional 3.5 miles of fence. Riparian vegetation regenerated and, by 1977, the agency identified 45 plant species within the enclosure. Only 17 had been present before fencing. As reestablished vegetation trapped sediment, the streambed built up with an apparent accompanying rise in the adjacent water table. Moreover, analysis of inflow and outflow sediment loads indicated that the reestablished riparian vegetation was filtering out extremely fine soil particles, decreasing water turbidity. Finally, during the dry seasons of drought years 1977-81, inflow to the fenced section of the stream ceased. Yet flows of 1/2 cfs were maintained within the enclosure, as the saturated riparian sponge and elevated aquifers discharged into the stream.

B. Resource Conflicts, Riparian Zone Degradation and Lack of Data

Riparian zone specialist Harold Winegar stated, "I submit without reservation that natural recovery of riparian systems, wherever permitted, will improve water quality, improve fish and wildlife habitat, reduce flood impacts, conserve soil, and enhance regulation and maintenance of [water] flows."[15]

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11. See Winegar, above note 9; see also Skinner et al., Reclamation of Riparian Zones and Water Law: First in Time - First in Right, reprinted in 1985 Riparian Report, above note 1, at 374.

12. See Winegar, above note 9. Riparian restoration and stream rebuilding do not produce more water. Rather, riparian restoration returns a stream system's natural ability to regulate water flow timing, duration, frequency and quality.

13. See Stabler, Increasing Summer Flow in Small Streams Through Management of Riparian Areas and Adjacent Vegetation: A Synthesis, reprinted in 1985 Riparian Report, above note 1, at 206. Stabler describes general treatments including introduction of beaver, livestock exclusion, and phreatophyte control. Phreatophytes are deep rooted plants that obtain their water from the ground. They can evapotranspire substantial quantities of water from a watershed. Phreatophyte control involves removal of such "water thieves" to increase flows. See also Southeastern Colorado Water Conservancy Dist. v. Sheldon Farms Inc., 187 Colo. 181, 529 P.2d 1321 (1975). Phreatophyte controls within the riparian zone presents a conflict: vegetation removal not only decreases evapotranspiration, but also eliminates the filtration, stabilization, and shading functions of riparian vegetation; see Ritzi et al. Water Resource Conservation by Reducing Phreatophyte Transpiration, reprinted in 1985 Riparian Report, above note 1, at 191.

14. The material in this section is taken from U.S. Dept. of the Interior, Bureau of Land Management, Prineville District, Camp Creek Watershed Revised Activity Plan (June 1985).

15. Winegar, above note 9.

The implications of these benefits for anadromous and resident fisheries are obvious. But "natural recovery" of riparian ecosystems is not without controversy: a conflict exists between recovery of some degraded riparian systems and their continued use by domestic livestock. Cattle prefer grazing on tender riparian vegetation and they tend to congregate along and in streams. Many ranchers deny that cattle degrade fish habitat, and they oppose stream fencing because restoring riparian systems could be expensive.[16] In particular, temporary loss of riparian forage, costs of supervising cattle, and costs of building watering projects remote from streams could fall upon ranchers.[17]

Generally overlooked are the long-term benefits to ranchers from riparian rehabilitation. First, it is not clear that cattle must be banished forever from riparian zones -- rehabilitated riparian vegetation may provide livestock forage in appropriate locations with proper grazing management with respect to seasons, intensity, and duration of use. Second, improved regulation of water flows may reduce the need for expensive structural water storage projects.[18] Third, revitalized fisheries could increase the value of adjacent lands. Fourth, elevated water tables may improve forage outside enclosures. Fifth, cattle excluded from grazed-out riparian zones, forced to rely on upland vegetation, have shown better weight gains. Studies indicate that many streams will require

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16. See, e.g., U.S.D.I., Bureau of Land Management, Andrews Grazing Management Program, Final Environmental Impact Statement, Response to Comments (Feb. 1983). For example,

> The miles of fencing proposed will cost thousands of dollars per mile and be almost impossible to maintain, move or remove at a later date without equivalent [sic] thousands of dollars in costs. None of the riparian problems indicated in the EIS are of severity to warrant the extreme exclusion measures recommended. More nearly stable and desirable minimum stream flows could and would be realized in the very near future by the simple expediency of juniper tree removal and control.

Id. at 23. One rancher objected to fencing and revegetation of riparian zones because unharvested vegetation will "become dense, rank and create an immense fire hazard." Id. at 30. Another rancher found it unreasonable to expect that many streams could support fish since "these streams dry up on short water years or are often hit with severe cloudbursts that destroy fish habitat and wash the fish out onto the desert." Id. at 33. Another stated "much of the area had a high level of sediment and erosion when white men first came into the desert area." Id. at 39.

The perception that streams have always been eroded is not unreasonable. Much of the massive erosion took place around the turn of the century. Most ranchers alive today were born too late to remember 19th century ecological conditions. Thus there is a tendency to accept current conditions as the norm. Some rancher criticisms of riparian restoration illustrate the intensity of vitriolic feeling they harbor for environmentalists. The Idaho Cattle Association accused environmentalists of suffering from "ripariopsychorrhea," a fictional mental disease with scatalogical overtones. Idaho Cattle Association, The Line Rider (Oct. 1985). Readers were urged to join the "cause in fighting this horrible epidemic ...." Id.

17. Within the Columbia River Basin, capital costs of riparian zone restoration could be at least partially borne by electricity ratepayers under provisions of the Pacific Northwest Electric Power Planning and Conservation Act, 94 Stat. 2697, 16 U.S.C. §§ 839 et seq. The Act requires the Northwest Power Planning Council to develop and adopt a program to "protect, mitigate, and enhance" fish and wildlife, including spawning grounds and habitat, with the Columbia Basin. 16 U.S.C. § 839b(h)(1)(A). See generally Blumm & Johnson, Promising a Process for Parity: The Pacific Northwest Electric Power Planning and Conservation Act and Anadromous Fish Protection, 11 Envtl. L. 497 (1981). The program is implemented and funded by the Bonneville Power Administration (BPA), 16 U.S.C. § 839b(h)(10). The current Program provides for habitat restoration projects including riparian zone revegetation. See Northwest Power Planning Council, Columbia River Basin Fish and Wildlife Program, § 704(d) (1984). Pursuant to the program, BPA commissioned an inventory and watershed rehabilitation plan for the Trout Creek Basin, a Deschutes River tributary system. See Northwest Biological Consulting, Trout Creek Natural Propagation Enhancement Protect, Phase 3 Final Plan (Discussion Draft Oct. 1985) [hereinafter cited as Trout Creek Plan]. The plan states that stream fencing "has been one of the most consistently successful methods for protecting and restoring the stream corridor on lands that are grazed." Id. at App. F, at F2. Further, fencing appears to have a positive benefit to cost ratio. The Trout Creek plan provides for extensive livestock exclusion in vegetation-poor stream reaches on both private and public land. The costs of the plan are borne by BPA.

18. The water flow benefits of riparian zone rehabilitation are difficult to quantify. On May 9, 1986, the Water Resources Research Institute of Oregon State University held an indisciplinary workshop with the following objectives: (1) to develop and demonstrate one or more techniques to estimate the expected changes in surface and ground water flow and in water storage from improvement in riparian vegetation; (2) to develop a consensus on the proper techniques and devices to use for measuring the effects of riparian management; (3) to develop evaluation criteria for the cost-effectiveness of riparian manipulation to increase water yield. See Oregon State University, Water Resources Research Institute, Workshop on Non-Structural Methods for Increasing Basin Water Yields: Summary of Presentations and Ideas (undated).

"rest" -- no grazing periods -- of 5 years or ore to begin rehabilitation of woody and herbaceous riparian vegetation.[19]

The Northwest Power Planning Council recently recognized that grazing-associated riparian habitat degradation contributed to the decline in Columbia Basin anadromous fish population.[20] The Council also noted that grazing impacts on fish production have received "considerably less mitigation" than other detrimental influences.[21] Importantly, the Council recognized that insufficient late season water flows due to irrigation withdrawals are a major cause of fish losses and suggested that minimum streamflows be established and enforced by the states within the Columbia Basin.[22] However, minimum flow laws protect only unappropriated water. Basin-wide riparian zone restoration projects could enhance late season flows which might then be protected from appropriation by minimum flow law.[23] If these flow benefits are substantial, riparian restoration could minimize the water resource conflict between fish habitat and irrigation.

II. Law and Policy

A. Federal Land Management Law On The Federal Rangelands

1. Introduction

Various federal agencies administer 730 million acres of land in the United States, about 32% of the nation, almost three-fourths of which is managed by the BLM and the Forest Service.[24] For example, 29 million of Oregon's nearly 62 million acres are within the jurisdiction of those two agencies. East of the Cascades, the BLM manages about 12.5 million acres on which 245,228 cattle, horses, sheep, and goats grazed in 1984.[25] In 1983, these animals consumed over one million animal-unit-months of forage.[26]

The BLM is a land management agency whose statutory mission has developed relatively late.[27] The lands the BLM manages have been described as "the least desirable leftovers," lands which "throughout almost 200 years of fraud, theft, chicanery, and unparalleled generosity in land disposition, nobody bothered to steal ... or ... dedicate[d] to a specific purpose."[28] BLM land management policy is the product of 52 years of agency history. During the first 40 years of BLM's history, the livestock industry was effectively the agency's sole constituency, exerting virtually unchecked influence on BLM grazing policy. That influence was guaranteed by a legal requirement that the agency consult with the representatives of the industry, and by failure of the law to require widespread public participation in agency decision making. With no formal channel to the

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19. See U.S. Environmental Protection Agency, Livestock Grazing Management and Water Quality Protection (Nov. 1979).

20. Northwest Power Planning Council, Compilation of Information on Salmon and Steelhead Losses in the Columbia Basin (Mar. 1986), at 174 [hereinafter cited as NWPPC Losses Compilation]. The study also identified other non-hydropower causes of fish habitat loss such as logging, mining, agriculture irrigation, urbanization, pollution, and nuclear reactor operations.

21. Id.

22. Id. at 174, 197. The law of minimum streamflows is complex. For a concise sketch of state minimum flow laws in Idaho, Oregon, and Washington, see U.S. Fish and Wildlife Serv., Opportunities to Protect Instream Flows in Idaho, Oregon, and Washington (1985) (Biol. Rep. No. 85(9)).

23. Although riparian zone restoration does not increase the total quantity of water in a watershed, it is possible that some of the total yearly flow is not appropriated because it occurs at times when it is not needed. Much water that rushes to the sea through degraded stream systems during winter and spring high flow events may be available for storage by restored riparian systems and adjacent aquafirs. When that water is released during dry months, it would then be subject to appropriation or minimum flow protection.

24. U.S. Dept. of the Interior, Bureau of Land Management, Public Land Statistics 1984 (Aug. 1985), at 39, 40.

25. Id. at 72-73.

26. Id. at 78-79. An animal-unit-month (AUM) is "the amount of forage consumption necessary for the sustenance of one cow or its equivalent for one month." 43 C.F.R. § 4100.0-5 (1985). Compare "animal month," defined as one month of use and occupancy of range by one weaned or adult cow, bull, steer, heifer, horse, burro, or mule, or five sheep or goats. U.S.D.I., BLM, U.S.D.A. Forest Service, Grazing Fee Review and Evaluation (Feb. 1986) at 95. In BLM literature the term "animal unit" includes "four reindeer all over 6 months of age." Public Land Statistics, above note 24, at 205. Yet another definition of animal-unit-month includes the amount of forage consumed in one month by a "cow and calf under six months." U.S.D.I., BLM, Baker Resource Management Plan Draft Environmental Impact Statement (Mar. 1986).

27. For histories of federal rangeland policy, see generally P. Foss, Politics and Grass (1960); L. Peffer, The Closing of the Public Domain (1950); W. Calef, Private Grazing and Public Lands (1960). Five articles providing a legal treatment of range law have been provided by Professor George Cameron Coggins. With a general overall title of The Law of Public Rangeland Management they consist of: (1) The Extent and Distribution of Federal Power, 12 Envtl. L. 535 (1982); (2) The Commons and the Taylor Act, 13 Envtl. L. 1 (1982); (3) A Survey of Creeping Regulation at the Periphery, 1934-1982, 13 Envtl. L. 295 (1982); (4) FLPMA, PRIA, and the Multiple Use Mandate, 14 Envtl. L. 1 (1983); and (5) Prescriptions for Reform, 14 Envtl. L. 497 (1984).

28. Fairfax, Coming of Age in the Bureau of Land Management: Range Management in Search of a Gospel, reprinted in NRC/NAS Report at 1715, 1719 (1984).

agency for interests contrary to the grazing industry, fishery and habitat rehabilitation received low priority in rangeland management.

Over the past dozen years, the legal context for BLM range management has changed. Influence of the livestock industry has been curbed because public participation requirements have expanded the number of actual and potential BLM constituencies. Nevertheless, influence of new constituencies such as fisheries interests has only very recently produced sympathetic agency policy.

This section discusses the evolution of today's context for BLM riparian zone policy. The section concludes that despite legal realignment of constituency power, the lack of concrete, enforceable riparian standards will handicap the new BLM constituencies' ability to effect basic programmatic changes in range policy. However, interested parties can use the Clean Water Act's enforceable standards to influence BLM's priority regarding riparian zone rehabilitation.

2. The Taylor Grazing Act--Range Regulation and Agency Capture

Until enactment of the Taylor Grazing Act of 1934,[29] the public rangelands were an unregulated commons for domestic livestock.[30] As a commons, the range provided strong incentives to overuse and none to conserve. In order to establish some dominion over a portion of the range, a stockman would overstock to drive out or discourage competitors.[31] Eventually, various forces -- including incursions by homesteaders, depletion of range forage, and violent range disputes -- led western stockmen to seek legally secure tenure on the public lands to end the physical competition for grazing resources.

The Taylor Act authorized the Secretary of the Interior to create grazing districts within the public lands.[32] The Secretary was given broad authority to "insure the objects of such grazing districts, namely, to regulate their occupancy and use, to preserve the land and its resources from destruction or unnecessary injury, to provide for the orderly use, improvement, and development of the range ...."[33] Within those districts, grazing was allowed by permit only, with preference for permits going to persons "within or near a district who are landowners engaged in the livestock business" and those with water rights necessary for use of the land.[34] Permits were authorized for periods of "not more than ten years."[35] The Act termed the permits "privileges," to be "recognized and acknowledged" and "adequately safeguarded."[36]

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29. 48 Stat. 1269, <u>codified as amended</u> at 43 U.S.C.A. §§ 315 <u>et seq.</u>

30. The range was not completely lawless. Stockmen used a myriad of legal and extralegal means to obtain control of large blocks of federal land for grazing livestock. Those means included purchase of railroad lands, control of water, agreements among ranchers to respect boundaries not legally recognizable, state law purporting to give rights to federal public land, and fencing. <u>See generally</u> Scott, <u>The Range Cattle Industry: Its Effect on Western Land Law</u>, 28 Mont. L. Rev. 155 (1967); <u>see also</u> Coggins & Lindeberg-Johnson, <u>The Law of Public Rangeland Management II: The Commons and the Taylor Act</u>, 13 Envtl. L. 1 (1983).

31. <u>See</u> G. Libecap, <u>Locking Up the Range</u> (1981); <u>see also</u> Hardin, <u>The Tragedy of the Commons</u>, 162 Science 1243 (1968). Hardin postulates that individual graziers will overstock the range because the costs of overstocking are not borne by the individual resource user. Thus, overstocking is a rational profit maximizing decision. In Libecap's model, the motivation for overstocking is to define property rights in the range. By overstocking, the grazier makes competitive entry economically unprofitable. The ecological consequences in either case are the same.

32. 43 U.S.C. § 315. The Act originally authorized the Secretary of the Interior to establish up to 80 million acres to grazing districts. In 1936 the acreage was raised to 142 million, Act of June 26, 1936, ch. 842, title I, § 1, 49 Stat. 1976. The acreage limitation was repealed in 1954. Act of May 28, 1954, ch. 243 § 2, 68 Stat. 151. Designation of grazing districts withdrew them from operation of the homestead laws. 43 U.S.C. § 315. However, the Secretary was granted discretion to reclassify lands within the districts and open them for entry, selection, or location. 43 U.S.C. § 315f.

33. 43 U.S.C. § 315a. Within the Department of the Interior, the grazing districts were administered originally by the Division of Grazing, later the Grazing Service. In 1946, the Grazing Service and the General Land Office merged, forming the Bureau of Land Management. 1946 Reorg. Plan No. 3, § 403, 11 Fed. Reg. 7876, 60 Stat. 1100.

34. 43 U.S.C. § 315b.

35. <u>Id.</u> This provision was amended in 1976 to limit discretion of the Secretary to issue permits of less than 10 years duration. Pub. L. No. 94-579, § 402, <u>codified at</u> 43 U.S.C. § 1752(b).

36. 43 U.S.C. § 315b. The BLM has broad authority to adjust the timing and numbers of livestock grazing on public land. The Secretary "shall specify from time to time numbers of stock and seasons of use." 43 U.S.C. § 345b. The Federal Land Management and Policy Act of 1976 (FLMPA) provides that grazing permits and leases must contain a term setting forth the Secretary's authority to cancel, suspend, or modify the permit or lease. 43 U.S.C. § 1752(a). Permits must specify the numbers of animals to be grazed and permitted seasons of use; the Secretary may order "adjustment" if he determines that range conditions require them. 43 U.S.C. § 1752(e). This authority is not unfettered; grazing reduction orders may be appealed within the agency (43 C.F.R. § 4160.2), and final agency decisions are subject to judicial review. Perkins v. Bergland, 608 F.2d 803 (9th Cir. 1979). However, the courts will overturn agency reduction orders only if a contest-

Additionally, the Act expressly provided that grazing permits create no "right, title, interest, or estate in the lands."[37]

The Taylor Act still forms the basis for livestock grazing on the public lands, but it is incapable of remedying ecological damage caused by decades of abusive range use, particularly damage to riparian and aquatic ecosystems requiring years of livestock exclusion to regenerate. Although the Act ostensibly regulated grazing for the purpose of protecting the land, its permit system and its preferences created a class of entrenched resource users whose interests did not coincide with fish habitat rehabilitation.

From the beginning, grazing permittees had a powerful role in administration of the Act. The Grazing Service interpreted the Act's provision requiring "cooperation with local associations of stockmen" to allow consultation on range management matters with local advisory boards of stockmen.[38] Congress ratified that interpretation in a 1939 amendment which required the Grazing Service to consult with the advisory boards on virtually every aspect of range management.[39] Moreover, despite provision of that formal mechanism for the livestock industry to influence the agency, no similar mechanism was provided for other interests.[40] It is difficult to imagine a scheme more effectively capturing an agency for a special interest group.

As a result, fisheries and recreation received little, if any, consideration in range management. Moreover, agency entanglement with the stock industry's interests was built into the system by a requirement that assistant directors of the Grazing Division be considered for their "practical range experience in public-land States" and be a "bona-fide citizen or resident of the State ... in which such ... Assistant Director, or grazier is to serve" for at least one year prior to service.[41] Thus, the industry received assurance that the regulators would be selected from industry ranks.

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ing party shows "that there is virtually no evidence in the record to support the agency's methodology in gathering and evaluating the data" used to support the reduction order. Id. at 807 n.12. See also Hinsdale Livestock Co. v. United States, 501 F. Supp. 773 (D. Mont. 1980) (court enjoined BLM ordered grazing reductions on finding that the agency had developed no record of data used to support reduction order).

BLM's authority to effect grazing reductions is constrained by an obscure scrap of law enacted annually since 1979 as a rider to BLM appropriations legislation. Known as the "McClure Amendment," it stipulates that "any proposed reduction in excess of 10 per centum shall be suspended pending final action on the appeal, which shall be completed within 2 years after the appeal is filed." Act of Dec. 19, 1985, Pub. L. No. 99-190, § 101(d) in part, 99 Stat. 1226. The only case involving operation of the McClure Amendment is not particularly instructive. See Valdez v. Applegate, 616 F.2d 570 (10th Cir. 1980), where the plaintiff permittees challenged implementation of a BLM grazing management plan that, among other things, reduced authorized livestock use. The district court denied a preliminary injunction and on appeal the BLM's brief relied solely on the Amendment to argue that the appeal was moot. As in Hinsdale, above, the BLM failed to provide evidence supporting its plan. Thus, the Valdez court enjoined implementation of the BLM plan entirely pending trial.

Taken together, Perkins, Hinsdale, and Valdez demonstrate that the BLM should be able to make grazing reductions, provided there is data in the record to support those reductions. The McClure Amendment may delay reductions, but it cannot ultimately prevent them.

37. 43 U.S.C. § 315b. Despite this language, the state of California levies property taxes against permittee's possessory interest in federal lands granted by grazing permits. See Board of Supervisors of County of Modoc v. Archer, 18 Cal. App. 3d 717, 96 Cal. Rptr. 379 (1971); Dressler v. County of Alpine, 64 Cal. App. 3d 557, 134 Cal. Rptr. 554 (1976). See also United States v. County of Fresno, 429 U.S. 452 (1977), where the Supreme Court upheld state taxation of Forest Service employees' possessory interests in housing provided by the Forest Service. Oregon statutes expressly exempt from property taxation real property of the United States held or occupied primarily for livestock grazing. Or. Rev. Stat. § 307.060.

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38. 43 U.S.C. § 315h.

39. Act of July 14, 1939, 53 Stat. 1002, codified at 43 U.S.C. § 315-1. The 1939 amendment required the Secretary of the Interior to set up grazing advisory boards of "local stockmen in each district." Id. Each board included 5 to 12 stockmen and, at the Secretary's discretion, one wildlife representative. Id. The boards were required to (1) offer advice or recommendations concerning Taylor Act rules and regulations, establishment of grazing districts, seasons of use and range carrying capacity, and "any other matters" affecting range management, and (2) offer advice and a recommendation on each application for grazing permit.

40. Although the Act required public notice and comment regarding establishment of grazing districts, there was no provision for public notice and comment on proposed range regulations. The 1946 Administrative Procedure Act, requiring proposed federal regulations to be published for public comment, exempted public land management regulations from those requirements. 5 U.S.C. § 553(a)(2). That exemption was effectively repealed as to the BLM in the 1976 FCPMP, 43 U.S.C. § 1740. Thus, for 3-1/2 decades, range management was virtually a private matter for livestock interests and the government with little public interference. See generally Bonfield, Public Participation in Federal Rulemaking Relating to Public Property, Loans, Grants, Benefits, or Contracts, 118 U. Pa. L. Rev. 540 (1970).

41. Act of June 26, 1936, ch. 842 § 6, 49 Stat. 1978, codified at 43 U.S.C. § 315o, repealed by Pub. L. No. 89-554 § 8(a) (1966).

A 1975 report on range conditions from the BLM to the Senate Appropriations Committee disclosed the Taylor Act's legacy, indicating that, based on forage production, 83% of the range was in fair or worse condition.[42] The BLM attributed the sorry state of the range to events that transpired before passage of the Taylor Act. Even if true, that assertion demonstrates that 40 years of Taylor Act administration produced little in terms of range rehabilitation. That conclusion is bolstered by the BLM's admission that livestock forage conditions were improving on only 19% of the range, declining on 16% and indefinite or stable on 65%.[43]

3. The Rise of Public Participation and Multiple-Use in BLM Management, 1974-1978[44]

Between 1974 and 1978, several events combined to dramatically alter the legal and political context for BLM decision making. In 1974 the Natural Resources Defense Council obtained a court decision that required the BLM to produce Environmental Impact Statements (EISs) under to the National Environmental Policy Act on the effects of present and proposed grazing on specific areas of the public lands.[45] Preparation of EIS's requires that drafts be made available for public comment. Decisions regarding grazing use of the public lands became, to an unprecedented extent, open to public scrutiny. BLM began preparing over 200 EISs. That process continues and is now integrated into the BLM's land management planning process.[46]

In 1976 Congress enacted the Federal Land Management Policy Act (FLPMA).[47] FLPMA is a complex omnibus statute providing the basic framework for managing the public lands. FLPMA did not repeal the Taylor Grazing Act, but amended several of its features. Importantly, FLPMA attempted to equalize interest group influence on BLM policy making by (1) limiting the role of grazing advisory boards, and (2) requiring the agency to provide the public with an opportunity to "comment and participate in the formulation of plans and programs relating to the management of the public lands."[48]

Substantively, FLPMA requires the Secretary of the Interior to (1) prepare and maintain a continuing inventory of all public lands and resources,[49] and (2) develop and revise land use plans for all the public lands based on multiple use sustained yield principles,[50] giving prior-

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42. Doc. No. 207. U.S. Bureau of Land Management, Range Condition Report, (Wash. D.C.: U.S. Government Printing Office, 1975) at II-12 to II-13.

43. See General Accounting Office, Public Rangeland Improvement -- A Slow Costly Process In Need of Alternate Funding (GAO/RCED-83-23, Oct. 14, 1982) at 12. The BLM stated that between 1934 and 1975, range conditions had improved but admitted there was still "a long way to go." Id.

44. In 1964 Congress enacted the Classification and Multiple-Use Act, Pub. L. No. 88-607, codified at 43 U.S.C. §§ 1411-18 (expired 1970). However, the CMUA was temporary and did not provide any substantial opportunity for public participation in range management. See Coggins & Lindburg-Johnson, above note 30, at 98-100.

45. Natural Resources Defense Council v. Morton, 388 F. Supp. 829 (D.D.C. 1974).

46. See generally G. Coggins & C. Wilkinson, Federal Public Land and Resources Law (1981) at 575-81; see also id. (1983 Supp.) at 126.

47. 43 U.S.C. §§ 1701 et seq.

48. 43 U.S.C. § 1753(b); compare 43 U.S.C. § 315o-1. The grazing boards were actually abolished by the Federal Advisory Committee Act of 1972, Pub. L. No. 92-463, codified at 5 U.S.C. App. I., § 14. FLPMA reauthorized the boards but limited their role to offering advice on development of allotment management plans and utilization of range betterment funds. 43 U.S.C. § 1753(b). That reauthorization expired December 31, 1985. 43 U.S.C. § 1753(f).

However, Secretary Hodel unilaterally reauthorized the boards on May 14, 1986. 51 Fed. Reg. 17,674. The Secretary's authority to do so is questionable. FLPMA does not grant authority to reauthorize the boards. Apparently the Secretary relied on the Federal Advisory Committee Act, (FACA) to find such authority. This reliance is vulnerable in view of the holding in Carpenter v. Morton, 424 F. Supp. 603 (D. Nev. 1976) that the Advisory Committee Act revoked the Secretary's power to create grazing advisory boards. The Carpenter decision predated enactment of FLPMA by over 4 months. Congress' express application of the FACA to the grazing boards, 43 U.S.C. § 1753(e), and its failure to authorize them beyond Dec. 31, 1985 evinces an intent that the grazing boards should cease to exist after that date.

Simultaneously, FLPMA authorized the Secretary to create general advisory councils composed of "persons who are representative of the various major citizens interests concerning the problems relating to land use planning or management of the public lands ...." 43 U.S.C. §§ 1739(a), 1712(f). Theoretically, these changes together produced a balanced political climate for management of BLM lands. In practice, the advisory boards consist mainly of representatives of extractive and development interests. See Callison, Partisan Advice Strictly Preferred, The Amicus Journal (Fall 1985); see also Secretary Hodel Names Four to Public Lands Advisory Council, Public Lands Institute Newsletter (May 1986).

49. 43 U.S.C. §§ 1712(e)(4), 1711.

50. 43 U.S.C. § 1712(c)(1). Multiple use is defined at 43 U.S.C. § 1702(c). This provision is the first permanent law mandating multiple-use sustained-yield management of BLM's public domain. For a full explanation of the evolution and implications of multiple-use management, see Coggins, The Law of Public Rangeland Management IV: FLPMA, PRIA, and the Multiple Use Mandate, 14 Envl. L. 1 (1983); see also Culhane, Public Lands Politics: Interest Group Influence on the Forest Service and the Bureau of Land Management (1981). Culhane accurately notes that multiple use is a philo-

ity to designation and protection of "areas of critical environmental concern" (ACEC).[51] FLPMA defines ACEC as "areas within the public lands ... where special management attention is required to protect and prevent irreparable damage to important ... fish and wildlife resources or other natural systems or processes...."[52] Riparian zones easily fall within this definition, both as natural systems and as fish and wildlife resources.[53] FLPMA's priority for designation and protection of ACEC's is evident in several provisions of the Act, indicating congressional intent that historic damage to these areas cease and be reversed.[54]

Congress did not expressly order the BLM to stop cattle caused riparian zone destruction, but FLPMA did declare that "a substantial amount of the federal range is deteriorating in quality and that installation of additional range improvements could arrest much of the continuing deterioration ...."[55] Consequently, Congress directed that 50% of all grazing fee receipts be available for appropriation to provide "on the ground" range rehabilitation, protection and enhancement, and suggested that such projects could include seeding and reseeding, fence construction, water development, and fish and wildlife habitat enhancement.[56] These provisions clearly anticipate rehabilitation of riparian zones. FLPMA thus provides the congressional intent, sufficient delegated authority, and a source of funds for riparian ecosystem restoration projects on the federal rangelands.

Congress reinforced its intent that the BLM restore degraded riparian ecosystems by passing the Public Rangeland Improvement Act of 1978 (PRIA).[57] Just two years after enacting FLPMA, Congress declared that "vast segments of the public rangelands are ... in an unsatisfactory condition."[58] PRIA associated deteriorated range with soil loss, desertification, increased siltation and salinity, reduction of water quantity and quality, loss of fish and wildlife habitat, increased surface runoff and flood danger, and the potential for undesirable long-term local and regional climatic and economic changes.[59] Several of those conditions are directly caused by riparian zone degradation, particularly degraded water quality, loss of fish habitat, and desertification.[60] Congress

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sophy, not a precise management formula. Id. at 126. Apparently, the range management profession embraced the philosophy slowly. See, e.g., Behan, Multiple Use Management: Kudos and Caveats, NRC/NAS, Report, above note 4, 1991, 1997 (1984):

> It was fully sixteen years after the first issue of the Journal of Range Management appeared that multiple use was recognized in print. Mr. Wayne Gonder, President of the White Pine County Farm Bureau of Garrison, Utah, was terribly impressed that a public water development project -- a small dam and some irrigation ditches -- benefited both livestock and wildlife. Simultaneously. And so he wrote a report of the project, indulging in almost delirious praise of all the good folks who made it happen, and published his piece, "Multiple Use at Work," (Gonder 1964).
>
> And the Journal of Range Management has been silent on the topic of multiple use management ever since.

51. 43 U.S.C. § 1712(c)(3).

52. 43 U.S.C. § 1702(a).

53. In October 1977, the BLM Washington, D.C. office issued interim guidance to all field offices for identification and management of ACEC's. Bureau of Land Management, Organic Act Directive No. 77-77 (Oct. 28, 1977). Explanatory materials accompanying the directive listed "wetlands-riparian areas" as examples of natural systems and processes contemplated for ACEC designation by FLPMA. However, the words "wetlands" and "riparian areas" did not appear in the final regulations. See generally Callison, Areas of Critical Environmental Concern on the Public Lands Part II: Record of Performance by the Bureau of Land Management (The Public Lands Institute, 1986).

54. See, e.g., 43 U.S.C. § 1711(a) (mandatory inventories of lands and resources to give priority to ACEC); § 1712(c)(3) (land use plans to give priority to designation and protection of ACEC); § 1701(a)(11) (congressional declaration that regulations and plans for protection of ACECs be promptly developed). However, nearly 4 years elapsed between enactment of FLPMA and promulgation of final regulations concerning ACEC's. Cf. 45 Fed. Reg. 59,318 (Aug. 27, 1980).

55. 43 U.S.C. § 1751(b)(1).

56. Id. Facially, the range improvement funding provision of FLPMA appears to require expenditures for fish and wildlife habitat restoration. However, the Act biases such expenditures in favor of ranching interests by (1) exempting distribution and use of range improvement funds from the NEPA process, and (2) requiring "consultation with user representatives" before engaging in range improvement projects. Id. Further, one of the duties of the grazing advisory boards was to advise regarding range improvement expenditures. Thus, use of range improvement funding is unlikely to be devoted to projects that conflict with livestock production. Also, no funding is earmarked for research.

57. Act of Oct. 25, 1978, Pub. L. No. 95-514, 92 Stat. 1803, codified in part at 43 U.S.C. §§ 1901 et seq.

58. 43 U.S.C. § 1901(a)(1).

59. Id. § 1901(a)(3).

60. Desertification is a process of ecological change in arid areas marked by (1) declining groundwater tables, (2) salinization of topsoil and water, (3) reduction of surface waters, (4) unnaturally high rates of soil erosion, and (5) elimination of native vegetation. See Sheridan, Desertification of the United States (Council on Environmental Quality, 1981). Sheridan states "'improvident pasturage' or

deemed special attention to rehabilitation necessary to "restore a viable ecological system that benefits both range users and the wildlife habitat."[61]

PRIA mandates that the goal of range management, "shall be to improve range the conditions ...."[62] The Act's legislative history strongly implies that degraded range conditions were caused by livestock overuse subsequent to enactment of the Taylor Grazing Act.[63] Considered together, FLPMA and PRIA provide ample authority for the BLM to undertake programmatic exclusion of livestock from degraded riparian zones for the purpose of reestablishing riparian vegetation and aquifer recharge. However, FLPMA and PRIA do not guarantee such a program.

4. BLM Discretion and the Lack of Standards in Range Management Law

Unfortunately, the promise of riparian zone restoration contained in FLPMA and PRIA may prove to be illusory. Despite strong declarations and findings in the statutes regarding range conditions, Congress failed to give the BLM range improvement priorities. PRIA defined "range improvement" so broadly as to be virtually meaningless.[64] Moreover, riparian systems are not mentioned in the statutes. Although the BLM clearly has authority and the data to support systematic exclusion of cattle from degraded riparian zones, the priority, method, and scale of such projects appear to be matters of agency discretion. This conclusion is reinforced by a recent federal district court decision ruling that BLM's discretion to choose methods of range improvement is virtually unlimited under FLPMA and PRIA.

In Natural Resources Defense Council v. Hodel,[65] the plaintiffs asserted that past overgrazing on BLM's Reno, Nevada Planning Area had caused degradation of the range, and that FLPMA and PRIA required the BLM to reduce livestock use. The court found that 4 of the area's allotments were overgrazed by livestock, and 8 were overgrazed by a combination of livestock and wildlife. However, the court refused to conclude that FLPMA and PRIA require the BLM to reduce livestock use to rehabilitate the range. Stating that FLPMA and PRIA's declarations of policy and goals, "can hardly be considered concrete limits upon agency discretion," the court deferred to the BLM's assertions that methods other than livestock reduction will improve range conditions in the planning area.[66] The court limited its review to asking whether BLM's contention that methods other than reduction of livestock use to improve range conditions was rational. Although NRDC v. Hodel did not focus on the effects of overgrazing on riparian zones, the case is important for its precedential value, especially the court's unwillingness to look deeply at the meaning of range rehabilitation. If the decision is upheld on appeal, the methods, scope, and priority of range improvement projects, including riparian restoration, will remain issues committed to BLM's discretion.[67]

'overgrazing' as it has come to be known, has been the most potent desertification force, in terms of total acreage affected, within the United States." Id. at 9. For explanation of the effects of overgrazing on water quality, see U.S. Environmental Protection Agency, U.S.D.I. Bureau of Land Management, Livestock Grazing Management and Water Quality Protection (1979) [hereinafter cited as EPA/BLM Grazing and Water Quality Reference Document].

61. Senate Comm. on Energy and Natural Resources, S. Rep. No. 95-1237, 95th Cong., 2d Sess. 6, reprinted in 1978 U.S. CODE CONG. & AD. NEWS 4069, 4070.

62. 43 U.S.C. § 1903(b).

63. [The Taylor Act] marked the first major effort to control grazing on the public domain and it came about as a result of the disastrous conditions of the range existing at that time. Although the Taylor Grazing Act has been relatively successful, after 40 years the range is still in a deteriorating state ....

S. Rep. No. 95-1237, above note 60, at 4070.

64. The term 'range improvement' means any activity or program on or relating to rangelands which is designed to improve production of forage; change vegetative composition; control patterns of use; provide water; stabilize soil and water conditions; and provide habitat for livestock and wildlife. The term includes, but is not limited to, structures, treatment projects, and use of mechanical means to accomplish the desired results.

43 U.S.C. § 1902(f).

65. 624 F. Supp. 1045 (D. Nev. 1985).

66. Id. at 1058. The court stated:

> Although I might privately agree with plaintiffs that a more aggressive approach to range improvement would be environmentally preferable, or might even be closer to what Congress had in mind, the Ninth Circuit has made it plain that the courts are not at liberty to break the tie choosing one theory of range management as superior to another.

Id. However, NRDC v. Hodel does not entirely foreclose judicial intervention into BLM range management. The court noted that the plaintiffs could judicially enforce BLM compliance with the agency's land management plans. Also, it seems clear that the Hodel court would enjoin a BLM plan that made no pretense of improving range conditions. See id. at 1058.

67. Prior to the decision in Hodel, there was a split of academic opinion regarding how courts would treat FLPMA and PRIA. G. Coggins, The Law of Public Rangeland III: FLPMA, PRIA, and the Multiple Use Mandate, 14 Envtl L. 1, 129 n.1015. In the earlier NAS study, Professor

The BLM is currently formulating a nationwide policy for riparian management. An agency policy statement currently awaits the signature of Director Robert Burford.[68] The statement recognizes that riparian zones are "unique and among the most productive and important ecosystems ... affecting most other resources and values." If implemented, the new policy would require (1) a current ecological inventory of all riparian areas and their potential, (2) planning that ensures management to "maintain, restore, or improve" riparian zone "values," (3) preference for maintaining riparian zone values when "mitigation measures" will not protect those values, (4) site-specific management, (5) site monitoring and management changes where objectives are not being met, (6) cooperation with "all interested" governmental and private parties, and (7) continued research "to ensure that riparian area management objectives can be defined and met."[69]

The effectiveness of the BLM riparian policy will depend on the extent to which it is actually implemented.[70] Thus, the policy contains

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George Coggins asserted:

> The decided cases (and their paucity) thus seem to confirm the common impression that multiple use, sustained yield management is too esoteric for effective judicial oversight. But that conclusion is at least premature and probably wrong. First, the tradition of nonreviewability, especially in the Ninth Circuit, is now eroding rapidly. With its erosion will come more cases and more opportunities for statutory construction. Second, once the hurdle of reviewability is surmounted, the history of developments in parallel areas indicates that the review will broaden and deepen. Courts confronted with equally opaque commands in other areas of administrative endeavor have been able to fashion reviewable standards from them.

Coggins, Public Rangeland Management Law: FLPMA and PRIA, reprinted in NRC/NAS study, above note 4, at 1901, 1946. Professor Dan Tarlock disagreed with Professor Coggins:

> My basic criticism of Professor Coggins' thesis is that his failure to probe more deeply into what courts have been doing with respect to judicial review of agency discretion since 1969 has led him to confuse the extent to which Congress clipped the Bureau's stock grazing promotion discretion in FLMPA with the possible development of a judge made law of Bureau management duties. In an unfocused attempt to change the outcome of public land allocation decisions, Congress imposed an open-ended planning process on the Bureau, but it did not rank the land uses that the Bureau is to prefer. In short, the Bureau is told to act rationally in choosing among competing land uses, but it is not told what final choices are rational. As a result, courts may poke at the Bureau's planning process, but they are not likely to develop a law of multiple-use duties along the lines that Professor Coggins suggests.

Tarlock, The Law of Public Rangeland Management or How Professor Coggins Proposes to Transform the Bureau of Land Management's FLPMA Discretion to Duties, reprinted in NRC/NAS study, above note 4, at 1977-78.

The Hodel decision certainly adds support to Professor Tarlock's position. However, it is probably too early to pronounce FLPMA and PRIA dead in terms of providing judicially enforceable substantive standards. First, the decision could be reversed by the Ninth Circuit. Second, the case was decided on motions for summary judgment; Judge Burns noted that without a trial, he could not "attempt the fine evaluation and weighing that would even bring me close to deciding the BLM's decision was irrational." Hodel, 624 F. Supp. at 1062. In a different procedural posture, the court might have acted differently. Third, Judge Burns was leary of becoming involved in oversight of BLM range management" "[T]his is a case in which plaintiffs ask me to become -- and defendants ask me not to become -- the rangemaster for 700,000 acres of federal lands in western Nevada." The judge concluded [T]he role plaintiffs would have me play in this controversy is an unworkable one." Id. Another judge may have perceived the case differently and followed the judicial model Professor Coggins advocates. Nevertheless, Hodel may foreshadow future judicial treatment of FLPMA and PRIA.

68. See Bureau of Land Management, Riparian Area Management Policy (undated) (available from BLM Oregon Office, Portland, Oregon).

69. Id. The policy statement recognizes the functions of healthy riparian ecosystems that the BLM is documenting at Camp Creek. The introduction to the statement reads:

> Riparian areas are unique and among the most productive and important ecosystems, comprising only 1 percent of the public lands, but affecting most other resource uses and values. Characteristically, riparian areas display a greater diversity of plant and animal species and vegetation structure than adjoining ecosystems. Healthy riparian systems filter and purify water as it moves through the riparian area, reduce sediment loads and enhance soil stability, provide microclimatic moderation when contrasted to extremes in adjacent areas, and contribute to groundwater recharge and base flow.

70. There is no evidence that BLM intends

sufficient latitude to allow managers to "maintain" current conditions on a "site-specific" basis. The "cooperation with interested parties" requirement is already the law. Although the purposes and objectives of the policy are laudable, it contains no schedules or standards by which to measure its effectiveness. The policy binds the BLM only to the extent the agency chooses to be bound.

Analysis of the Taylor Grazing Act, FLPMA, PRIA, and the BLM's policies promulgated pursuant to those statutes reveals no enforceable mandate for riparian zone and fisheries rehabilitation. NRDC v. Hodel confirms the BLM's discretion to choose the scope, methods, and priority of range rehabilitation programs. However, the BLM's duties regarding restoration of riparian ecosystems does not end with Taylor, FLPMA, and PRIA. Other laws governing specific resources provide the enforceable standards and mandate to rehabilitate riparian zones that the land management statutes lack. One such overlaying statute is the federal Clean Water Act. The following section discusses the potential for Clean Water Act lawsuits to force riparian zone rehabilitation.

B. Water Quality Law and Cattle In the Riparian Zone

1. Grazing and Water Pollution

Cattle are the cause or source of several types of water pollution.[71] On uplands, they accelerate erosion when removing vegetation and trampling soil.[72] Through runoff, eroded soil eventually finds its way into streams, creeks, and rivers, leading to sedimentation and turbidity. Sediment destroys stream habitat in at least 2 ways. Suspended sediments reduce light penetration causing reduction in aquatic plant photosynthesis and dissolved oxygen levels.[73] Bioload sediment clogs gravel areas used by spawning fish for egg deposition and can entomb various aquatic life forms that are major sources of fish food.[74]

When grazing livestock move on to the riparian zone, water pollution effects increase dramatically. The literature of professional range and fisheries societies recognizes that excessive livestock grazing in riparian zones is a major cause of high sediment levels and fish habitat destruction.[75] Livestock remove succulent riparian vegetation, and their sheer weight destroys streambanks destabilized by vegetation removal. Destabilized streambanks are vulnerable to erosion by storm and spring runoff. Loss of streamside vegetation also produces thermal pollution; without shade, greater expo-

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to adopt the new riparian policy as a regulation. More likely the policy, when formally adopted, will be added to the BLM Manual. Manual provisions are not adopted as rules under the Administrative Procedure Act, and do not have the same legal effect as rules. See United States v. Fifty-three Eclectus Parrots, 685 F.2d 1131 (9th Cir. 1982); Lumber Prod. & Indus. Workers Log Scalers v. United States, 580 F. Supp. 279 (D. Or. 1984). In the Eclectus Parrots case the Ninth Circuit Court of Appeals stated that "general statements of policy" contained in agency manuals are not enforceable against the agency. 685 F.2d at 1136.

71. Both federal and state water quality laws define "pollution" very broadly. The Clean Water Act defines pollution to mean "[t]he man-made or man-induced alteration of the chemical, physical, biological and radiological integrity of water." 33 U.S.C. § 1362(19). The state of Oregon defines pollution to mean:

> ... such alteration of the physical and chemical or biological properties of any waters of the state, including change in temperature, taste, color, turbidity, silt or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive or other substance into any waters of the state, which will or tends to, either by itself or in connection with any other substance, create a public nuisance or which will or tends to render such waters harmful, detrimental or injurious to public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational or other legitimate beneficial uses or to livestock, wildlife, fish or other aquatic life or the habitat thereof.

ORS § 468.700(3).

72. Determination of the precise effects of cattle on upland watershed erosion is complex and involves a number of variables including soil type, vegetative type, slope steepness, percentage of vegetative capacity, number of grazing animals including non-domestic wildlife, duration of grazing, season of grazing, and weather history. See Blackburn, Impacts of Grazing Intensity and Specialized Grazing Systems on Watershed Characteristics and Responses, reprinted in NRC/NAS study, above note 4, at 927; see also Environmental Protection Agency, Livestock Grazing Management and Water Quality Protection (1979).

73. Oregon Department of Environmental Quality, Best Management Practices for Range and Grazing Activities on Federal Land (1982).

74. Id.; see also American Fisheries Society, Western Division, Management and Protection of Western Riparian Stream Systems, above note 1. Discharge of sediment into a stream also creates an energy demand on the kinetic energy of streamflow which may result in a change in channel erosion and deposition processes. EPA/BLM Grazing and Water Quality Reference Document, above note 60, at 22. Thus, not only does increased sediment pollute, it alters natural stream dynamics possibly causing cumulative polluting effects.

75. See above note 72; see also Platts, above note 3; Oregon/Washington Interagency Wildlife Committee, Managing Riparian Ecosystems (Zones) for Fish and Wildlife in Eastern Oregon and Eastern Washington (1979).

ure to solar energy increases stream temperature.[76] The effect of solar heating increases as a stream's width to depth ratio rises; such changes in the ratio are caused by streambank erosion. Further, highly eroded streams tend to have little or no flow in late summer. In addition to causing sediment and thermal pollution, cattle themselves discharge urine and manure, which produce chemical and biological pollution.[77] Thus, excessive cattle grazing produces multiple detrimental impacts on water quality.

Range cattle exhibit a distinct preference for riparian vegetation in the early season, and they tend generally to concentrate in or near water over the summer.[78] These bovine proclivities have led the Environmental Protection Agency (EPA) to conclude, "Livestock access in the riparian or streamside zone should be restricted for sufficient periods to allow vegetative recovery and maintenance. Livestock exclusions are primarily important in areas where water uses to be protected include fisheries production, wildlife, primary contact recreation, and human consumption."[79] EPA also emphasizes that, "Watershed protection cannot be sustained on deteriorating rangeland vegetation."[80] Because of the long history of rangeland overuse, the generally unsatisfactory condition of rangeland, and the relatively recent understanding of riparian zone ecology and potential, management for water quality must be remedial. Overgrazed riparian zones may require rest periods of at least 5 years to restore riparian vegetation and water of sufficiently high quality to support viable fisheries.[81]

Although federal land management statutes grant the BLM very wide discretion in resource allocation and management decision making, the Clean Water Act[82] substantially constrains that discretion. Both FLPMA and the Clean Water Act mandate BLM compliance with all state and federal water pollution laws.[83] Because livestock-caused riparian zone destruction results in several types of water pollution, the BLM may find that such compliance limits agency discretion to postpone needed riparian zone restoration projects. Recent legal developments indicate that private parties interested in clean water and productive fisheries may be able to enjoin execution of federal land management plans that violate state water quality laws.

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76. Thermal pollution clearly falls within the legal definitions of "pollution" under both federal and Oregon law. See above note 71.

77. Dry feedlot beef cows produce about forty-three pounds of manure per day per head. A.L. Nuemann, Beef Cattle (1977). This amounts to nearly two-thirds of a ton per month per head. Cattle manure is rich in nitrogen, phosphoros, potassium and organic matter. Id. When flushes of these nutrients are injected into streams, "nutrient loading" can occur, resulting in algal blooms which interfere with normal aquatic life. EPA/BLM Grazing and Water Quality Reference Document, above note 60, at 21-22.

78. See generally Skovlin, above note 4, at 1010-14; see also EPA/BLM Grazing and Water Quality Reference Document, above note 60, at 14.

79. EPA/BLM Grazing and Water Quality Reference Document, above note 60, at 16-17.

80. Id. at 14.

81. Id. at 45. The BLM recognizes the relationships among land management, water quality and fisheries production.

> Management of public lands influences anadromous fish primarily through maintaining or modifying water quality and the characteristics of spawning and rearing habitat. Wild fish runs are the major concern to public land managers since salmon and steelhead are dependent on fresh water streams which pass through or originate from BLM-administered lands. Bureau land and resource management programs affect habitats, and therefore ultimately affect the condition of the commercial and sport fishing industries.

U.S. Dept. of the Interior, Bureau of land Management, Oregon and Washington Policy and Program Direction for 1984, at 26 (1984). Ironically, another BLM policy document contains a photograph of about 28 range cattle standing in and around a small stream. See U.S.D.I., BLM, Managing the Nation's Public Lands Fiscal Year 1984 (1984) at 29.

82. 33 U.S.C. §§ 1251 et seq.; see generally Bonine & McGarity, The Law of Environmental Protection (1984), at 421-575.

83. The relevant Clean Water Act provision states:

> Each ... agency ... of the Federal Government (1) having jurisdiction over any property or facility, or (2) engaged in any activity resulting, or which may result, in the discharge or runoff of pollutants, and each officer, ... shall be subject to, and comply with, all Federal, State, interstate, and local requirements, administrative authority, and process and sanctions respecting the control and abatement of water pollution....law.

33 U.S.C. § 1323(a) (emphasis added). This provision has been interpreted to include rainwater runoff caused by roadbuilding and timber harvesting. Northwest Indian Cemetery Protection Association v. Peterson, 764 F.2d 581 (9th Cir. 1985). There is no reason runoff caused by federally permitted cattle grazing should be treated differently. See Breen, Federal Supremacy and Sovereign Immunity Waivers in Federal Environmental Law, 15 Envtl. L. Rep. 10326 (1985).

FLPMA requires BLM land management plans to "provide for compliance with applicable pollution control laws, involving State and Federal air, water, noise or other pollution standards or implementation plans ...." 43 U.S.C. § 1712(c)(8).

2. The Clean Water Act Scheme

The Clean Water Act's overriding objective is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters."[84] The Act's twin "goals" are elimination of the discharge of pollutants into the navigable waters by 1985, and achievement of water quality providing for "protection and propagation of fish, shell fish, and wildlife ... by July 1, 1983."[85]

The Act's scheme elaborately combines environmental quality and technology-based approaches to pollution control.[86] For regulatory purposes, the Act classifies pollution by mode of introduction into receiving waters. The category of pollution from discrete, confined conveyances, termed "point source" pollution, is prohibited unless the discharger obtains a permit for the discharge.[87] The permits specify the amount of pollution allowed at the "end of the pipe," determined by technological and economical feasibility.[88] Maintenance or improvement of water quality presumably follows.[89]

All pollution that is not "point source" is considered "non-point," including cattle grazing. The Act approaches control of "non-point" pollution by requiring each state to (1) identify non-point pollution causes and sources and (2) set forth "procedure and methods to control to the extent feasible (including land use requirements) such sources."[90] The Act requires state water quality management plans to identify agricultural non-point sources of pollution including, "land used for livestock ... production," and set forth procedures to control such sources, "to the extent feasible."[91] EPA regulations require states to provide for control of non-point pollution by promulgation of "Best Management Practices" (BMPs).[92] EPA regulations require that states develop specific BMPs for agriculture, including range cattle grazing.[93]

Oregon developed BMPs for grazing on the federal lands, and the BLM has agreed to meet or exceed Oregon's BMPs.[94] Oregon's federal range grazing BMP document discusses riparian zone management and directly relates improper grazing in stream corridors with existing severe streambank erosion, channel widening, depth reduction, elevated water temperatures, and increased streamborne bacteria.[95] The document calls for

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84. 33 U.S.C. § 1251(a).

85. Id. § 1251a(2). The 1977 Amendments to the Act did not change these goals or the target dates. Amendments to the Act proposed by the Senate in 1985 did not alter those dates. S. 1128, 99th Cong., 1st Sess. (1985) (passed by the Senate June 13, 1985).

86. The environmental quality approach focuses on how clean an environmental medium such as water should be. Pollution standards are adopted that define the minimum acceptable quality of the medium in terms of objective pollutant concentrations or some subjective quality such as "fishable and swimmable." Regulation of pollution sources is based on achievement of those standards. Environmental quality standards can be set irrespective of their economic cost or current technological feasibility.

The technology-based approach focuses on the sources of pollution and directly regulates the quantity of pollutants a particular source may add to the environment. This approach considers the cost and feasibility of achieving pollution control. For a fuller explanation, see J. Bonine & T. McGarity, above note 82, at 252-75.

87. 33 U.S.C. § 1311(a). The Act defines the term "point source" to mean "any discernible, confined and discreet conveyance, including but not limited to any...concentrated animal feeding operation...." 33 U.S.C. § 1362(12). A common practice in western ranching is to provide cattle with "watering holes." These locations are known as "sacrifice areas" because constant trampling and elimination by cattle create a muddy and fetid environment around the watering facility. See generally D. Ferguson & N. Ferguson, Sacred Cows at the Public Trough (1983).

An alternative practice is to provide cattle with direct access to a small length of stream that has otherwise been fenced to keep the cattle out. These areas are known as "water gaps." Both "sacrifice areas" and "water gaps" are analogous to "concentrated animal feeding operations" and probably qualify as point sources subject to Clean Water Act permit requirements. No court has yet addressed this question. See generally Annot., What Constitutes Point Source Pollution Subject to Control by Provisions of Water Pollution Control Act as amended, 52 A.L.R. Fed. 855 (1981). If "sacrifice areas" and "water gaps" are point sources, their operation without permits may be enjoined by citizens pursuant to the Clean Water Act. 33 U.S.C. § 1365.

88. See 33 U.S.C. §§ 1311(b)(1)(A), 1314(b)(1)(A), 1311(b)(2)(E). These sections provide that effluent limitations from point sources be based on "best practicable technology currently available," best available technology economically achievable," and "best conventional pollution control technology." These terms are intended to balance environmental and economic concerns.

89. But see 33 U.S.C. §§ 1311(b)(1)(E), 1312 (providing that in certain cases point sources may be regulated to achieve specific water quality standards). Note that meeting prescribed water quality standards is required regardless of the cost involved.

90. 33 U.S.C. § 1288(b)(2)(F-K).

91. 33 U.S.C. § 1288(b)(2)(F).

92. 40 C.F.R. § 130.2(l). The regulations define BMPs as "Methods, measures or practices selected by an agency to meet its non-point source control needs. BMPs include but are not limited to structural and nonstructural controls and operation and maintenance procedures." Id.

93. 40 C.F.R. § 130.6(c)(4)(iii)(C).

94. See Memorandum of Understanding Between the Oregon Department of Environmental Quality and the Bureau of Land Management (Dec. 1978).

95. Oregon DEQ, above note 73 at 2-4.

exclusion of livestock from riparian zones with degraded vegetative cover.[96]

Use of "best management practices" to control non-point source pollution has the appearance of a technology-based scheme, similar to the point source control scheme.[97] However, unlike the point source control scheme, non-point sources are not subject to effluent limitations; by their very nature non-point sources do not have an "end-of-the-pipe" at which to measure and regulate pollution output. Thus, the non-point control scheme may appear standardless, with no clear point at which non-point polluters have violated the law and fall subject to legal sanction. But this appearance is incorrect.

Section 303 of the Clean Water Act requires each state to adopt water quality standards for its waters.[98] Water quality standards have two components: designated uses of the applicable water body,[99] and criteria necessary to achieve the designated uses.[100] The purpose of the standards is to maintain the quality of clean water and improve the quality of polluted water for fish and wildlife propogation and recreation, among other purposes.[101]

Water quality standards are provisions of state law that must be approved for consistency with the Act by EPA.[102] EPA regulations require states to certify that water quality standards have been adopted pursuant to state law.[103] Water quality standards provide an objective legal basis for controlling non-point pollution. Best management practices are not themselves goals or desired ends. They are merely means to achieve water quality standards. Thus, federal land management agencies do not comply with the Clean Water Act simply by complying with state BMPs. The Ninth Circuit Court of Appeals confirmed this important principle in July 1985.

3. The Northwest Indian Cemetary Protective Association v. Petersen: Subjecting Federal Land Managers to State Water Quality Standards

In Northwest Indian Cemetery Protective Association v. Peterson,[104] the Ninth Circuit Court of Appeals rejected the U.S. Forest Service's assertion that adherence to BMPs alone satisfies the requirements of the Clean Water Act. The district court found that certain proposed road construction and timber sales would result in violation of state water quality standards by causing increased water turbidity.[105] On appeal, the Forest Service argued that (1) the state's water quality standards did not apply to the agency because EPA and the state had accepted the agency's BMPs as part of the state water quality management plan, and (2) even if the standards applied, compliance with BMPs ensured that no violation of the standards would occur. The Ninth Circuit rejected both arguments. Noting that federal agencies must comply with state water quality standards,[106] the court ruled, "The BMPs ... are merely a means to achieve the appropriate state ... water quality standards .... Adherence to the BMP's does not automatically ensure that the applicable state standards are being met."[107] Consequently, the court upheld an injunction barring the contested road construction and timber sales as planned. Irrespective of BMP's, the Forest Service had to amend its plans to ensure that water quality standards would be met.

In essence, the court held that non-point pollution is regulated under the water quality-based approach. Although the court's reasoning was sparse, the decision is supported by the

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96. Id. Oregon identifies 16 BMPs for grazing. Seven of those BMPs are methods of restricting or discouraging livestock grazing in riparian zones.

97. Compare the term "best management practice," above note 92, with technology based terms used in the point source effluent limitation provisions of the Clean Water Act, above note 88.

98. 33 U.S.C. § 1313.

99. EPA regulations define 2 types of uses. "Existing uses" are uses of water actually attained on a water body after November 28, 1975 whether or not they are included in water quality standards. 40 C.F.R. § 131.3(e). "Designated uses" are uses specified in water quality standards whether or not they are attained. 40 C.F.R. § 131.3(f). Designated uses are goals for improvement of water quality. Because use designation is a prospective exercise, designated uses are subject to a "use attainability analysis." 40 C.F.R. §§ 131.3(g), 131.10(d). A use is considered attainable if it can be achieved by implementing "cost-effective and reasonable best management practices for non-point source control." 40 C.F.R. § 131.10(d).

Once uses are designated, they are almost impossible to downgrade. Existing uses may not be eliminated. 40 C.F.R. § 131.10(h). Designated uses may not be dedesignated unless the state "can demonstrate" that the use is not attainable. 40 C.F.R. § 131.10(g)(1-5).

100. 33 U.S.C. § 1313(c)(2); see also 40 C.F.R. § 131.10.

101. The Act provides, "such standards shall be such as to protect the public health or welfare, enhance the quality of water and serve the purposes of this chapter" (emphasis added). 33 U.S.C. § 1313(c)(2). Importantly, water quality standards must serve the purpose of the Act, which is "to restore and maintain the chemical, physical and biological integrity of the nation's waters." 33 U.S.C. § 1251(a). See generally Gaba, Federal Supervision of State Water Quality Standards Under the Clean Water Act, 36 Vand. L. Rev. 1167 (1983).

102. 33 U.S.C. § 1313.

103. 40 C.F.R. § 131.6(e). After state water quality standards receive EPA approval, they become federal law. See Bonine & McGarity, above note 82, at 319-27.

104. 795 F.2d 688 (9th Cir. 1986).

105. 565 F. Supp. 586, 605 (N.D. Cal. 1983).

106. The court relied on § 313 of the Clean Water Act. 33 U.S.C. § 1323, above note 83.

107. 795 F.2d at 697.

Clean Water Act and regulations. Prior to 1972, all identifiable sources of pollution were subject to abatement on a water quality basis. The 1972 Clean Water Act amendments did not wholly eliminate that scheme. Although the amendments subjected point sources primarily to technology based limitations, water quality standards remained a regulatory mechanism. The 1972 amendments retained water quality standards of prior law and expressly provided that point sources could be regulated on a water quality basis if a technology approach would "interfere with the attainment or maintenance" of water quality necessary to protect public water supplies, shell fish, fish and wildlife.[108] The purposes of the Act[109] would be defeated if identifiable nonpoint polluters could prevent attainment or maintenance of water quality standards.[110] The Northwest Indian holding is consistent with Congress's intention that the 1972 amendments strengthen pollution control laws rather than weaken them, and that improved water quality remain the primary focus for pollution control. The court correctly recognized that application of water quality standards to control non-point pollution is exactly analogous to use of effluent limitations to control point sources.[111]

The decision is also consistent with EPA regulations. The regulations are premised on the agency's determination that the Clean Water Act mandates maintenance, improvement, and protection of national water quality.[112] First, existing water quality necessary to support existing or designated uses may not be degraded.[113] Second, prospectively designated, but unachieved, uses of water may not be redesignated unless the state finds them unattainable.[114] Third, where water quality exceeds that necessary to support "propagation of fish, shell fish, and wildlife and recreation in and on the water," that quality must be "maintained and protected" unless the state finds that lower water quality is necessary to "accommodate important economic or social development."[115] In no case may water quality be lowered below that necessary to support existing instream uses. These regulations apply to both point and nonpoint pollution.[116]

The Northwest Indian decision makes execution of the EPA regulations possible. If nonpoint polluters may prevent achievement of designated uses, or lower water quality below that necessary to support uses, EPA's regulations are meaningless. Non-point polluters could eliminate or prevent achievement of uses with virtual impunity. Further, states would have no objective standard by which to comply with EPA's regulations. The Northwest Indian holding is consistent with EPA's policy of maintenance and enhancement of water quality and control or elimination of pollution from all sources. BMP's are merely a means of achieving those ends. They are not themselves legal standards. Activities conducted pursuant to BMP's that cause water quality to degrade or go below water quality standards may be enjoined, including livestock grazing in riparian zones.

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108. 33 U.S.C. § 1312.

109. See above text at notes 84, 101.

110. There is incidental language in the Act supporting application of water quality standards to non-point polluters. See, e.g., 33 U.S.C. § 1285(j) (providing that EPA may make grants to states to carry out water quality management planning including "nonpoint measures to meet and maintain water quality standards)."

111. 795 F.2d at 697.

112. 40 C.F.R. 130.0(a). EPA's language is substantially identical to the Act's. See 33 U.S.C. § 1251(a).

113. 40 C.F.R. § 131.12(a)(2).

114. A use is considered attainable if it can be achieved by imposition if "cost effective and reasonable" BMPs. 40 C.F.R. § 131.10(d). See also above note 99.

115. 40 C.F.R. § 131.12. This is EPA's "antidegradation" policy. This potentially far-ranging policy was included in EPA's first water quality standards regulations in 1975. See 40 Fed. Reg. 55,340-41 (Nov. 28, 1975). Although the Clean Water Act contains no express requirement for an antidegradation policy, EPA justifies that policy on the following rationale.

> [T]he policy is consistent with the spirit, intent, and goals of the Act, especially the clause '... restore and maintain the chemical, physical and biological integrity of the Nation's waters' (§ 101(a)) and arguably is covered by the provision of 303(a) which made water quality standard requirements under prior law the 'starting point' for CWA water quality requirements.

Environmental Protection Agency, Questions and Answers on Antidegradation at 1 (emphasis in original) [hereinafter cited as Questions & Answers].

116. The regulation requires that "the State shall assure that there shall be achieved ... all cost effective and reasonable best management practices for nonpoint source control." 40 C.F.R. § 131.12(a)(2). However, this requirement is not intended as a substitute for actual compliance with the antidegradation policy. EPA explains:

> This requirement ensures that the limited provision for lowering water quality of high quality waters down to 'fishable/swimmable' levels will not be used to undercut the Clean Water Act requirements for point source and non-point source pollution control. Furthermore, by ensuring compliance with such statutory and regulatory controls, there is less chance that a lowering of water quality will be sought in order to accommodate new economic and social development.

Questions and Answers, above note 115.

4. Back at the Ranch; Cattle, Clean Water, and the Riparian Zone

The Northwest Indian decision, if not overturned by the Supreme Court, promises to have substantial impact on federal land management in general, and riparian zone management in particular. Many miles of degraded riparian zones continue to be grazed by domestic livestock, and the water quality in those streams does not meet water quality standards.[117] EPA recently informed the Salmon, Idaho BLM office that cattle grazing in degraded riparian zones is unacceptable and is preventing achievement of water quality standards in streams within the Salmon River drainage.[118]

Northwest Indian confirms that citizens can bring suit to enjoin federal land management plans that will result in violation of state water quality standards or any other state law respecting control of water pollution. The Clean Water Act requires every federal agency with jurisdiction over any property or facility to comply with all substantive and procedural federal, state, and local water pollution laws regarding control and abatement. Citizens may seek review of federal agency actions and plans by way of the Administrative Procedure Act,[119] and may request that the court enjoin land management plans that will result in violation of or failure to achieve state water quality standards. Citizens and interested groups are likely to develop hard data regarding grazing caused pollution if that data may lead to successful enforcement actions. Even if suits are never filed, citizen work in the field and the potential for judicial intervention may accelerate the BLM's efforts to rehabilitate riparian zones.

In a broader sense, by clarifying that Clean Water Act standards impose enforceble limits on federal land management practices, the Northwest Indian decision may have a revolutionary impact on federal land planning for BLM lands and national forest lands. Clean water concerns may soon become the driving force behind the planning processes mandated by FLPMA and the National Forest Management Act. Some land managers may object on the grounds that they had been led to believe that compliance with EPA-approved "best management practices" for nonpoint source pollution was the extent of their Clean Water Act obligation. But BMPs were never designed to be an end in themselves, just a means to the congressionally-prescribed goal to restore and maintain the chemical, physical, and biological integrity of the nation's waters.[120] Moreover, the chief means to achieve this goal is through meeting water quality standards,[121] the only enforceble means of combatting nonpoint source pollution, which constitutes more than half of the water pollution problem in many public land states like Oregon.

One probable legacy of Northwest Indian will be a revision of nonpoint source BMPs where they do not ensure attainment of water quality standards. This should interject state and federal water quality officials heavily into ongoing land management processes of the BLM and the Forest Service. Conversely, it should also invest federal land managers with an interest in the water quality standard setting process, long an overlooked aspect of Clean Water Act regulation.[122] This cross-fertilization could not

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117. See, e.g., Bureau of Land Management, Oregon Wilderness Draft Environmental Impact Statement, vol. 1 (1985) (noting that during summer some streams in the study area have low dissolved oxygen, high temperatures, pH, and fecal coliform counts, which BLM attributed to cattle grazing). See also Oregon Dept. of Environmental Quality, Statewide Assessment of Nonpoint Source Problems (1978).

118. See, e.g., U.S. EPA, Review Report, Lemhi Resource Area Draft Range Management Plan and Environmental Impact Statement and the Eightmile Wilderness Study Area EIS (Jan. 2, 1986). EPA's review concluded that

> None of the alternatives, except designating the entire area as wilderness, would comply with federally approved state water quality standards. As you will remember, the Clean Water Act requires that federal agencies comply with these standards. Thus, at this time the only alternative which BLM may currently select for implementation would be the all wilderness alternative.

Letter from Robert S. Burd to Jeffrey Wilfong (Jan. 2, 1986) (cover letter to EPA Review Report, above). The basis of this assessment was that BLM planned to allow continued cattle grazing in riparian areas. EPA stated,

> Even Alternative C, emphasizing amenities, may not offer adequate protection to riparian areas. The Draft EIS (page 2-21) states that 'livestock would be removed from pastures when 50 percent utilization of the riparian forage was reached.' This is the most stringent of all the alternatives presented. However, the 50 percent utilization standard would not necessarily afford appropriate protection to water quality (from coliform bacteria, sediment, or temperature changes), streambank stability (from trampling), or important fish habitat (from gravel sedimentation and from water quality changes).

Review Report, above at 3.

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119. 5 U.S.C. § 706 ("the reviewing court shall .... hold unlawful and set aside agency action, ... found to be ... not in accordance with law ...").

120. 33 U.S.C. § 1251(a); see above text accompanying note 107.

121. See above note 101 and accompanying text.

122. Water quality standards are subject to

only produce more stringent nonpoint source BMPs, but may yield water quality standards that are more responsive to the aquatic resources they are designed to protect. These prospects omen well for those who are committed to the restoration of the salmon and steelhead runs that are the chief barometer of the health of the Pacific Northwest's water quality and associated riparian ecosystems.

C. Conclusion

Riparian ecosystems in the semi-arid rangelands are extremely important resources. The condition of riparian zones directly bears on the quantity and quality of fish habitat and water resources. Unfortunately, those resources were largely degraded or destroyed during the period of unregulated range use from about 1860 to 1934. Destruction of riparian vegetation brought major ecological changes to the range including massive stream channel erosion and lowered water tables. Fish habitat was lost to erosion, water loss, and vegetation removal. In addition to detrimental effects on fish habitat, riparian zone degradation rendered once perennial streamflows intermittent. Currently, research suggests that degraded riparian zones possess a remarkable ability to regenerate healthy streams and fisheries. However, riparian zone restoration requires either complete exclusion of livestock for a period of years or restricted access and only short duration grazing.

Although the statutes governing federal rangeland management express strong policy for range rehabilitation, those statutes do not expressly refer to riparian ecosystems or mandate any particular method for accomplishing range rehabilitation. This leaves the BLM with considerable discretion to prioritize and target range improvement programs. Although the agency recognizes the need for riparian zone restoration, there is resistance from the livestock industry to programs that systematically exclude range livestock from riparian and aquatic areas. Traditionally, the agency has been reluctant to pursue major policies opposed by its grazing permittees, and it appears that FLPMA and PRIA give the BLM sufficient discretion to formulate and implement a rehabilitation policy that is tempered by the interests of the permittees.

However, BLM decision making is not governed by FLPMA and PRIA alone. If riparian ecosystems are thought of simply as land areas, their management appears to fall within the vast discretion granted by FLPMA and PRIA. But because riparian areas are primary determinants of water quality and quantity, their management is constrained by the federal Clean Water Act, a statute that provides concrete standards for judicial review. Application of the Clean Water Act to BLM riparian zone management provides the agency with a legally enforceable duty to programmatically restore those areas. Discharge of that duty will be critical in assuring that the nation's rangelands are truly multiple-use lands.

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review and modification every 3 years. 33 U.S.C. § 1313(c)(1).

Bob -
Here is the paper from
Envtl. Mgmt. for you to keep.
KDF

1. which sites were channelized?
2. How long were sites? says at least 1 Riffle & 1 Pool
3. Why delete % Diseased & % Hybrids because didn't find any? Decreases scores

[1986]

springlink

Biomonitors of Stream Quality in Agricultural Areas: Fish versus Invertebrates

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ABSTRACT / Although the utility of using either fish or benthic invertebrates as biomonitors of stream quality has been clearly shown, there is little comparative information on the usefulness of the groups in any particular situation. We compared fish to invertebrate assemblages in their ability to reflect habitat quality of sediment-impacted streams in agricultural regions of northeast Missouri, USA. Habitat quality was measured by a combination of substrate composition, riparian type, buffer strip width, and land use. Invertebrates were more sensitive to habitat differences when structural measurements, species diversity and ordination, were used. Incorporating ecological measurements, by using the Index of Biological Integrity, increased the information obtained from the fish assemblage. The differential response of the two groups was attributed to the more direct impact of sediments on invertebrate life requisites; the impact of sedimentation on fish is considered more indirect and complex, affecting feeding and reproductive mechanisms.

The evaluation of water quality by an examination of resident aquatic life, an approach long espoused by aquatic biologists, was legislated by the US Clean Water Act (PL 95–217) of 1977. Biological communities, or assemblges of similar organisms, have been generally recognized as useful in assessing water quality because they are sensitive to low-level disturbances and function as continuous monitors (Chandler 1970). Although both fish and benthic invertebrate communities have been used in such assessments, there has been little agreement on which group is the more efficient.

Invertebrate communities have often been used to assess stream perturbation (Chutter 1969, Cummins and Lauff 1969, Hellawell 1977), and are considered good indicators because they are relatively sedentary and enable the detection of localized disturbances. Their relatively long life histories allow for integration of pollution effects; qualitative field sampling is easy; and since the communities are heterogeneous and several phyla are usually represented, the chances are high that at least some groups (and therefore the community as a whole) will respond to environmental impacts (Hellawell 1977). But there are several disadvantages: quantitative samples are difficult to obtain; similar substrates must be sampled; the many species that drift may be found in areas where they normally do not occur; and the laboratory effort required to sort and identify specimens is often extensive, time consuming, and costly.

The use of fish communities as water quality monitors is becoming more common (Hocutt and Stauffer 1980, Karr 1981). In a review, Hendricks and others (1980) pointed out that fish provide an interpretable endpoint of environmental degradation (that is, more people recognize the importance of fish in aquatic ecosystems than recognize the importance of other taxa). There is extensive life history information available for many species, and since many fishes are high-order consumers they often reflect the responses of the entire trophic structure to environmental stress. However, quantitative samples are difficult to obtain, and fish are mobile and can avoid areas of environmental stress. Species diversity may vary in different drainages due to factors other than water quality (Gilbert 1980), and longitudinal distribution of fish makes comparisons on a site-to-site basis difficult. Yet many authors have concluded that the advantages of using fish communities outweigh the disadvantages (Hendricks and others 1980, Hocutt 1981, Karr 1981).

Little information is available on the comparative sensitivity of the two faunal groups to a particular perturbation. Such knowledge is important in conducting an efficient, cost-effective monitoring program. In a recent survey of water quality agencies, Perry and others (1984) documented a need for information that

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will assist monitoring personnel to evaluate various methods of achieving monitoring objectives. These authors found that extensive monitoring conducted under severe manpower and fiscal restraints is often the norm for public agencies charged with water quality responsibilities. Biologists must frequently make decisions on the basis of limited data collected over a short period. Considering these constraints, we compare the relative ability of fish and invertebrate assemblages to reflect perturbation to streams by agricultural activities in northeast Missouri, USA.

Study Area

Sampling was conducted at 12 sites—four in each of three streams in northeast Missouri in summer 1983: Honey Creek, Clark County; Grassy Creek, Lewis County; and South River, Marion County. This region is approximately 85% agricultural—55% cropland and 30% pasture (Yount 1983). The three streams lie in the physiographic region termed the *dissected till plain* (Fenneman 1983, Rafferty and others 1970).

Sites were selected to control the variation in geographic and hydrologic variables and avoid effects of urban development. All sites were of stream order two or three (Strahler 1957), with comparable morphology but with a diversity of both habitat types and habitat quality. One site in each stream consisted of a channelized stretch; otherwise the sites contained at least one riffle, one run, and one pool. Mean stream measurements (standard deviations in parentheses) were as follows: riffles averaged a width of 2.6 m (1.6), depth 7.6 cm (2.3), and current velocity of 0.41 m/s (0.19); pools—width of 6.6 m (2.3), depth 38.7 cm (5.8), and current velocity 0.02 m/s (0.02).

Methods

Habitat Quality

Several nearstream habitat measurements were combined with substrate particle size information to create a habitat quality index (HQI) that quantitatively described environmental quality at each site. This index was created because no concise way has been described for summarizing habitat variables in relation to sedimentation. Each variable included in the HQI either directly or indirectly describes the process of sedimentation in streams (Hockensmith and Steele 1962, Karr and Schlosser 1978, Platts and others 1983).

Variables chosen for inclusion in the HQI were weighted equally between a "direct" measure of sedimentation—percentage of fine substrate in the stream bed—and other "indirect" measures relating to land use and quality and quantity of riparian vegetation. We used the equation

$$HQI = BSU + BSS + LU + C + NSV + 5S$$

where BSU = the width of the buffer strip upstream from the site, BSS = width of the buffer strip at the site, LU = land use, C = cover, NSV = nearstream vegetation type, and S = 100 − percentage by weight of substrate <0.5 mm (fine sand and silt/2). The substrate values contributed 50% to the HQI, and each other variable contributed 10%; consequently the HQI could range from 0 (the worst case) to 100 (the best possible habitat).

The first three variables were determined by using recent aerial photographs from the US Agricultural Stabilization and Conservation Service. Buffer-strip width, both BSU and BSS, was defined as the average width of natural vegetation parallel to and on both sides of the stream. The widest buffer strip was assigned a value of 10 and other widths were assigned proportionally lesser values. Land was (LU) was estimated as the percentage of forest land, as opposed to cultivated land, in a 250-h^2 area centered at the site and standardized to a 1–10 scale. Nearstream vegetation (NSV) was estimated in the field and assigned a value in accordance with its capacity to reduce erosion as defined by Platts and others (1983). Shrubs, as the dominant vegetation, received the highest value (10), and progressively lower values were assigned to trees (7), grass or forbes (4), and no natural vegetation (0). The percentage of cover (C) was also determined in the field as the percentage of the water shaded at noon, on a sunny day, and standarized to a 1–10 scale.

We took a substrate sample at a randomly selected location along three representative transects in each habitat type, using a modified core sampler with a 10-cm diameter, sunk to a depth of 3 cm. Dried samples were sieved into particle sizes with a shaker and US standard mesh size sieves to determine the percentage by weight of particles ≤0.5 mm, which represented the fine sands and silt (Platts and others 1983).

Biotic Collections

We sampled fish at each habitat type at each site twice, using two collection methods—seining and electrofishing—to ensure that a representative sample of the community was obtained. We used a 4-mm mesh minnow seine, but the seining technique depended on the habitat type. Pools and runs were seined using five downstream sweeps, whereas the shallower riffle areas were sampled by placing a seine at the downstream end while the upstream area was disturbed by kicking and overturning rocks. Five such kick samples were taken in each riffle. Additionally, all habitat types at each site were sampled with a 110-V DC battery-operated backpack electroshocker for a timed collection period that allowed for similar effort per unit area in each habitat type. The electrofishing and seining collections at any one site were taken at least one week apart. Fish were identified in the field and released.

Macroinvertebrates were collected at the same sites and habitat types that were sampled for fish. A 3-min kick sample was taken in each habitat type of each site with a fine-mesh D-frame dip net. This method, although seemingly unsophisticated, has been shown to yield more consistent results than other more "quantitative" devices such as Surber samplers or artificial substrates (Frost and others 1976, Pollard and Kinney 1979). The invertebrates were picked and washed off the net and preserved in alcohol for later identification.

Data Analysis

Ordination was used to assess similarities in species composition and relative abundance among communities. Ordination arranges the communities, based upon species abundance, in a way that places similar communities closer together and dissimilar communities farther apart. A subsequent examination of the pattern of the arrangement of communities allows the investigator to infer environmental influences (Gauch and Whittaker 1972, Rabeni and Gibbs 1980). Detrended correspondence analysis (DCA) (Gauch 1982), which is a modification of reciprocal averaging (Hill 1972, Culp and Davies 1980), was the form of ordination used. All DCA plots were produced using DECORANA, a Cornell Ecology Program (Hill 1979).

Community diversity was characterized using Shannon's diversity index (Wilhm and Dorris 1968), which is useful in describing community structure because it incorporates both species richness and equitability. Species diversity is frequently used to reflect the integrity of the community, which can then be related to the quality of the environment.

The index of biotic integrity (IBI) of Karr (1981) incorporates both structural and ecological factors of fish communities and is used to assess what is termed the *biotic integrity* of a stream. The IBI evaluates 12 attributes (termed *metrics*) of the fish community. These metrics are divided into categories that include species richness and composition, trophic composition, and fish abundance and condition (Table 1). Metrics are evaluated separately against the standard conditions in an unimpacted site of similar size and in the same regional location (Fausch and others 1984). Scores are assigned according to how closely the value determined approaches the standard value.

Table 1. Metrics used in assessment of fish communities (modified from Karr 1981).

Category	Metric
Species richness and composition	Total number of fish species
	Number and identity of darter species
	Number and identity of sunfish species
	Number and identity of sucker species
	Number and identity of intolerant species
	Proportion of individuals as green sunfish
Trophic composition	Proportion of individuals as omnivores
	Proportion of individuals as insectivorous cyprinids
Fish abundance	Number of individuals in sample

The total value for the IBI is the sum of the scores assigned to the 12 individual metrics (Karr 1981). The IBI is the first index of its kind and the effectiveness of the metrics, as well as of the index as a whole, is still being evaluated (Fausch and others 1984). An advantage of using the IBI is that it is based on features of stream fish communities that are relatively easy to measure. However, an element of subjectivity enters into the assignment of values to the individual metrics. When we modified the IBI and applied it to the fish community data, we included nine of the original 12 community metrics. We excluded three metrics that were inappropriate to our situation: proportions of hybrids, diseased or fin-damaged fish, and top carnivores. We found either none of these metrics or too few to establish appropriate abundance ratings among sites. Stream size and zoogeography were considered in assigning scores. The index values obtained were examined for their relation to habitat quality as measured by HQI.

Results

The six families and 27 species of fish collected (Table 2) represented nearly all species known to inhabit medium-sized northeastern Missouri streams (Pflieger 1975). The 47 invertebrate taxa were divided among six insect orders (Table 2). About one-fourth of the species were considered abundant or common, and the rest were classified as rare.

Detrended Correspondance Analysis ordination was used to examine similarities among the assemblages for both groups of organisms (Figure 1). The

Table 2. Fish and invertebrate fauna collected from three streams in northeast Missouri.

Invertebrates
Ephemeroptera—*Isonychia, Baetis, Caenis, Heptagenia, Stenonema, Stenacron, Hexagenia*
Plecoptera—*Perlesta*
Trichoptera—*Hydropsyche, Cheumatopsyche, Chimarra*
Diptera—*Simulium, Limnophila, Tipula, Atherix, Tabanus, Odontomyia, Palpomyia, Hemerodromia, Dolichopodidae, Hydroporus, Chironominae-Orthocladiinae, Tanypodinae*
Hemiptera—*Hesperocorixa, Belostoma*
Coleoptera—*Stenelmis, Dubiraphia, Macronychus, Dineutus, Cymbiodyta, Hydrochus, Tropisternus, Berosus, Enochrus, Cyphon, Peltodytes, Laccophilus, Paracymus, Hydrocanthus*
Odonata—*Amphiagrion, Argia, Enallagma, Coenagrion, Boyeria, Hetaerina, Progomphus, Libellula*
Fish
Cyprinidae—*Campostoma anomalum, Cyprinus carpio, Notropis dorsalis, N. lutrensis, N. stramineus, N. umbratilis, Phenacobius mirabilis, Pimephales notatus, P. vigilax, Semotilus atromaculatus*
Catostomidae—*Carpiodes cyprinus, Catostomus commersoni, Moxostoma erythrurum, M. macrolepidotum*
Ictaluridae—*Ictalurus melas, I. natalis, I. punctatus, Noturus exilis, N. gyrinus*
Poeciliidae—*Gambusia affinis*
Centrarchidae—*Lepomis cyanellus, L. macrochirus, Micropterus dolomieui, M. salmoides*
Percidae—*Etheostoma flabellare, E. nigrum, E. spectabile*

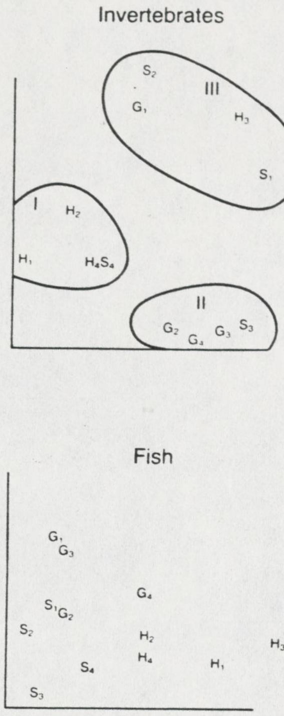

Figure 1. Ordination of invertebrate and fish communities. *Letters* represent streams (*H*, Honey Creek; *G*, Grassy Creek; and *S*, South River) and *subscripts* represent sites within streams. *Roman numerals* represent site groupings (see text for explanation).

invertebrate communities formed three distinct groups. In group I, which included three Honey Creek sites and one South River site, the collector–filterer *Cheumatopsyche* predominated over the generally collector–gatherer Chironominae–Orthocladiinae. In group II, which included three Grassy Creek sites and one South River site, Chironominae–Orthocladiinae predominated over *Cheumatopsyche*. Other differences between groups I and II were the relatively greater abundance of *Baetis, Simulium*, and *Stenelmis* in group I, and of *Isonychia, Caenis*, and *Hydropsyche* in group II. Tanypodinae were present in both groups. In group III, which included sites from all streams, the fauna were distinctly different from those in the other two groups and were dominated by Chironominae–Orthocladiinae.

The invertebrate groupings also had some relation to measures of habitat and water quality. The mean HQI score of 35 for group III was significantly less than that for the other two groups, whereas there was no significant difference between groups I (HQI = 59) and II (HQI = 55) (Kruskal-Wallis test, $p < 0.05$). Species diversity showed a similar pattern, being less for group III (1.9) than for I (2.7) or II (3.1).

There was not a distinctive grouping of fish communities similar to that which occurred with the invertebrates, and no relation to habitat or water quality could be discerned for this analysis (Figure 1). Many sites that were distinctly different in their invertebrate assemblage structure (for example, S_1 and G_2; G_1 and G_3; H_1 and H_3) were closely similar in their fish fauna.

Another comparison between fish and invertebrate sensitivity to habitat degradation was made by plotting Shannon's diversity index by the Habitat Quality Index for each site. The HQI and diversity index of the invertebrate communities (Figure 2), were significantly correlated ($r = 0.81$, $p < 0.01$). There was no significant correlation between fish diversity and HQI ($r = 0.45$), although a positive trend was evident. Fish assemblages from sites with an HQI value greater than 50 were more diverse than those from sites with HQIs less than 50 (Mann-Whitney test, $p < 0.05$).

The failure of fish diversity to correlate well with habitat quality does not necessarily mean that fish are not appropriate measures of water or stream habitat quality. The results may relate more to the properties of the diversity index, whose shortcomings are well

Deleted 3 metrics, so 45 is max score.

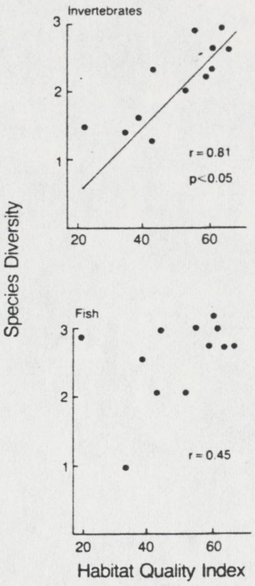

Figure 2. Relation of fish and invertebrate species diversity to the habitat quality index.

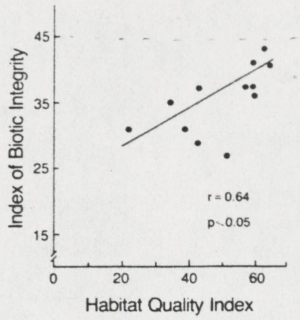

Figure 3. The relation of the fish index of biological integrity (from Karr 1981) to the habitat quality index.

documented (Green 1979, Hocutt 1981). A more ecologically realistic measure to use with fish communities may be the IBI. The correlation between IBI and HQI for all sites was significant (r = 0.64 and $p <$ 0.05). This analysis (Figure 3) indicated that fish assemblages were able to reflect differences in habitat quality. The IBI metric most responsible for this positive relation was an increase in the number of five intolerant species. *Micropterus dolomieui, M. salmoides, Lepomis macrochirus, Noturus exilis,* and *Etheostoma flabellare.* Other metrics (Table 1) did not exhibit consistent trends indicative of improving habitat quality.

would not consider intolerant in many places. what were original intol species, and how many extirpated.

Discussion

The differential response of the two faunal groups to the analyses may be due to the nature of the perturbation. Assuming that HQI is an adequate measure of sedimentation processes, the response shown by the biota is to substrate modifications. Substrate composition is probably the most important microhabitat variable influencing the abundance and distribution of stream benthic invertebrates (Nuttall and Bielby 1973, Rabeni and Minshall 1977, Lamberti and Resh 1978, Reice 1980). Seemingly minor changes in substrate particle size, organic content, and even texture can influence the associated invertebrate community structure (Cordone and Kelley 1961, Cummins and Lauff 1969). Many collector–filterers, such as *Cheumatopsyche,* lose their attachment to the substrate as sedimentation increases. However, many of the collector–gatherers are burrowers (for example, many of the chironomids). These organisms are not hindered by depositional material, and may actually benefit from the presence of additional soft substrate (Nuttall and Bielby 1973, Brusven and Prather 1974).

Sedimentation affects fish less directly and immediately than it affects invertebrates, and does so by influencing aspects of feeding and reproduction (Farnworth and others 1979). When sediment disrupts the production of benthic invertebrates and algae, the food of fish that are specialized feeders—including many fry and fingerlings—may become inadequate (Starrett 1950, Karr 1981). Increased turbidity may impair the feeding of the many benthic insectivores that are visual feeders (Keenleyside 1979, Farnworth and others 1979). More important may be the effects on fish reproduction (Langlois 1941, Smith 1971), especially on the degradation of spawning grounds, on behavior, and on egg survival (Cordone and Kelley 1961, Balon 1975, Muncy and others 1979). One should exercise caution when extrapolating our results to other pollutants, such as toxic chemicals and oxygen-demanding substances, and to other situations where substrate alteration does not occur.

Although several floral and faunal groups should ideally be incorporated into an integrated biological monitoring program, practical considerations often dictate that emphasis be placed on a single group. A decision on the most appropriate group should be based on (a) the amount of information provided, (b) time and cost considerations, and (c) the impact of the acquired information on environmental management policies.

We demonstrated that in agricultural situations of northeast Missouri both faunal groups adequately evaluate stream environmental quality, although the invertebrate data were more readily interpretable when community structural indices were used. We also found the effort required to process a sample of either faunal group to be roughly equivalent for the collection, identification, and counting steps. The main difference was the time needed to sort invertebrates from the associated stream-bottom material. This can amount to about 3 h/sample (Resh and others 1985) but can be reduced by subsampling, staining, and elutriation. We do not feel that the time differences are so substantial that this factor, by itself, should dictate the monitoring approach.

The relative impact of the information derived from either group on management policies is difficult to judge. However, Perry and others (1984) showed that, when state agencies were forced to cut back or eliminate parts of their monitoring program, benthic invertebrates were usually the first to be affected. Invertebrate monitoring may be considered expendable because of a lack of understanding of their usefulness and applicability to the overall water quality program. The use of fish could improve the situation. Not only is the significance of fish in aquatic systems more intuitively understandable to nonbiologists, water quality managers, and the general public, but fish are often directly related to state and federal legislative mandates (for example, the fishable waters provision of the Clean Water Act).

Conclusions

Both fish and benthic invertebrates reflected habitat quality of streams impacted by agricultural activity in northeast Missouri. Benthic invertebrates were more sensitive and provided considerably more information when structural analyses—ordination and diversity—were used. Fish adequately reflected habitat quality when ecological measures were incorporated into the analysis. The similarity of the information provided by both groups for the effort expended allows the investigator to make the choice of which faunal group to use on the basis of the ultimate impact on management decisions. Fish should be given greater consideration in biological water quality monitoring of streams because they are generally perceived to be more ecologically significant, and they are more directly related to legislative mandates.

Acknowledgments

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Steambank stability and cattle grazing in southwestern Montana

Clayton B. Marlow, Thomas M. Pogacnik, and Shannon D. Quinsey

ABSTRACT: Cattle have impacts on riparian communities by grazing and trampling. Reevaluation of management practices indicated that implementing rest-rotation grazing management and limiting cattle use of riparian vegetation will reduce animal impacts. Rest-rotation and light grazing may improve plant vigor, but little information is available on how well either practice controls trampling damage on banks. A 4-year grazing study in southwestern Montana indicated both streamflow and cattle use were highly correlated with the degree of change in stream channel profile. The greatest streambank change occurred during periods of high streamflow (positive correlation) and low cattle use (negative correlation). However, further statistical analysis of the data indicated that streamflow itself was not a major factor in bank erosion. Although not significant in all years, the decline in channel change appeared related to the seasonal trend in soil moisture. As streambank moisture levels declined, the extent of channel alteration also declined. Channel profile changes in paddocks grazed after early August when banks had dried were not significantly different ($P<0.05$) from those in an ungrazed paddock. The interval between pre- and post-grazing measurements that was negatively related to channel change explained about 40% ($r^2=0.389$) of the variation in channel profiles over the 4 years of study. However, examination of change in individual channel transects showed that measurement interval probably represented a seasonal or time-of-grazing effect. Streambank alteration may result from a combination of high soil moisture levels, high streamflow, and cattle use. Cattle use alone did not explain the degree of change in channel profile.

DEGRADATION of western riparian zones has been largely attributed to cattle grazing (*2, 3, 4, 9, 13, 15*). Cattle contribute to declines in riparian community stability and water quality by removing protective vegetation during grazing and increasing bank instability by trampling. Unstable banks lead to accelerated channel erosion and higher instream sediment loads (*5, 24*), while the corresponding removal of vegetation increased sediment production from surface runoff (*17*). Reduction in vegetation cover may also lead to higher water temperatures (*7, 22*) that are counterproductive to aquatic vertebrate and invertebrate populations.

These impacts have arisen because of past management or the lack thereof (*14*). In many cases riparian zones have been ignored in the planning process because their limited extent has made them sacrificial areas (*20*). Often, the sacrificial condition was created by incorporating streamside areas into large pastures and failing to identify them as separate, distinct management units (*11*). Consequently, management practices to reduce riparian degradation are recommended at all planning levels (*23*).

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Platts (*15*) doubted that existing grazing management strategies were capable of correcting cattle impacts in riparian habitats. But several management alternatives have recently been re-examined. May and Davis (*11*) recommended light grazing levels (20% forage removal) and pasture design changes to alleviate cattle-induced problems. Rest-rotation grazing systems appear promising for rehabilitating riparian areas with excluding cattle for long periods of time (*8*). But some biologists question its long-term effectiveness (*1, 16, 21*). The limited acceptance of rest-rotation grazing management could stem from inconsistent research results (*8*). Inconsistencies may result from inadequate information in developing site-specific criteria to protect the riparian resource or from a variety of different experimental purposes and procedures, all being titled rest-rotation.

Most grazing systems are designed to control the season and frequency of livestock use. Consequently, managers must know how grazing affects each component of the ecosystem. Although May and Davis (*11*) and Platts (*16*) suggest that light grazing will produce improvements in the riparian zone, little information is available on how streambanks respond to trampling at different times of the year. More information on the relationship of grazing season and streambank damage is needed to improve riparian grazing strategies.

A study was initiated in 1981 in southwestern Montana to determine the relationship between the time of cattle grazing and riparian degradation. Because foothill ranges are traditionally used from June to October, cattle grazed the study site from the third week in June until the first week of October. Stocking rates were developed to remove half of the annual forage crop.

The riparian study was conducted on a small tributary of the Madison River in southwestern Montana. Both the stream and its headwaters are located on the Montana Agricultural Experiment Station's Red Bluff Research Ranch. The Cottonwood Creek watershed (1,360 ha) is characterized by moderate to steep slopes; elevations range from 2,000 m at the headwater spring to 1,400 m where it enters the Madison River. The stream is bordered on the south by slopes of 30-50% and on the north by rolling hills with 15-30% slopes.

The riparian community is dominated by Kentucky bluegrass (*Poa pratensis* L.), redtop (*Agrostis stolonifera* L.), timothy (*Phleum pratense* L.). smooth brome (*Bromus inermis* Leyss.), beaked sedge (*Carex rostrata* Stokes), Sprengel's sedge (*Carex sprengelii* Dewey), and white clover (*Trifolium repens* L.). Overstory includes quaking aspen (*Populus tremuloides* Michx.), willow (*Salix* spp. L.), chokecherry (*Prunus virginiana* L.), and swamp gooseberry [*Ribes lacustre* (Pers.) Poir.].

The upland communities support Kentucky bluegrass, green needlegrass (*Stipa viridula* Trin.), needleandthread (*Stipa comata* Trin. & Rupr.), bluebunch wheatgrass (*Agropyron spicatum* (Pursh) Scribn. and Smith.), Idaho fescue (*Festuca idahoensis* Elmer), and cheatgrass brome (*Romus tectorum* L.). Scattered, dense stands of mountain big sagebrush [*Artemisia tridentata* ssp. *vaseyana* (Rydb.) Beetle] interspersed with Wood's rose [*Rosa woodsii* (Lind) L.] and Rocky Mountain juniper (*Juniperus scopulorum* Sarg.) occur throughout.

Cottonwood Creek is small (average flow 0.16 m^3s^{-1}). Its channel substrate consists of angular gravel, silt, and fine clay. Banks are less than 20% rock or gravel.

Mean daily air temperatures range from 20°C in July and August to -11°C in December. The 400-500 mm of annual precipitation is primarily from snowfall between October and March and rainfall during May and June. Precipitation from thunderstorms in July, August, and September contribute less than 20% of the annual total.

Study methods

A 5.5-ha section of Cottonwood Creek was fenced in the spring of 1981. Nine 0.6-ha paddocks, each containing equal amounts of upland and riparian communities, were created by cross-fencing the original enclosure (Figure 1). One paddock served as an ungrazed control, the other eight were grazed as follows: beginning with the paddock furthest downstream, four head of yearling cattle were grazed in each paddock for 14 days. Paddocks were grazed sequentially to prevent upstream use from confounding time-of-year effects. Each paddock was grazed once each year during the same 2 weeks.

Moisture content of streambanks was measured at two points in each paddock when the cattle were brought in. This provided nine sample dates from mid-June until early October. Percent moisture content of the soil column was determined at the 15-cm, 30-cm, and 45-cm depths by the neutron scattering technique (*12*). Streambank and channel alterations were monitored by establishing five permanent channel cross-section transects in each paddock. The vertical distance from the level transect line to the channel bed was measured at horizontal intervals of 10 cm (Figure 2) at the beginning of the grazing season and immediately after each paddock had been grazed. Consequently, the time between pre-grazing and post-grazing measurements increased as the grazing season progressed. Each vertical measurement in the pregrazing channel profile was subtracted from its corresponding measurement in the post-grazing profile. All differences were summed and the absolute value was used to develop a profile change index for each transect. The index was derived in the following manner:

$$\text{profile change} = \left(\sum_{i=1}^{n} ai - bi\right)$$

where a = post-grazing vertical measurement, b = pre-grazing vertical measurement, and n = the number of measurements in each transect.

Streamflow was recorded on a 24-hour basis with a Steven's flow recorder. Recorders were mounted on H-type flumes. Each flume was equipped with a stage-height indicator calibrated in tenths of feet (1 ft./sec. maximum). The creek's size allowed the flume/recorder combination to be placed in the channel to capture the entire flow. Flume/recorder units were positioned on the downstream boundary of the study area: at three locations along the creek in the grazed area and at the downstream boundary of the ungrazed paddock. Measurements were made during the study period each year and converted to centimeters for comparison with channel alterations. Streamflow from the unit nearest the paddock, representing a particular time period, was used in comparing streambank and channel changes to streamflow level during that period.

Cattle-use patterns were based on two, 24-hour observation periods each week in 1982 and 1983, a total of 32 observations annually. The activity (feeding or resting) and zone (riparian or upland) occupied by each yearling was recorded hourly during each observation period. The number of observations in each activity category and location was summed for each grazing period and divided by the total observations to ar-

Table 1. Changes in channel profile during different grazing periods (each value represents the average of five transects).

	Change (cm)				
Grazing Period	*1981^{a}**	*1982^{a}*	*1983^{a}*	*1984^{a}*	*Four-Year Average*
Late June	175	111	216	199	175^{b}
Early July	1,128	188	250	420	496^{a}
Late July	104	84	230	144	112^{bd}
Early August	153	82	103	265	151^{bd}
Late August	85	40	52	95	68^{cd}
Early September	82	24	52	69	45^{cd}
Late September	90	58	71	63	70^{cd}
Early October	16	19	22	32	22^{c}
Ungrazed	32	28	28	84	43^{c}

*Years and grazing periods with different superscripts are significantly different at the 0.05 level.

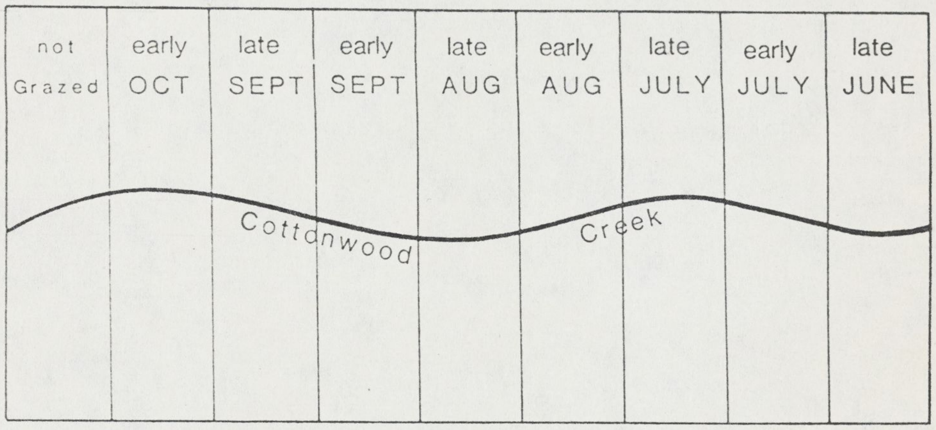

Figure 1. Arrangement of paddocks representing the different grazing periods.

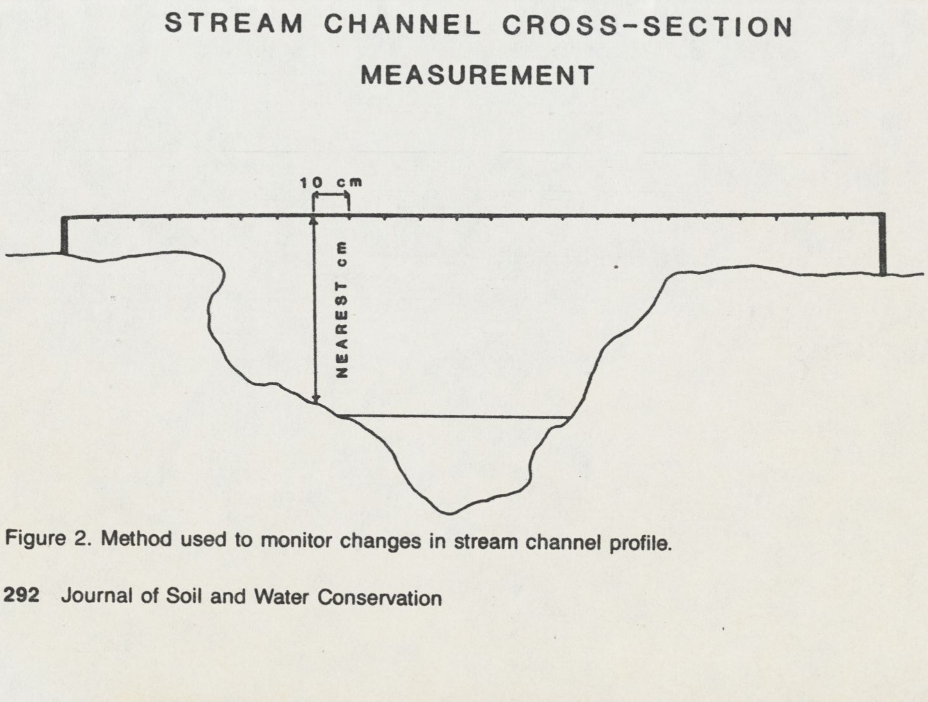

Figure 2. Method used to monitor changes in stream channel profile.

rive at the percentage of time spent in each zone.

The change in channel profile was tested with a two-way (grazing period x year) analysis of variance using a repeated measurements design. A square root transformation in the statistical test achieved homogeneity of variance among the grazing periods by year cells. The least-significant-difference test was used to separate significant grazing period means (*6*). Channel profile changes, grazing periods, measurement interval, streambank moisture, streamflow, and cattle use-levels were tested with correlation and multiple regression for possible relationships (*6*). It also became necessary to test individual channel transects for significant differences between pre- and post-grazing measurements. This was accomplished with a signed rank test. Potential differences in streamflow between paddocks was tested with a one-way analysis of variance for each year of the study. The relationship between streamflow and channel alteration was evaluated with a simple correlation test (*6*). All statistical tests were performed at the 0.05 probability level.

Cattle effects

There was a distinct downward trend in channel profile change during the season (Table 1). The magnitude of change was greatest in early grazing periods, late June through early August, and lowest in early October. Change occurring from late August onward were not significantly different from the level of change in an ungrazed portion of the same stream. Although the channel profile change level declined dramatically in late August each year, variation among channel transects in paddocks grazed in late July, August, and September was great enough that the seasonal pattern of change appeared to be more continuous than disjunct. The pattern of change was similar in all 4 years (Table 1).

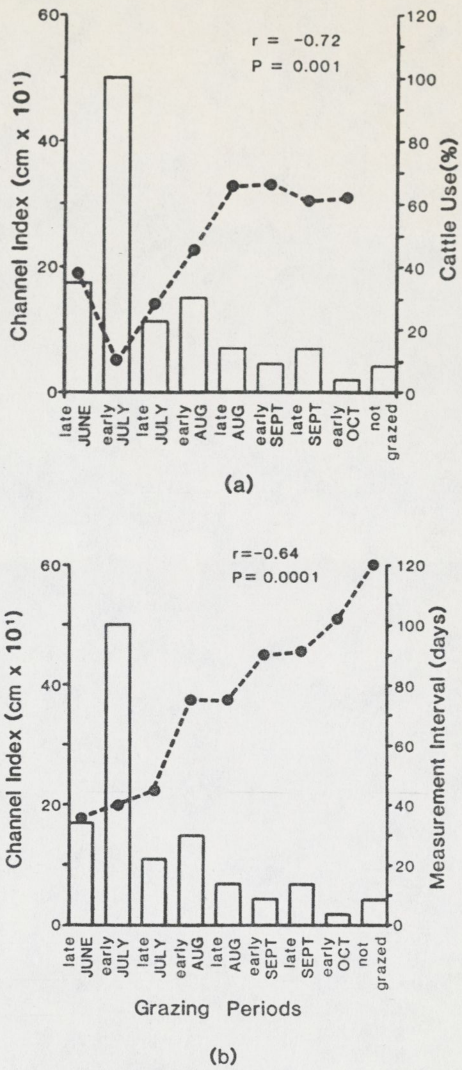

Figure 3. (a) Comparison of change in channel profile during each grazing period with the corresponding level of cattle use. (b) Comparison of change in channel profile during each grazing period with the corresponding interval between pre- and post-grazing measurements.

Comparing channel change with cattle use and measurement interval indicated that both use and interval were closely related to the pattern of change (Figures 3a and 3b). Alterations in channel profile appeared to decline as the percentage of time cattle spent in the riparian zone or the interval between pre- and post-grazing measurements increased.

The negative relationship between cattle use and channel change was puzzling because previous case studies suggested that high cattle use altered stream channel profiles (*1, 3, 14*). However, a recent study on an ephermeral Wyoming stream indicated greater channel changes in an ungrazed paddock than in paddocks grazed during spring, summer, or fall (*19*). The Wyoming study also reported high levels of riparian use by cattle during summer and fall. The negative relationship between channel alteration and the measurement interval suggests that either the procedure for monitoring streambank change was not sensitive enough or a factor other than cattle use was responsible for channel deformation.

The possibility exists in this study that changes in channel profile during late August, September, early October, and in the ungrazed paddock were not detected because the interval between pre- and post-grazing measurements was too long. Because major bank erosion is seasonal (*18*), deposition during the long interval between measurements may have led to few, if any, changes in channel profile during the late grazing periods. However, examination of the type and degree of change occurring between measurements of individual transects indicated significant changes in all paddocks in all 4 years (Table 2).

Although early grazed paddocks with

Table 2. Pattern of change among transects within respective grazing periods or pastures.

Grazing Period	Average Measurement Interval (days)	1981 No. of Transects*	1981 Trend†	1982 No. of Transects	1982 Trend	1983 No. of Transects	1983 Trend	1984 No. of Transects	1984 Trend
Late June	37	2	E,D	3	E,E,D	4	E,D,E,D	5	E,E,E,E,E
Early July	46	4	E,E,E,E	5	E,D,D,D,D	3	E,E,E	4	D,D,D,E
Late July	53	2	E,E	2	D,E	4	E,E,E,D	3	D,E,E
Early August	72	4	E,E,E,D	3	E,E,E	4	D,E,E,E	2	E,E
Late August	77	4	D,D,D,E	2	D,E	2	D,D	3	E,E,E
Early September	101	3	D,D,D	3	D,E,E	2	E,E	3	E,E,E
Late September	108	2	D,D	1	E	1	D	2	E,E
Early October	128	2	D,E	1	D	1	D	0	
Ungrazed	128	2	E,D	3	E,D,D	1	D	3	D,E,E

*Number of transects with a significant difference (P < 0.05) between pre- and post-grazing measurement. Each paddock representing a specific grazing period had a total of five channel transects.
†Channel change was erosion (E) or deposition (D).

short measurement intervals appeared to have more transects with significant changes, regression analysis showed little association between measurement interval and the number of transects with significant differences. Except in 1983, the long period between pre- and post-grazing measurements did not appear to hinder the identification of significant changes in channel profile even in the late or ungrazed paddocks. If long periods between measurements had increased the opportunity for natural changes to occur, deposition should have been the prevailing cause of change. Instead of repeated deposition during all years of the study, some transects experienced alternating patterns of deposition and erosion (Table 2). In addition, the lack of significant change in a number of transects with measurement intervals greater than 100 days would indicate that deposition was not altering the channel profile sufficiently to effect the comparison of profile changes that occurred during the grazing season. If the method for monitoring channel profiles was not biased, it is possible streamflow dynamics may have played a role in bank erosion patterns.

It has been suggested that high streamflow during periods of high soil moisture causes severe bank erosion (*18*). High levels of streamflow were significantly related to the amount of change in the channel profile during 2 of the 4 years (Figure 4). Even though streamflow appeared to be the major factor in bank erosion on Cottonwood Creek, the consistently greater amount of alteration during the early part of the grazing season suggests that either streamflow differed from paddock to paddock or some other factor was augmenting channel alteration during high-flow periods. Disproportionately greater flow in the early grazed paddocks, which could have led to more bank erosion than in the late-grazed paddocks, appeared unlikely because there was no significant difference in flow among the five recording locations in 3 of the 4 years (Table 3). Consequently, the presence of cattle during periods of high flow appeared to be the only explanation for the elevated levels of streambank erosion in late June, July, and early August.

Although the combination of high-flow events and high bank moisture levels is cited as being responsible for major bank erosion (*18*), soil moisture was significantly related to channel profile change only during 1983 (Table 4). Several factors may have been responsible for the apparent limited relationship between soil moisture and channel change in this study.

First, the neutron access tubes in the ungrazed paddock had apparently been placed in an area with a very high groundwater table. Streambanks in the ungrazed paddock had as high or higher soil moisture levels in October as the late June grazed paddock had 128 days earlier (Table 5).

Second, neutron access tubes in the late September and early October grazed paddocks were initially placed in a boggy area. By the end of 1982 it was apparent that such areas were not representative of the banks cattle used, so the tubes were relocated in an area frequented by cattle. Tube relocation produced a set of soil moisture readings significantly related to channel change in 1983 and nearly so in 1984 when the ungrazed paddock was excluded from analysis (Table 4). Had the tubes been initially located in bank sites more often used by cattle, a significant relationship between bank moisture levels and channel change during all 4 years might have been noted.
complicated by too few tubes per paddock. Each moisture level used in the correlation analysis was the average of only two tubes, while channel change data points were the average of five transects. If streambank areas corresponding to each channel transect had been sampled for moisture conditions, a higher correlation between soil moisture and channel change may have been reported.

Because streamflow generally declines from June to October (Table 3) and streambanks become progressively drier (Table 5),

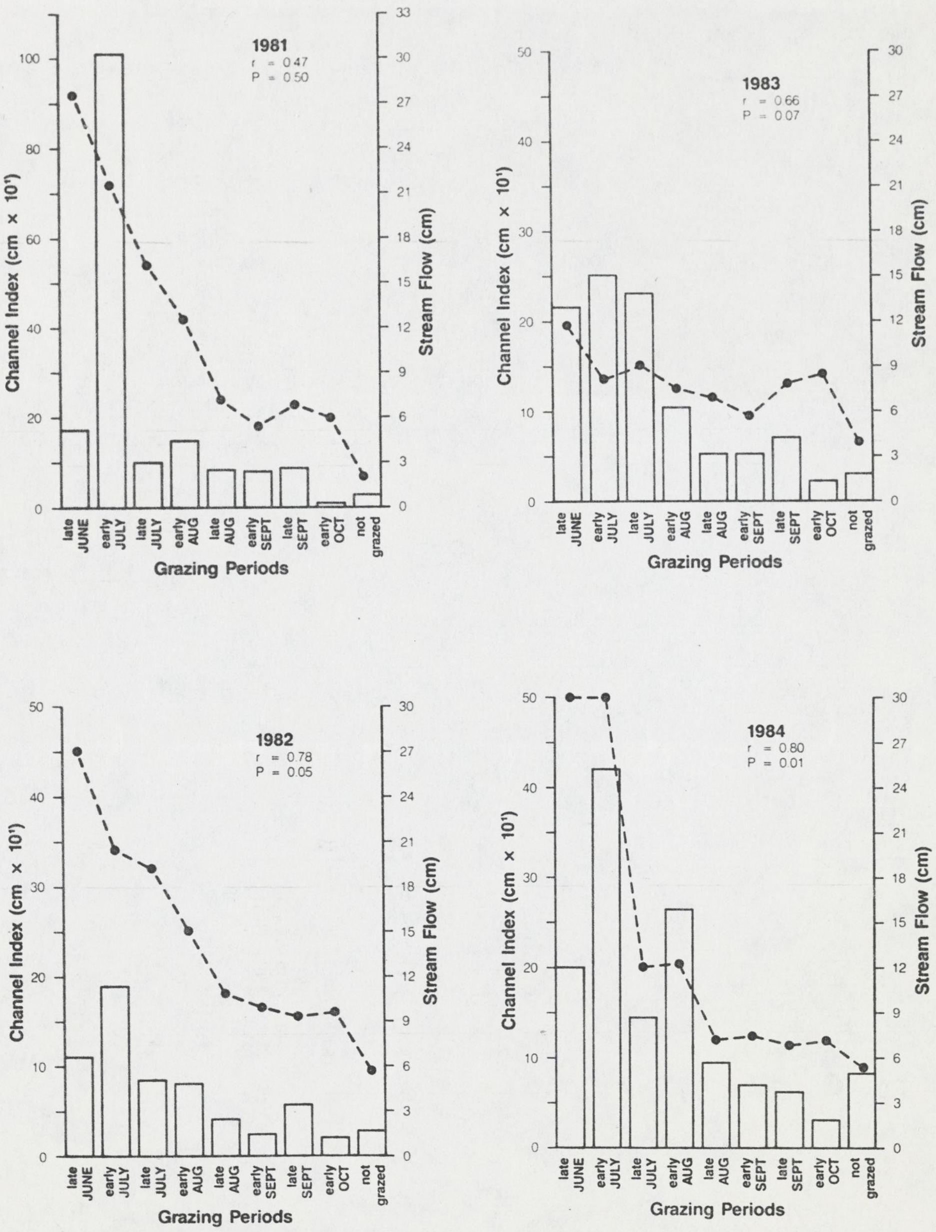

Figure 4. Comparison of stream flow and channel alteration during different grazing periods, 1981-1984.

Table 3. Height of streamflow (cm) recorded bimonthly at five permanent locations within the Cottonwood Creek riparian grazing area for 1981 through 1984.

	1981 Station					1982 Station					1983 Station					1984 Station				
Grazing Period	A[a]*	B[a]	C[a]	D[a]	E[b]	A[a]	B[a]	C[a]	D[a]	E[a]	A[a]	B[a]	C[a]	D[a]	E[a]	A*	B[a]	C[a]	D[a]	E[a]
Late June	30	30	26	26	21	27	29	28	28	22	12	16	16	16	10	30	24	23	25	23
Early July	28	27	21	22	16	21	24	22	22	16	8	13	13	14	9	27	23	15	18	16
Late July	22	22	18	18	12	16	19	17	17	11	6	9	10	11	7	21	15	11	13	10
Early August	15	16	13	14	8	12	15	13	13	8	10	7	8	9	5	7	12	8	10	8
Late August	10	13	10	12	4	8	11	11	11	7	9	7	7	8	5	4	12	7	9	7
Early September	7	9	7	9	1	7	9	10	10	7	3	7	6	7	4	3	12	7	8	6
Late September	8	7	5	8	1	7	9	9	9	6	3	8	7	8	4	1	10	7	7	5
Early October	10	7	4	7	1	7	10	10	10	6	4	7	7	8	4	2	8	6	7	5
Ungrazed	9	6	3	6	2	7	10	9	9	6	6	6	6	8	4	2	7	6	7	5

*Stations with the same superscript are not significantly different at the 0.05 level.

it is possible that the inverse relationship between channel change and measurement interval (Figure 3b) represents a seasonal pattern of streambank erosion similar to that reported by Richards (*18*). Although soil moisture data were not reported by Siekert and associates (*19*), the general lack of significant profile change in an ephemeral or dry channel under cattle grazing supports the idea that streambank moisture levels at the time of grazing may be responsible for the degree of alteration that occurs.

On the basis of multiple regression analysis, measurement interval was the only factor that explained a significant amount of change in channel profile ($r^2 = .389$). However, because of study design, it is difficult to determine whether this interaction was a function of time, grazing period, or a combination of both. This relationship and the apparent continuous decline in channel change suggests that the level of cattle impacts on streambanks may be seasonal.

Table 4. Pearson correlation coefficients and significance levels for streambank moisture levels and the change in channel profile.

	All Paddocks		Ungrazed Paddock Excluded	
Year	Coefficient	Sig. Level	Coefficient	Sig. Level
1981	−0.01417	0.9711	0.13262	0.7542
1982	0.02685	0.9453	0.15392	0.7159
1983	0.32203	0.3980	0.77177	0.0249
1984	0.43427	0.2428	0.66787	0.0703
Four-year average	0.15504	0.3666	0.31416	0.0799

Conclusions

The magnitude and extent of channel change in a small Montana foothills stream steadily declined from late June until early October. This decline was in sharp contrast to the pattern of cattle use on the same stream; lowest in late June and early July and highest in September and October. Although it was difficult to prove a direct relationship, soil moisture levels that also declined during the grazing season may have accounted for the apparent limited streambank impact during late summer and early fall. Conversely, high soil moisture levels during late June and early July may have caused streambanks to be more easily deformed by cattle. This, in turn, may have led to greater erosion of the streambanks by high water than would have occurred if the paddocks had not been grazed.

Increased streambank erosion by high flows when bank moisture content is high supports this argument and further suggests that a combination of high flow, moist streambanks, and cattle use leads to major streambank alteration. Because the measurement interval used in this study was additive, it was a measure of the passage of time. The negative relationship between time and channel change reinforces the point that the magnitude and extent of change are a function of the season of grazing.

It is possible that the animal density (4 head/0.6 ha) used in this study created a level of riparian impact different from that in larger pastures. However, comparison of riparian and upland use patterns between the study cattle and unrestricted cattle using the same riparian zone indicated no significant differences between the two groups (*10*).

Because the possibility of a seasonal effect exists, investigation of the impact of time of grazing on streambank and channel profile should be conducted in a number of other riparian zones with differing soil types and climatic patterns. Until this information base is developed, a generally applicable livestock management strategy to protect streambanks could be to defer grazing until mid- to late-summer rather than excluding livestock. Because grazing is the primary use of riparian areas in August and September (*10*), forage utilization in the riparian zone must be monitored closely to enhance improvements in bank protection.

Table 5. Average streambank soil moisture levels for each grazing period and the ungrazed paddock.

	Percent Moisture			
Grazing Period	1981	1982	1983	1984
Late June	18.5	19.6	18.9	24.8
Early July	18.1	19.3	18.2	23.5
Late July	11.7	12.3	11.8	11.7
Early August	11.1	11.1	10.4	9.6
Late August	13.7	12.8	11.7	12.8
Early September	10.7	10.9	9.7	11.1
Late September	20.4	21.3	9.0*	9.3
Early October	20.0	21.7	9.5*	9.2
Ungrazed	21.7	21.0	20.9	26.3

*Soil moisture sample sites were relocated in 1983.

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1951 $12 AUM

Fees $5 AUM $8

OFFICE MEMO

TO: 1981-$2.31 - 1985-present $1.35

Date

FROM:

SUBJECT: Opportunity and Challenge, the story of the BLM

REMARKS: Muhn, J. and H.R. Stuart. 1988 U.S.D.I. B.L.M.

Until 1960's days, open range - grazers considered right not privelege - Taylor Grazing Act. - specifically BLM monopurpose - Grazing = Grazing Service + Gen. Land Office Local Advisory Bd. all mgt - decisions - by local ranchers. 1976 FLPMA - mandate to multiple use.

Burford - sagebrush rebel - took pride to set BLM back on track as multipurpose agency to all) Expose as before (Carter - Frank Gregg) BLM - managed as private playgrounds for special interest (environmentalists) _ Be good neighbors w/ local (users) - fish wild boat ↓ since 4- - 1-0

1987 Audubon Rep. - on BLM

[1989]

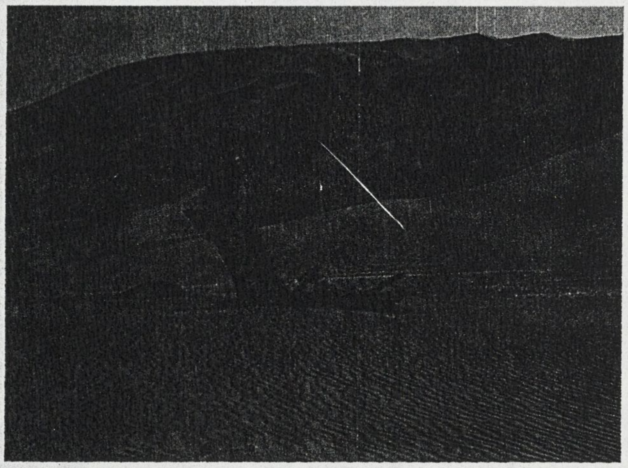
A Public BEEF

Are Grazing Cattle Turning the American West Into a New Desert?

By Dyan Zaslowsky

Late on an August afternoon, beneath an unremitting blue sky, the foothills of northeastern Utah's Uinta Mountains seem remarkably green for a droughty summer. But on the approach to the Strawberry River, which skirts the Uinta National Forest, the green drains from the landscape, which fades to an ashen color. This is what author Edward Abbey meant when he called the Rocky Mountain West "cowburnt."

On the slope across the river, a clutch of white-faced cows stand as though planted. They look up momentarily and then resume grazing on the pale plants well above the river. Closer to the water, the smell of ripe manure lifts into the sun-warmed mountain air. Examining the clumps of sagebrush, an observer can see that each is elevated on a pedestal of receding dirt, a high-soil marker of where the land once stood.



Willows and birches that typically grow thickly at the river's edge, even in an arid climate like Utah's, have been eaten to short sticks, leaving the banks and water exposed to the unforgiving sun. Cattle have tarried too long by the Strawberry River. Its riparian zone, what should have been a verdant streamside border, looks like a war zone.

The sight brings to mind another western river seen at another time: its banks grazed too long by too many cattle, the water so thick with mud from the collapsing riverbanks that trout suffocate as they try to spawn.

Livestock graze on 70 percent of the public land in the West, an area more than twice the size of France. Although the number of sheep grazing on public land nearly equals the number of cattle, cattle consume 90 percent of the forage and cause most of the damage. Yet the 3.6 million head of cattle taking nourishment from public land constitute less than 5 percent of the nation's beef supply. Of the top 10 beef-producing states, only Montana, number seven in ranking, is located in the Mountain West. Considering denuded riverbanks like the Strawberry's and streams so thick with silt that trout cannot breathe, it is reasonable to ask whether too much damage is being done for too little food. And should it be tolerated on public land, the 307 million acres of federally owned rangeland, especially since the land was supposed to be saved for the perpetual pleasure and use of all Americans?

For the privilege of grazing their livestock on the public's estate of grass all or part of every year, 23,000 ranchers and corporations, or about 15 percent of the country's livestock operators, pay the United States government $1.54 per animal unit month (AUM, defined as the amount of forage it takes each month to feed a cow and her calf). Each permittee is assigned his own allotment, as the sections of range are called; allotments run from under 40 acres to over one million.

Due to overgrazing, public lands in the West may come to resemble African deserts.

The grazing fee does not nearly cover the government's costs of managing public lands to control grazing abuses that, in turn, impinge upon wildlife, water quality and recreation. The Bureau of Land Management (BLM), which administers

Illustration: Tom Curry. *Photograph:* Arthur Gloor / Earth Scenes.

If cowboys—and cattle—are to survive in the West, taxpayers must continue to underwrite their brand of agriculture.

G.A. Belluche, Jr./FPG International

60 percent of the public rangeland, and the United States Forest Service, which administers the other 40 percent, calculate their costs at about $4.50 per AUM.

The low grazing fee does help sustain the nation's cowboy heritage, America's favorite invention of itself, judging from the more than 4,000 Westerns made in Hollywood in the last 74 years. The cattleman is depicted as the personification of independence, determined to surmount any obstacle by his wits or will. Yet, ironically, this singular individual is possible today largely because of his dependence on all taxpayers. Cowboys and cattle grew out of ground that was once free and is now subsidized, as is their water. For cowboys—and cattle—to survive in the arid West, others must continue to underwrite their brand of agriculture. It may well be worth doing; society supports other forms of agriculture and other historical artifacts. And regardless of the myths, it is also true that cattle ranching has, during the past century, become central to Western society and culture. The issue in this situation, however, is that grazing practices endanger the nation's patrimony. A culture of long standing is pitted against distressing ecological consequences.

In the world outside the United States, the word *desertification*, coined by a French scientist in the 1940s, is used to define the impoverishment of productive yet arid land. Desertification, which is both a process and a condition, can be caused by climatic changes beyond human control; but at first, because of improper cultivation, irrigation and livestock grazing, it mostly spreads like a patchy skin disease over already fragile land.

Desertification's symptoms are the inability of native animals and plants to hold their own territory; precipitous declines in the water table; silting up of scarce rivers and streams; salinization of the soil and excessive soil erosion.

Globally, desertification proceeds apace. The United Nations Environmental Programme reports that 15 million acres in arid regions are turned into unreclaimable desert annually and that another 50 million acres a year are placed at risk. In its terminal stage, desertification leads to mass starvation, as it did in the African Sahel during the 1970s. When such tragedies are linked to overgrazing, as they usually are, they lead to scathing views of cattle, whose numbers are expanding in vulnerable arid places as well as in tropical rain forests. "Cattle are the scourge of the earth," says Richard Rice, a resource economist with The Wilderness Society, and he is not alone in thinking so.

Most of desertification's early and more advanced symptoms are evident on the rangelands of the American West, but the term has not been officially used in the United States since 1982. Before then, Carter Administration officials had heeded a warning from researchers at a 1977 United Nations conference in Nairobi, Kenya. Those researchers reported that the United States was undergoing severe desertification, which in places was worse than Africa's. The conference identified the most desertified parts of the nation as the

Navajo Reservation, which operates much like a sovereign state, and the Western public lands, which do not, and blamed the condition on livestock overgrazing.

To follow up on the U.N.'s assertion, the Council on Environmental Quality (CEQ) confirmed the situation and published its findings in 1981. A separate critical report by the Bureau of Land Management followed in 1982.

"Improvident grazing, or overgrazing, as it has come to be known, has been the most potent desertification force, in terms of total acreage affected, within the United States," the CEQ stated. According to its report, about 225 million acres, an area comparable to the 13 original colonies, were being desertified, and the process "has some very far-ranging implications, in terms of the nation's food and energy supplies, balance of payments, and environment." The CEQ report also included a map of the West's desertification drawn by Harold Dregne, one of the nation's leading experts in aridity, which showed that 36.8 percent of the North American continent's dry lands has suffered "severe" desertification.

And then the matter "just fell off the agenda," says Dr. Cyrus McKell, dean of agriculture at Weber State University in Ogden, Utah, and chairman of the Association for the American Advancement of Science's committee on arid lands.

A change in the presidential administration and its priorities stopped cold the distribution of the CEQ's report. And when the BLM's subsequent "Desertification in the U.S.: Status and Issues" was published in 1982, it marked the last official use of the word desertification as it applied to American property.

"You have to remember that this was the midst of the Sagebrush Rebellion, supported by ranchers who wanted less to do with the federal government, and that the Reagan Administration had a similar hands-off philosophy about federal land management," says Dr. Eleonora Sabadell, an Argentine-born chemical engineer who headed the BLM study.

"The word *desertification* turned off James Watt, who was Secretary of the Interior, so much," she says. "It was an absolute no-no. I was told that desertification is something that happens in the Sahel, not in the United States." Sabadell says, "Our study was completely ignored."

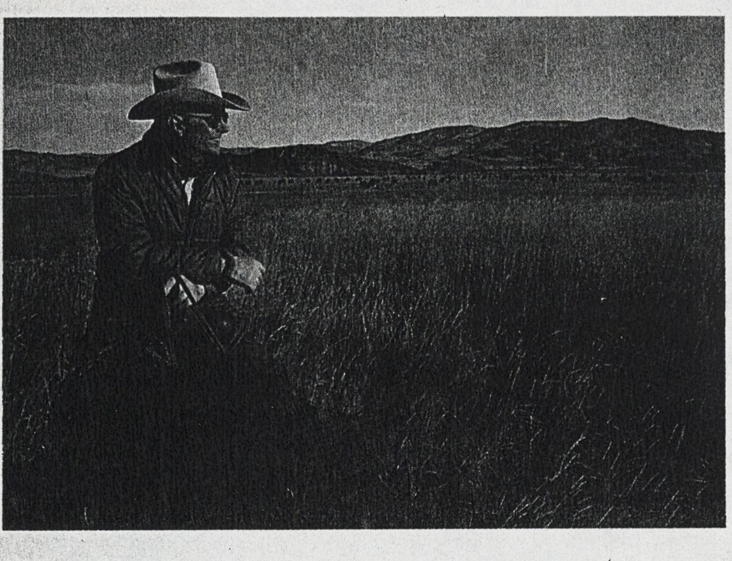
"The vision most of us have of sand dunes moving into African villages did not fit what we saw in the United States," says Weber State's McKell. "But that doesn't mean we don't have serious range problems that need to be addressed, or that desertification does not exist here."

"There simply has been no commitment to good land management during the Reagan Administration," says Dr. John Malechek, head of Utah State University's range science department. Malechek believes that a few rainy years during the last eight dampened the talk heard in the late 1970s about the desertification of the West. "You don't talk about it when you are up to your ears in water," he says. "But a few more years of drought, and we could be at the edge of desperation. There's nothing like a drought to turn things around."

While quelling scientific debate on desertification in the United States, the government did address the problem in its own way. In 1985, the BLM completed its most extensive survey of range conditions to date. The agency's findings sound dismal, if not desertified. The survey states that 71 percent of the land studied was in poor or fair condition. (The rating refers to the degree to which grazing has damaged vegetation, soil and water.) Less than 2 percent of the range was rated excellent. The most promising assessment offered was that almost half the land surveyed was in "stable" condition, which is to say, even if its condition was not improving, at least it was not declining.

Two studies released by the General Accounting Office in June of 1988 reaffirm that range conditions remain a problem. One study examined the condition of riparian zones like the area along the banks of the Strawberry River. Riparian areas are the biotically rich sponges of the public rangelands, and they are crucial to maintaining the supply of pure, ample water downstream. Destruction of streams and rivers was found to be common; where federal agencies have devoted their money and manpower, however, rehabilitation has been sucessful. The second GAO report noted that, generally, the number of cattle on public land still exceeds the land's carrying capacity. The number of cattle must be reduced if the range is to improve.

"Grass is a nice renewable resource. We can't eat it ourselves, but we can make meat out of it."

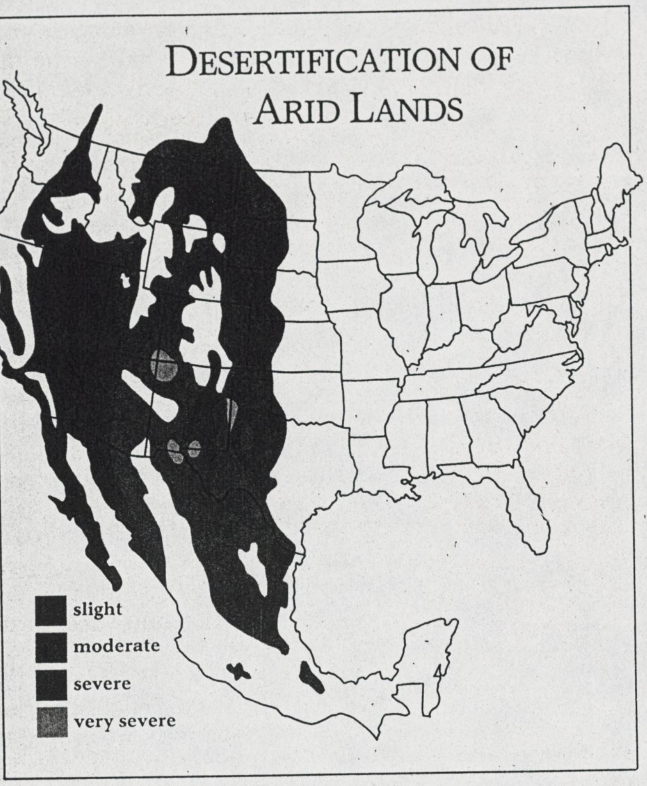


Colorado rancher Mel Coleman believes in the relationship between cattle and Western land.

TOM STACK

Scientists have said for years that grazing by domestic livestock, particularly cattle, has diminished or destroyed more Western land than all other human activities combined. Mining, logging, river damming and diversion, test bombing and city building profoundly affect the region's environment, but they still take up far less room than cattle do.

An enormous amount of land is required to feed cattle in the arid climate that defines the American West. Between the 98th meridian (which runs through the middle of the Dakotas, through central Nebraska and Kansas and western Oklahoma) and the Pacific coastal ranges, less than 20 inches



According to a 1981 report, about 225 million acres—an area the size of the 13 original colonies—are being desertified.

MAP ADAPTED FROM *Desertification of Arid Lands* BY H.E. DREGNE

of rain falls annually. The East, South and Midwest receive twice as much rain or more, so that an acre in the West produces much less vegetation than an acre where water is plentiful.

It takes at least 20 acres of forage to feed a steer or a cow and her nursing calf in Colorado, compared to 1 acre in Iowa for the same purpose. Where rainfall declines to 5 inches or less, as it does on much of the range in Utah, Nevada, Arizona and New Mexico, 100 acres of rangeland per animal is usual.

Much of the land in the West is unsuitable for cultivation, giving rise to the cattle industry. Where it is too arid or rugged to grow crops, turning cattle out to graze on whatever grows naturally is considered the best, if not the only, economic use of the land. "Grass is a nice renewable resource," says Mel Coleman, a 63-year-old Saguache, Colorado, rancher, whose family has raised cattle since 1875. Coleman, who is the first in his family to sit at a desk to direct the family's small, successful—and recently, organic—beef business, believes fervently in the relationship between cattle and Western land. "We can't eat grass ourselves," he says, "but we can make meat out of it."

Cattle are walking fermentation tanks. A bovine's rumen—the first chamber in its four-part stomach—produces volatile fatty acids that render the cellulose in plants it eats into beef, the protein Americans have traditionally preferred. On the range, a steer daily consumes about 25 pounds of grass, forbs, shrubs and, when nothing better can be found, even noxious weeds. It takes 20 pounds of forage to produce 1 pound of beef.

While this process is not very efficient, it is one that nonruminating meat animals— chickens and hogs—are incapa-

THE SWEET SMELL OF SUCCESS

Getting a whiff of feedlot beef

At Monfort of Colorado's Feedlot 2323 on the plains east of Greeley, a cowboy on horseback moves cattle to the feed troughs in a treeless pen. The air is acrid with the stench of manure, 400 acres' worth, where thousands of animals mill about with nothing to do but eat.

Suffering from the sensory assault, a second cowboy says, "There's an old joke. It says that if you're making a profit in this business, that's the smell of money to you. And if you're not making money, then it just smells like s—."

For many in the cattle industry, the whiff of money around feedlots is not as powerful as it once was. During the last 15 years, people have increasingly looked askance at the kind of cow feedlots "build," as they say in the business.

The nation's per capita beef consumption has declined from 94 pounds per person a year in 1976, to just over 70 pounds per capita last year, as people cut back on fat and cholesterol in their diets. But concern about the nation's beef lingers, largely because of the industry's heavy reliance on growth hormones and antibiotics in cattle feed.

"A growing body of consumer studies shows that shoppers are increasingly concerned with additives in the food supply, particularly with antibiotic and hormone residues in meat," stated an editorial in the February 1988 issue of the trade journal *Meat & Poultry*. "But the industry has shut its ear," it stated.

The failure of the beef industry to respond to such concerns will soon be especially costly. As of January 1, 1989, the 12-country European Economic Community (EEC) will ban the importation of all U.S. beef products derived from animals that have been implanted with any synthetic sexual hormones used to stimulate growth.

Pellets of both synthetic and natural hormones are buried behind the ear or other inedible portion of the feedlot steer. The hormones promote growth, enabling an animal to grow fatter or leaner, depending on whether female or male hormones are implanted. By aging the cattle more rapidly, hormones also make livestock more docile at the feedlot.

The EEC's hormone ban extends one that was instituted several years ago against the EEC nations' own beef producers. The recent ban will translate into the loss of $150 million annually for U.S. beef producers, according to Jacques Vonthron, the EEC's agricultural attaché in Washington, D.C.

Vonthron says Europeans' fears about the long-term effects on humans of hormonally induced growth in livestock stem from cases in which babies and young children sprouted breasts and developed other secondary sexual characteristics, reportedly triggered by the presence of hormonal residues in meat. Much of the U.S. beef exported to Europe consists of organs, like livers and kidneys, where residues of hormones typically accumulate.

Also, the memory of the beef industry's one-time reliance on diethylstilbestrol (DES), a synthetic hormone once commonly used to stimulate cattle growth, contributes to European wariness of American meat. DES, which can cause cervical cancer in women, was used by beef producers for 29 years before it was withdrawn by the Food and Drug Administration in 1979.

"In the United States, people use a risk-based approach to determine whether or not something is safe to eat," Vonthron says. Standard risk assessment is based on statistical measurements that allow scientists to state with a given level of confidence – but not with absolute certainty – that a particular compound is relatively – but again, not absolutely – safe. "In Europe," he says, "we take the no-risk approach."

Meanwhile, subtherapeutic dosages of antibiotics in U.S. livestock have caused more alarm than hormones have. Among the 35 million cattle slaughtered last year, most of the antibiotics were given in feed to prevent respiratory-related illnesses that fall under the broad rubric of "shipping-fever complex," primarily caused by the transporting of cattle from range or pasture to feedlot.

Antibiotics, such as Auremycin, are automatically administered in dosages too low to fight disease, yet high enough to kill lurking bacteria. Two years ago, a study by the Centers for Disease Control suggested that antibiotics in cattle feed are largely to blame for the growing drug-resistance of even minor infections in people. Today, livestock are given 40 percent of all the antibiotics produced in the United States.

GRANT HEILMAN

Cattle spend their last 130 days at feedlots – fattened on grains, pumped with hormones, inoculated with antibiotics.

Much of the concern about antibiotics remains speculative. "There haven't been any blockbuster discoveries about routinely administered drugs," says Orville Schell, organic-beef farmer and author of *Modern Meat,* which revealed the extent to which drugs are used in the livestock industry. But raising cattle has gotten more complex, he says, and so have the consequences. "One new example is worming agents that are injected right into an animal's system," Schell says. According to research, he says, "The animals need a considerable withdrawal time from them before slaughter; otherwise, when you eat beef, you may end up getting wormed on the side."

The cattle industry, the largest sector in American agriculture, has always prided itself on efficiency. At feedlots around the country, cattle spend the last 130 days of their lives consuming enough corn, diverse grains and hay to pack 300 pounds on an 800-pound yearling steer. Animals eat around the clock, encouraged to continue feeding at night under blazing lights.

"We're basically in a very competitive industry, trying to produce protein as economically as possible," says Dell Allen, director of quality and training for Excel Corporation in Wichita, a subsidiary of Cargill Inc., and one of the three largest beef producers in the country. "As we now raise cattle, it would be too costly not to use antibiotics and growth promotants," he says. "We'd have to keep cattle at the feedlot another 30 days to accomplish what we do now with hormones and antibiotics. The demand for hormone- and antibiotic-free beef has not been great enough for a big company like ours to make that kind of change."

"Cattlemen have just started down the long road of being consumer-driven rather than production-driven," says Steve Kay, editor and publisher of the influential *Cattle Buyers Weekly.* "They are beginning to learn that they are producing for consumers, not for themselves," he says.

Another reason why the cattle industry may be set in its ways is that beef production is concentrated in the hands of three agricultural conglomerates: Omaha-based ConAgra Red Meat Company (which owns Monfort of Colorado), IBP Inc., in Dakota City, Nebraska, and Excel. These three produce about 70 percent of the nation's beef.

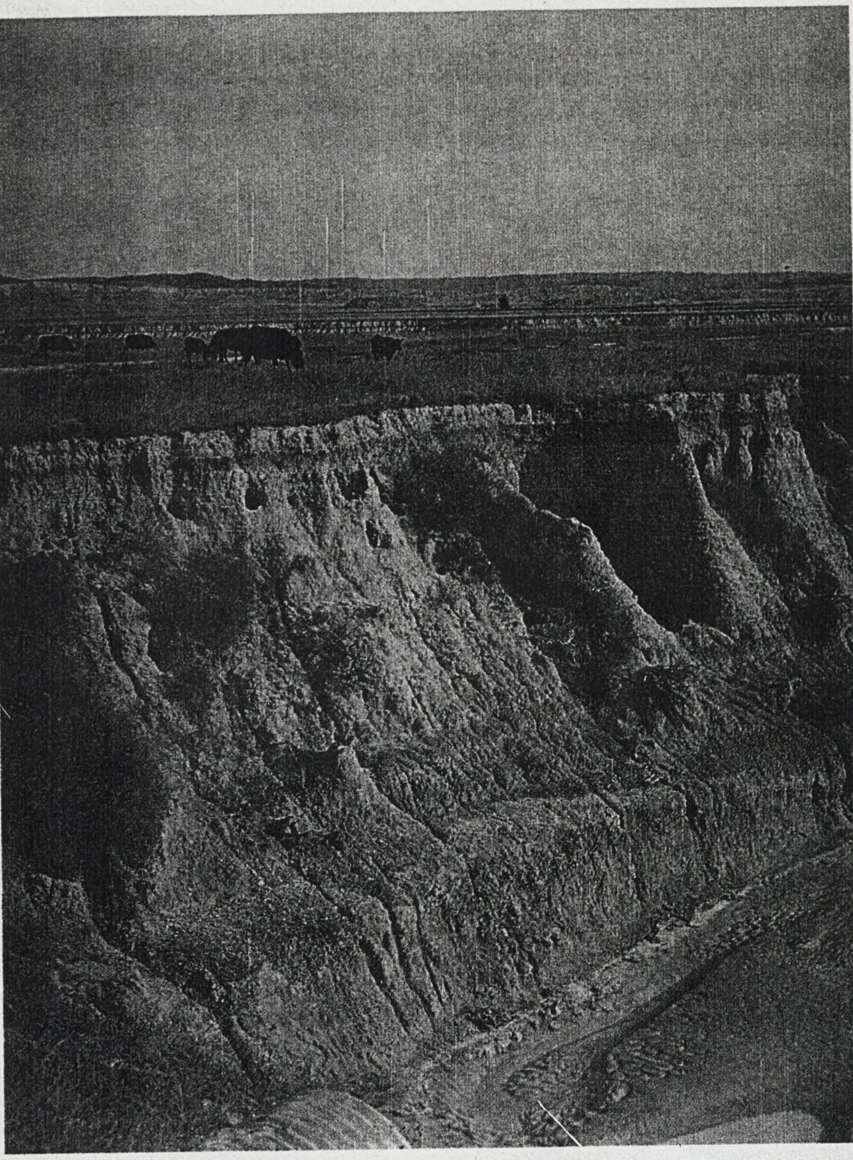
"The beef industry is so big it can't change," says Mel Coleman, who started Coleman Natural Beef in Denver on that assumption. "It's like doing a 90-degree turn with an enormous ship; it can't move that quickly."

Coleman, a Saguache, Colorado, rancher, was scraping by 10 years ago, selling his cattle to traditional feedlots. He had never used drugs and hormones to raise his cattle, and in an attempt to save his ranch, he decided to try marketing the kind of beef his own family ate. Since Coleman cattle are not fed any chemical additives "from conception to consumption," it takes longer to raise them, resulting in higher feed and care costs. Customers pay about 25 percent more for his beef than for conventionally produced beef, he says.

"Opportunity didn't knock very loud at first," Coleman says. Ten years ago, too broke to stay in a hotel room, he slept in a rented car while hunting through Los Angeles for grocery stores that would sell his chemical-free beef. Last year, his company grossed $19 million in sales, and it leads the tiny field of chemical-free beef producers. All told, this portion of the industry accounts for less than 1 percent of the beef sold.

Coleman says that he is regularly accused by conventional cattle producers of destroying the beef business by implying that their meat is unhealthy. "I've got some arrows in my back," he says. The chairman of a large chemical company "is really mad at me, just hates me with a passion," Coleman says. At a major farm forum attended by both beef and chemical-industry executives, Coleman stood up and told them, "Our good chemical companies found all the pesticides and all the chemicals we use. I think the challenge to those companies now is to find chemicals we can live with."

–D.Z.



Overgrazed land deteriorates into widening gullies (arroyos), which are incapable of supporting the life the land once did.

so enormous that one area might not be revisited for years, giving it a chance to recover.

By comparison, cattle are lazy creatures. They do not wander freely, even over the 50 or 100 acres required to feed them. Cowboys on horseback prod them to move, or they are trucked to the next plate of land. Unsupervised cattle will crop the plants nearest them well past satisfying their own nutritional needs and beyond a plant's ability to replenish itself.

Through rotation-and-rest grazing systems, ranchers now commonly model the movement of wild species. But the range is smaller, and after years of misuse, it can support fewer animals, both domestic and wild.

In the last century, the native bunchgrasses have been replaced by plants better suited to drier zones; soil compaction by sharp hooves has made it difficult for native grasses to reseed and has prepared the ground for erosion. An inexorable process of drying up and dying out continues, until plants, soil and water are gone. Arid land readily deteriorates into ever-widening gullies, or arroyos. For example, in the Rio Puerco area between Albuquerque and Santa Fe, grazing over the years has left the ground slashed by arroyos 35 feet deep, 300 feet wide – and worsening. Nothing will close these expanding rifts of desert, and ultimately they will become incapable of supporting any of the life they used to – or any life at all.

Usually, evidence of overgrazing is more subtle than land eroded to cavernous gullies, and it is easy for the untrained eye to miss. But anyone can see that the sea of grass that once flooded the Western basins and grew stirrup-high – the grasses that originally drew livestock interests to the area – has been crowded out by sagebrush, rabbit brush, creosote, halogeton, Russian thistle (tumbleweed) and a complex of other shrubby plants designated by range ecologists as being either "increasers" or "invaders." Increasers are the native species that flourish when conditions are altered; invaders are intrusive newcomers. Both thrive at the expense of perennial grasses, which are the first choice of livestock, and therefore are aptly described as "decreasers." Surly, gray-green sagebrush, which is believed to have once covered no more than 20 percent of the Western landscape, has become the region's dominant plant.

ble of. By the time an 800-pound steer is taken off the range and shipped to a feedlot to be fattened, or "finished," on grains (see "The Sweet Smell of Success," page 42), it will have eaten about 8,500 pounds of forage.

Native wildlife like buffalo, deer, elk and pronghorn have always been a part of the arid grassland ecology, so there is no reason to think that the vegetation cannot tolerate any grazing. A number of plant species benefit from light grazing, just as some cultivated plants do from judicious pruning. But wildlife biologists believe there are significant differences between native and domestic species that account for the deterioration in the West's vegetative cover. Native ungulates, like pronghorn and elk, and a wild ruminant like buffalo are more choosy eaters than cattle and will move on – or starve to death – if they do not find what they need.

When the millions of buffalo had filled up on the grass in one space, they swarmed off to another, leaving the range shorn and saturated with excrement and urine. But they left enough plant life for it to regenerate, and their habitat was

Not all the damage can be blamed on past ignorance. Today, anyone who scans the ranges cannot help but notice the barbed-wire fence lines that often sharply demarcate where overgrazing presently occurs.

"I have never known a person who, once being shown a dramatic fence line, does not become an advocate for range improvement," observes Johanna Wald, an attorney specializing in public land issues for the Natural Resources Defense

Council in San Francisco for the last 20 years. In many places, improvement begins when the land is given a rest. That means reducing the time livestock spend on the land or removing the animals altogether.

Range scientists and federal land managers maintain that the public range is in the best condition it has been in for 100 years. Overgrazing was most severe between the 1880s and 1935. The public domain was free for all to use and lay outside the bounds of federal regulation, creating a situation the biologist Garrett Hardin has labeled "the tragedy of the commons." The land was intended to be homesteaded by the freehold yeoman farmers who embodied the Jeffersonian ideal; but without the water such a vision was based upon, cultivation was destined to fail.

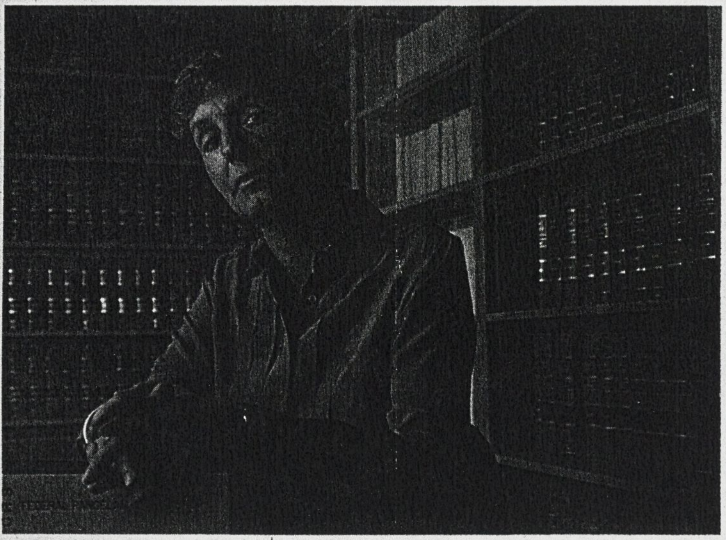
Cattle from the Texas beef boom poured into the unappropriated ranges, and herds about four times greater than today's devoured the land, turning it into one of the nation's worst dust bowls.

The Taylor Grazing Act brought some relief back in the 1930s. It regulated the number of livestock on the BLM range and required ranchers to pay 5 cents per AUM. (Ranchers who ran their cattle within the national forests had been regulated and charged a 5-cent AUM since the forest system was established in 1905.)

But the BLM was—and is still—known derisively as the Bureau of Livestock Management because livestock interests have traditionally carried the agency around in a hip pocket. The agency has not required reductions in stock on the range. Its focus on keeping the cattle industry prospering has meant that deer or pronghorn were not considered in the placement of barbed-wire fences, which are a leading cause of wildlife injury and death. Favoring the cattle industry meant that ravaged ground was reseeded monoculturally at tremendous public expense. Some introduced grasses, like crested wheat, tend to die out after a few years, leaving the land open to invasion by undesirable plants. Herbicides like 2,4-D were applied not for the sake of flora and fauna, but to stop the invasion, precipitated by grazing cattle, of unpalatable scrubby brush.

The passage of the Federal Land Management Policy Act in 1976 broadened the BLM's mandate by requiring it to consider matters besides cows. Wildlife, water quality and recreation, all the underpinnings of the West's expanding tourist economy, demanded immediate attention. But the BLM, and the Forest Service, for that matter, are still behind in their work of improving public ranges. Looking at the ranges, Johanna Wald says she wonders "what people have been doing for the last 40 years. They haven't yet come to grips with misuse."

"Looking at the ranges, I wonder what people have been doing for the last 40 years."



DOUG MENUEZ

Attorney Johanna Wald, who specializes in public land issues for the Natural Resources Defense Council, believes that the current grazing fees are too low.

For both political and budgetary reasons, the agencies have been incapable of restoring the thousands of miles of streamsides that need help. The range staff has been cut deeply during the Reagan years; in Colorado, the number of people out in the field has been reduced from 54 to 38; the annual budget for range management has been pared by $1.3 million from $3.6 million in 1981. These reductions are ironic, considering that the presence and expertise of federal range managers were cited eight years ago as a prime reason why the United States would never have to worry about desertification.

"BLM is not managing the permittees; permittees are managing BLM," GAO investigators stated in their report last June. In one instance cited in the GAO report, a BLM range manager asked a rancher to stop cutting trees along the riparian zone. Because of the rancher's political connections, word of the confrontation reached the range manager's boss, who told the range manager: "Apologize to the permittee and deliver the wood to his ranch." Elsewhere, in a case not included in the federal report, a range manager pleaded with a local environmentalist, "Give us some bad publicity," because only pressure from without would force a change within.

Jim Mower, a staff officer for range and wildlife on the Wasatch-Cache National Forest in Utah, returned from a disheartening week of surveying ranges last September. After the dry summer, some riparian areas looked like "stockyards," he said. The national forest plan states that after cattle have grazed, enough forage must be left to meet the needs of wildlife. But last year, because of drought and overstocking, some allotments were in no condition to support wild creatures. "We have allotments that need an 80 percent reduction in cattle," Mower says. "But we're told to ease up on the ranchers, since they're also facing a drought."

While the drought raises fears of wildfire, Mower is more cynical about that possibility. He says many ranges he inspected at the end of last summer "are so overgrazed, there isn't enough fuel on the ground to start a fire."

In many respects, the challenge to traditional grazing practices grows out of the struggle between the West's old way of life, dominated by ranchers, and the new West, populated by those who migrated in large part so they could have the serenity and beauty of the public lands in their backyard. The

Despite problems from overgrazing, cattle ranching remains central to the culture and economy of the West.

shift in demographics is palpable. "Within nearly every rural Western community there was this newly arrived, squirmy body of newcomers," wrote Ed Marston, the publisher of the *High Country News*, an environmentally oriented biweekly that covers the Rocky Mountain region. These newcomers were "incredulous both at how much was right within the community and on the public land around it, and at how much needed improving."

Malechek, from Utah State, says, "The ranges are not worse than they were 20 years ago. It's just that there is more competition for the use of these zones from recreation. The same damage is being seen by more people."

Campsites are overrun by cattle during the night, and lakes and streams are bordered by slicks of cow manure. The Tonto National Forest outside Phoenix has grown into the most heavily used recreational forest in the country, a situation that has convinced area ranchers to get out of the cattle business. In Colorado, several large ranches attached to national forest allotments have been bought by expanding ski resorts in the last few years.

The economic and political base of the West has begun to shift from the inconsistently profitable livestock business to the lucrative activities stemming from recreation and tourism. Now that states are basing their sales pitches on wildness and purity, it is hard to be nostalgic about cowboys when the degradation by cattle is right before your eyes. The problem is even more difficult to tolerate, grazing critics say, when it is supported by taxpayers' money.

"It is hard to be nostalgic about cowboys when the degradation by cattle is right before your eyes."

The $1.54 per AUM charged for a federal grazing permit is about one-fourth the cost of an AUM on leased private land. The grazing fee is determined by a Congressional formula that fluctuates about 20 cents a year. These fees cover only between 30 and 37 percent of the federal agencies' cost of maintaining the land for cattle. The shortfall of about $30 million a year subsidizes a handful of permittees, made up of both family ranches and large corporations like Unocal and Texaco.

"The current fees do not produce proper stewardship," says Wald of the Natural Resources Defense Council. "By being set so low, the fees are denying the agencies the ability to do their job better, if not right. The agencies remain vulnerable to more cuts, since they are not capable of covering their fees, and the low fees encourage people to continue grazing on public land, even if they are doing it improperly."

The latest reason why fees have remained artificially low is a February 1986 executive order signed by Ronald Reagan at the behest of Western senators, which simply stipulated that fees should not be raised. The executive order overrode the findings of a massive rangeland audit completed that year, which showed that the difference in value of public and private grazing allotments was only about 75 cents, even though private allotments on average cost some $4 more per AUM.

Ranchers struggle to keep their federal AUM low because "it's the only cost they can control," says Terry Crawford, head economist for the USDA's Livestock Research Section. "A cowboy can't do a darn thing about the price of pickups coming out of Detroit. He doesn't vote on that," Crawford says. "But do you hear him grumbling that the 5 percent increase in price will put him under? At least when it comes to the grazing fee, he can call his senator and do something about it."

The National Cattlemen's Association submits that ranchers are not subsidized; the association argues that the current AUM may even be too high, given the ranchers' additional costs of fencing, putting in water holes and providing any other amenities cattle require. Ranchers argue that they are helping wildlife at personal expense by bringing water to the range, a point environmentalists counter by saying that, in nature's unimproved state, animals have always found a place to drink without help, and that the new watering holes are insufficient replacements for silted-in streams.

Another aspect of the permit system that bothers critics is that, traditionally, the value of a federal grazing allotment is added to the value of private land when a rancher sells or leases his ranch to someone else. This practice puts the allotments in a murky place between public and private ownership. It verges on turning a grazing privilege into a grazing right, Crawford says. He calculated that of the ranches sold in 1982, the average grazing permit added $68 per AUM to the price a ranch fetched. In effect, ranchers with federal grazing permits sold public land for private gain.

Theoretically, a rancher is not supposed to transfer a federal grazing permit without prior approval, nor may he profit from the transaction, but in practice, transfers are routinely honored by the agencies. The main reason grazing allotments are "sold" at many times their original price is that the leases are far more secure than those for private land. Federal allotments are so secure, in fact, that ranchers use them as collateral on bank loans.

If subsidies on Western *land* are an issue, they are probably nowhere near as vexing a matter as subsidies for Western *water*. Irrigation, much of it made available through federally financed water projects over the last 80 years, is essential to grow alfalfa and other winter feed for cattle. Cultivation of crops for cattle accounts for more than 70 percent of the water used in the West, while metropoli-

LARSH BRISTOL

Duane Davis / FPG International

Grazing by domestic livestock has diminished or destroyed more Western land than all other human uses combined.

tan areas such as Phoenix, Los Angeles or Denver use less than 10 percent of the region's water. The Bureau of Reclamation sells that irrigation water for as little as a quarter-cent per ton, although its cost may be more than 100 times greater.

"Never in history," writes Philip L. Fradkin in *A River No More*, "has so much money been spent, so many waterworks constructed, so many political battles fought, so many lawsuits filed to succor a rather sluggish four-legged beast."

Assessing the importance of public land in the overall livestock picture is somewhat like looking in a funhouse's distorting mirror; from one angle something looks small, and from another, it appears large. In Idaho, where 88 percent of the cattle are fed at least part of the time on public land, the beef industry would die if grazing on federal range were ever halted. But the state's contribution to the 99 million head of beef cattle in the nation is a mere ½ of 1 percent.

Historian William Prescott Webb recognized in the 1930s that there are actually two cattle countries in the United States. "The East," he wrote, "did a large business on a small scale; the West did a small business magnificently." People are often surprised to learn that more than 80 percent of the nation's beef cattle come from outside the West, on privately owned pastures and ranges. (Seventeen percent of the West's beef is also raised on privately owned land only.) Florida, the ninth-ranking beef-producing state in the nation, raises 1.1 million head of cattle, compared to Wyoming's 630,000. Kentucky, number 10, by itself raises more cattle than New Mexico, Arizona and Utah combined.

Texas is the nation's largest beef cattle producer, and is the only state that fills the boots of legend and fact. But in Texas, which is as much a southern state as it is a western one, cattle are almost entirely raised on private land.

Conflicts over grazing in the West are characterized by the same kind of emotion that touches all the country's agricultural policies. Everyone wants the family farm to survive, and nostalgia looms especially large in the West, where cowboys have always held the greatest fascination for pot-bound Americans. Working a spread that runs from here to the horizon comports with the classic American image of freedom and rugged individualism.

Such myths, according to Johanna Wald at the NRDC, have become embedded in public policy. "People can't believe that all those clouds of dust raised by cattle are environmentally destructive in an arid place," she says, "so they support anything having to do with ranching."

Now the question is: "But at what cost to the land?"

Dyan Zaslowsky wrote "Hired Gun," about U.S. Forest Service logging practices, in the January/February 1988 issue of HARROWSMITH.

PLAN

PUBLIC LANDS ACTION NETWORK

Volume 1, No. 1 Summer 1990

At Last! National Group to Combat Overgrazing in the West!

Over fifty environmentalists, hunters, fishers, ranchers, and farmers from across the U.S. gathered in Albuquerque, NM on April 27-29 to discuss public lands ranching, and to formalize a national Public Lands Action Network (PLAN). Our goals are to provide a central source of information and support to local activists working on public lands ranching issues; to systematically address the impacts of public lands ranching; and to define policies for protection and restoration of native ecosystems on our public lands.

Jim Fish, who founded PLAN as an informal network two years ago, called the meeting "a powerful success." He continued, "It was the first time so many of us working on reform of public lands ranching have come together." Tony Povilitis of the Humane Society of the United States stated, "Western public lands are the last chance for wildlife, in the broadest sense of the word. There is no other place where providing habitat for native plants and animals can be given top priority." On the need for restoring lost habitat, Steve Johnson of Tucson-based Native Ecosystems said, "The widespread destruction of riparian areas is a 'smoking gun' for threatened and endangered vertebrates, 80 percent of which depend on these areas."

Johanna Wald, a Natural Resources Defense Council attorney who has scored a number of BLM land management reform victories, said "Current laws give land management agencies too much discretion. You have to watch them like a hawk." Rose Strickland, vice chair of the Sierra Club Public Lands Committee, agreed, adding, "if the intent of the various environmental and public land laws were rigorously enforced, 75% of public lands ranching would be shut down."

Lynn Jacobs of Free Our Public Lands! raised the economic issue: "We Americans unknowingly shell out about $2 billion annually to support public land welfare ranching when all of the negative impacts are considered. Furthermore, even though these 30,000 livestock operators contribute less than 3% of the nation's beef, they have a political and social stranglehold on the West."

(see PLAN Meeting, page 2)

photo by Bob Sears

Fenceline contrast near Reserve, NM: a common sight on Western public lands.

How to Affect BLM Grazing Policy: A Do-It-Yourself Guide

Arch Canyon is as fine an example of Southern Utah canyon country as one could find. With spectacular red rock walls, soaring sandstone pinnacles, and impressive arches, this canyon is yet another national treasure tucked away in the Bureau of Land Management's empire.

(see Guide, page 3)

PLAN Research Program: A Call for References

Tony Povilitis of the Humane Society of the U.S. will help develop a PLAN bibliography on public land ranching. At the Albuquerque workshop, this effort was split into three phases: 1) a list of key references; 2) an annotated bibliography; and 3) a series of "white papers." Topics and contacts for phase 1:

1. Impacts on Wildlife (threatened and endangered, predators, etc.): Yvonne Chauvin, 3621 7th St. NW, Albuquerque, NM 87107.
2. Impacts on Ecosystems (vegetation, soils, water, etc.): Rosemary Lowe, 104 La Placita Circle, Santa Fe, NM 87501.
3. Economic Considerations (livestock vs. wildlife, tourism, etc.): Johanna Wald, NRDC, 90 New Montgomery #620, San Francisco, CA 94105.
4. Legal and Administrative: Linda Wells, PO Box 47116, Phoenix, AZ 85068.
5. Human Health and Global Impacts: Kelly Cranston, 5855 Abington Lane, Tucson, AZ 85743.

To participate in this program: Send a list of key references in each subject area to the respective contact. Please do not list every reference you have; just pick about five of the most useful ones for each area. We can add to the list later, but for now we want to have something basic out quickly. If you have the references, also send a copy for PLAN's files. Anyone providing references will receive a copy of the finished bibliography.

PLAN Meeting *(cont. from p. 1)*

The workshop attendees agreed that there is a crying need for a centralized clearinghouse for public land ranching information. People working in the field need information on legal and administrative aspects of the issue, as well as solid and accessible ecological information. We need rapid assistance when the media calls, and must be able to contact the various experts on these issues. We must have frequent updates on what's happening where; why it matters; and how it can be applied to our situations. We need a forum for discussing approaches to public lands reform.

Representation at the meeting included individuals from the Sierra Club, Natural Resources Defense Council, The Wilderness Society, The Humane Society of the United States, National Wildlife Federation, Sierra Club Legal Defense Fund, Earth First!, Lighthawk, Prescott National Forest Friends, The Imprinting Foundation, Free Our Public Lands!, Audubon Society, New Mexico Wilderness Coalition, Mexican Wolf Coalition, Southern Utah Wilderness Alliance, New Mexico Wildlife Legislative Council, LAW fund, Friends of the Gila River, Bisbee Women's Group, and the New Mexico Environmental Law Center, among others!

PLAN: Supporting Public Land Ranching Activists

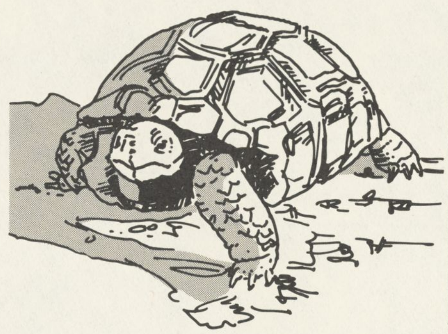
The PLAN newsletter is published quarterly on the solstices and equinoxes by the Public Lands Action Network, POB 5631, Santa Fe, NM 87502, (505) 984-1428. It covers timely happenings affecting public land ranching, and efforts to reform public land management, with an emphasis on action.

This publication's success depends on you. Submissions from you are vital, and should be typed or carefully printed, double spaced, and sent with a SASE if return is requested. Art, photography (black and white prints preferred), and poetry are great. Please include photo credits and explicit permission to reprint. The deadline for each issue is one month before the pertinent solstice or equinox.

-- Ron Mitchell, Katherine Bueler, and Jim Fish

Tortoise on the Brink

Place a desert tortoise on a table top: it will saunter along, explore the boundaries of the artificial confine, but unlike some others of its reptilian family, will stop short of going over the edge. But threats to its environment may send it literally over the edge in spite of its instincts. As an animal supremely adapted to its environment, a desert tortoise can survive on a mere 23 pounds of plants per year. But these must be plants that meet the tortoise's needs. The selective munching of a 1000-pound cow, which consumes about 1000 pounds of plants per month, often seriously competes with the tortoise menu.



The tortoise is no delicate newcomer dependent on tiny, specialized habitat. More than most creatures, it is a survivor, a master of life in slow motion and avoidance of the desert's harshness. The fact that a creature of such modest needs is in trouble over its entire habitat has profound implications for other forms of desert life with far greater demands. The desert tortoise may be a slow messenger, but it brings a message that must be heeded.

-- from Steve Johnson's writings

A Discouraging Herd

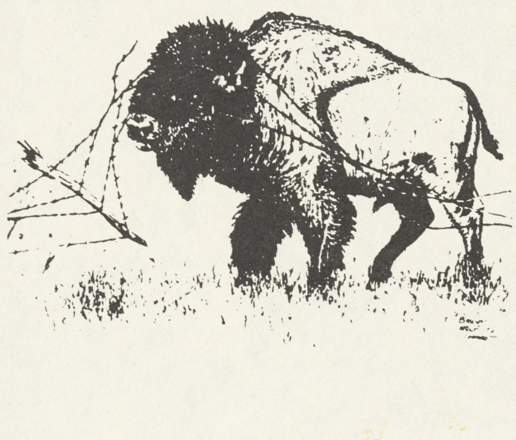
What has four legs and doesn't belong here? What turns singing high-country streams into silent mud bogs? What reduces green Arizona hillsides to brown earth and dust? What wipes out entire species if they get in its way?

Hint: It goes moo.

Grazing has rendered the land unihabitable. Arizona's quail aren't significantly affected by hunting, but their numbers are greatly affected by two factors. One is rainfall. The other goes moo.

What would we do without our Western cattle? We'd prosper.

Every cow evicted from our public lands would free up enough forage to support several elk, deer or antelope. The outlook for wild turkey would immediately turn brighter. Trees would return to riparian areas. Cattle-fouled streams might actually become drinkable. It's a long list. The single best thing that could be done for our Western lands, far and away, would be to get the cattle off.



In what other business could a few people hold much of the continent hostage to a destructive industry with a trivial output? If any other tenants did to our property what the cattle growers have done, they'd be booted out in a flash.

All the same, our nostalgia for the Old West makes us long for a happy medium. But trying to fit European cattle into arid North American ecosystems is like putting a size 12 foot into a size 8 shoe.

If a rancher wants to trash his own land, that's his business. But arguing about how many cattle should be allowed on our public lands is like arguing about how many termites we should allow in our houses. Ranchers should be given enough time to conquer, without undue stress, their addiction to using our public lands. After that, the cattle should go.

-- Donald M. Peters
(reprinted from the The Arizona Republic)

Do-It-Yourself Guide

(cont. from p. 1)

Joe Feller, an Arizona State University law professor, visited Arch Canyon only to find a "battlefield" of vegetation chopped off to the roots, soil pulverized and a devastated riparian area in the lower canyon. Instead of shrapnel, this battle field was littered with piles of manure.

This article, based on Feller's attempts to influence the grazing future of Arch Canyon, summarizes his recommendations for citizen participation in the BLM.

-- Editor

The BLM's regulations provide for public participation in the management of individual grazing allotments. Such participation may help to curb some of the worst abuses and to bring about some improvements in areas that are of particular concern because of their special value for scenery, recreation, wildlife habitat, etc.

Become an Affected Interest

If you are concerned about the impact of livestock grazing on a particular area of BLM land, write to the local BLM district manager or resource area manager and ask to be designated an "affected interest" with respect to the grazing allotment (or allotments) that includes that area. (If you don't know which district manager or resource area manager to write, write the state director.)

In your letter, explain why you are affected by livestock grazing in the particular area; for example, because you hike, camp, hunt, fish, or observe. It is also helpful if you can explain exactly how it is that the grazing affects your use or enjoyment of the area; for example, by dirtying the streams, by marring the scenery, by destroying wildlife habitat, etc. Make your letter as specific to the particular area as you can. Finally, state that you qualify as an "affected interest" under **43 CFR S 4100.0-5**, which is the regulation that defines "affected interest." Keep a copy of your letter and of any related correspondence.

How it Works

Once you are designated an "affected interest," the BLM must consult with you whenever it formulates or amends an allotment management plan, and whenever it makes an adjustment in the number of livestock on the allotment.

The BLM must also give you notice and an opportunity to protest whenever it issues or renews a grazing permit or license for the allotment.

The latter requirement is very important. Although BLM grazing permits are often issued for a term of 10 years, on some allotments the BLM issues a new permit each year or each season.

On many allotments, the BLM issues annual or seasonal grazing licenses even though a 10-year permit is in effect; an annual or seasonal license may authorize a different number of livestock than does the 10-year permit, such as which portions of the allotment are to be grazed and which rested, the exact dates of use for each pasture, etc.

In either case, an annual or seasonal license may determine whether, and how heavily, your area of interest is grazed each year. As an "affected interest," you have a right to be heard on such issues.

What if BLM Ignores You?

You may find that the BLM denies your request to be designated an "affected interest," or that, after granting your request, the BLM makes decisions about the allotment without consulting you.

If so, the BLM may have violated the law. The Natural Resources Defense Council is monitoring the BLM's implementation of its grazing regulations and would like to know when the agency denies affected citizens their right to participate in grazing management.

If your request to be designated an "affected interest" is denied, or if the BLM does not give you the opportunity to participate fully in its plans and decisions, send a copy of your correspondence with the BLM and any other relevant documents to: Johanna Wald, Director, Public Lands Program, Natural Resources Defense Council, 90 Montgomery St., San Francisco, CA 94105.

-- Joseph Feller
(reprinted from High Country News, 3/12/90)

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Useful Quotes

"Public lands ranching has long been a political octopus, its tentacles reaching into every policy-making body that might control exploitation of the land--state governments, Congress, and federal agencies...In fact, public lands ranchers are only a fraction--about one out of twelve--of all western ranchers."
-- John R. Luoma, "Discouraging Words," Audubon, 9/86.

"We'll pay to reseed this in crested wheatgrass because the ranchers love it. We'll pay for the seed. Then we'll get to pay for the Malathion to kill the grasshoppers. Then we'll get to pay in lost wildlife habitat and soil erosion and degraded riparian areas and polluted water. They'll pay $1.35 a month per cow, less money than the average person spends feeding a cat for a week."
-- Rose Strickland, quoted by Jon R. Louma in "Discouraging Words."

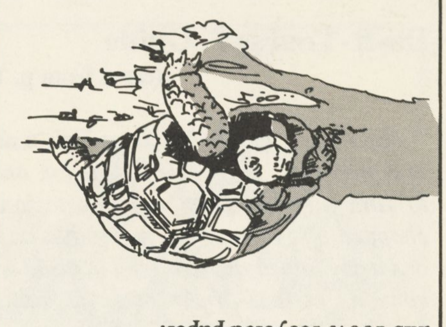
"Overall, there appears to be tacit resignation to the loss of climax species and little consideration for restoring them to anything like pristine numbers. The expressed concern is for keeping reasonable populations of disturbance species, primarily deer."
-- Denzel Ferguson, "Cowed by Welfare Ranching," Ambit, 3/86.

"We have let cattle displace at least 90% of native ungulates in the West. If the loggers wanted to replace 90% of the trees in the West with even-aged European pines, would we let that happen too?"
-- George Wuerthner.

"Amount of water used in production of the average cow: sufficient to float a destroyer. Gallons to produce a pound of wheat: 25."
-- John Robbins, Diet for a New America.

PLAN
A Publication of Public Lands Action Network

Thanks to all who helped with this first issue of the PLAN newsletter: to those who responded to the passed hat in Albuquerque; to the production artist, illustrator and printer who generously donated their services; to Lighthawk and Wilderness Exchange for the use of offices and computers; and to Rich Ryan of Think Like A Mountain for donating this 100% recycled paper.



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[1999]

blessed with what passes for modernity.

Paul Micou
United States Committee for the United Nations Population Fund
New York, N.Y.

Max Singer replies:

Sharon Stein says that increased fertility associated with the U.S. postwar Baby Boom contradicts my statement that in not one country did fertility stop falling when it hit the replacement rate. As I reported, a temporary upturn in U.S. fertility occurred more than a generation ago, after which the 200-year downward trend resumed, with fertility staying below replacement for twenty-five years. But that doesn't contradict the experience in some fifty countries that the replacement rate is not a barrier to falling fertility. Overall experience strongly indicates that unless values change, overall world fertility will go below replacement level in the first part of the twenty-first century and stay below long enough to produce many years of world population decline. My estimates are based on an attempt to impose as few assumptions as possible on the interpretation of the past. Lower or higher estimates would also be reasonable. We cannot get away from uncertainty.

I agree with Paul Micou that programs encouraging contraception should not be stopped even though world population will begin declining in 2050.

Tabloid Law

Alex Beam writes in "Tabloid Law" (August *Atlantic*), "The same First Amendment invoked by Williams & Connolly to allow *The Washington Post* to publish the Pentagon Papers grants the tabloids enormous leeway in examining celebrities' lives."

Williams & Connolly were not involved with the *Post*'s publication of the Pentagon Papers, because the firm was not representing the *Post* at that time. Ben Bradlee did consult Ed Williams as a personal friend, as described in Katherine Graham's *Personal History*. The *Post* was ably represented by William R. Glendon, of Royall Koegel and Wells.

Shirley R. Newhall
Londonderry, Vt.

Alex Beam replies:

Shirley Newhall is right that Williams & Connolly did not formally represent *The Washington Post* in the Pentagon Papers case. But I believe that most participants (my source was Evan Thomas's biography of Edward Bennett Williams) agree that it was Williams's informal advice to Bradlee that prompted the paper to push ahead with publication.

Grazing Problems

I was very interested to read Perri Knize's article on ranching ("Winning the War for the West," July *Atlantic*). Like Knize, I am a native New Yorker and a journalist who transplanted herself to the West, in my case more than fifteen years ago. In fact, one of Knize's sources, a New Mexico environmentalist whom I knew slightly, asked me to call Knize while she was working on the piece, because he thought we had a few things in common. I realized partway into the phone call, and later confirmed, that his real reason for asking me to call her was his fear that she wasn't doing her homework. That was my impression too.

Knize writes that "many scientists who study what happens to land where cattle graze admit that no definitive case can be made."

Sorry, that's just wrong. A recent paper by A. J. Belsky, published in the *Journal of Soil and Water Conservation*, took a comprehensive view of the peer-reviewed literature on grazing's effect on riparian habitat. Belsky's conclusion was this: "An extensive literature search did not locate peer-reviewed empirical papers reporting a positive impact of cattle on riparian areas when those areas were compared to ungrazed controls." Belsky reports that some papers showed no effects of grazing, but "the authors of these papers usually explained this absence of statistically significant impacts as being due to stochastic or design problems associated with their research."

Belsky, who grew up in Abilene, Texas, but spent most of her career working on National Science Foundation grants in East Africa, says she bent over backward to find papers that showed positive effects of grazing. There were none. What she did find was that the environmental effects of grazing can be reduced with improved management but not eliminated.

Robert Ohmart, of the Center for Environmental Studies at Arizona State University, published a similar literature review in 1996, in a book called *Rangeland Wildlife*, published by the Society of Range Management, a group certainly not known for its anti-ranching tendencies.

Ohmart's paper was narrower in scope, looking only at wildlife and fish, but inevitably it, too, focused on riparian habitat; 60 to 70 percent of Western bird species and perhaps 80 percent of wildlife species in Arizona, New Mexico, and southeastern Oregon are dependent on riparian habitats. Yet Ohmart's paper showed that in Arizona, at least, only two or three percent of the cottonwood-willow riparian association remains. That's 10,000 to 11,000 acres out of 260,000 acres of floodplain in the state of Arizona, which comprises 73 million acres of land. The effects on wildlife are about what you'd expect.

It's true that huge numbers of livestock and cataclysmic drought followed by severe rain damaged streams in the late 1800s. But according to Ohmart, these streams have been prevented from recovering by continued widespread grazing. Ohmart says that's why most of the cottonwoods you see along southwestern streams are old and decadent. Cattle have eaten so many young cottonwood and willow shoots over the past century that Ohmart predicts a crash in biodiversity in thirty to fifty years, when the last of the mature cottonwoods die out. And for Knize to say that all—or even most—ranchers use "ecosystem management" is plainly absurd.

Susan Zakin
Tucson, Ariz.

As a wildlife biologist who has worked on the public lands of the West, I found your recent article by Perri Knize to be full of errors and misrepresentations.

Knize glosses over the multiple impacts that livestock production has upon wildlife, and fails to note that both independent and government studies have identified livestock production as responsible for more endangered species in the West than any other human activity (such as logging, mining, and building subdivisions).

Though Knize continually asserts that "wildlife" benefits from livestock production, she usually fails to identify the species. And in the few instances when she does name specific animals, she refers mostly to elk, deer, and geese—all highly adaptable and relatively common animals that tend to flourish on human disturbance. Both deer and geese, in fact, thrive even in urban environments—which few biologists would identify as good wildlife habitat.

What Knize does not point out is that dozens of species, many of which were formerly widely distributed, are now on the verge of extinction or significantly reduced in numbers, largely as a consequence of livestock-induced habitat degradation, disease transmission from livestock, or persecution by ranchers. These include black-tailed prairie dogs, black-footed ferrets, sage grouse, bighorn sheep, wolves, grizzly bears, swift foxes, desert tortoises, Southwestern willow flycatchers, Bonneville cutthroat trout, and many others.

Mollie Matteson
Livingston, Mont.

Perri Knize did a great disservice to the hundreds of range, grassland, wildlife, and fisheries scientists who have spent their careers studying and publishing on the environmental effects of livestock grazing in the West. She is guilty of the same "half-truths, skewed facts, and outright fallacies" of which she accuses others. Let's look at the scientific evidence.

Although the federal range may, as she says, be "in better condition than it has been in more than a century," it had no direction to go but up. Decades of uncontrolled grazing prior to the Taylor Grazing Act of 1934 converted hundreds of millions of acres in the West into denuded, eroding moonscapes. These rangelands have improved somewhat since the 1930s not because of better grazing practices but because of significant reductions in cattle and sheep grazing. This proves that any form of livestock management is better than none. It doesn't show that grazing is beneficial to grasslands and shrublands, or that it does not harm the environment.

Knize also wrote that cattle grazing improves wildlife habitat, because elk, deer, and antelope prefer the more succulent shoots that grow after plants are grazed by cattle. She ignores data showing that elk actively avoid areas grazed by cattle, that these plants are not adapted to heavy grazing and are damaged by multiple defoliations, and that the regrowth may be only 10 percent of the amount of the forage originally available to wildlife. She also fails to mention that elk, deer, and other wildlife managed just fine before cattle were introduced.

It is true that pronghorn have been declining at the Hart Mountain National Antelope Refuge, in Oregon, where cattle were removed in the early 1990s, but the trend is similar among pronghorn throughout the West, from New Mexico to Canada. Pronghorn experts speculate that the recent decline is due to adverse climatic conditions and to the degradation of sagebrush communities by a hundred years of livestock grazing.

Knize's conclusion that "modern livestock grazing has comparatively little environmental impact" is strongly and convincingly refuted by even the most cursory review of the scientific literature.

A. Joy Belsky
Oregon Natural Desert Association
Portland, Oreg.

Perri Knize replies:

I never stated that all or even most ranchers practice ecosystem management. But more ranchers are interested in it and practicing it all the time. The point is that livestock grazing can coexist harmoniously with native species, and many of the changes ranchers need to make are not difficult or expensive, just creative.

Yes, riparian areas have been badly damaged, but our understanding of the importance of riparian areas is relatively recent, and they easily and quickly recover with good management. Solid programs are now in place to reverse the damage, and they have been very successful. Nowhere have I been able to find a study that says riparian areas are in the worst condition in history. The scientists I asked about it find this statement highly improbable, especially in light of the dramatic drop in livestock numbers over the past fifty years and the vast improvements in management over the same period. These scientists believe that grazed uplands are in the best condition they have been in since the beginning of the century.

Susan Zakin, as a journalist, should take better care to check her sources. Some of the scientists whose work A. Joy Belsky cites in her *Journal of Soil and Water Conservation* paper disagree with her and say their work was taken out of context for the purpose of supporting what they consider to be a highly biased and unwarranted conclusion. Even the premise of Belsky's study is dubious: she compares grazed land with ungrazed land, something that is rare—if not nonexistent—in the United States.

I have in hand many, many peer-reviewed research papers that find not only that cattle and wildlife are compatible but that well-managed grazing is beneficial to many kinds of wildlife. For example, mountain plovers require highly disturbed land, which can be created by livestock grazing. Sage-grouse numbers were higher a generation ago, when there were more cattle grazing in the birds' sagebrush-steppe habitat than there are today. Studies show that prairie dogs, bighorn sheep, sandhill cranes, and many other species benefit from well-managed livestock grazing. Raptors and other predators also benefit, because reduced cover makes it easier for them to find their prey.

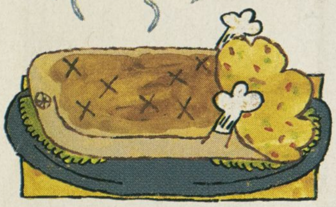
As for Mollie Matteson's assertion that livestock are the single greatest threat to endangered species, a research paper published in volume 45, No. 7 of *Bioscience*, "Taxpayer-Subsidized Resource Extraction Harms Species," by Losos, Hayes, et al., states that livestock grazing is the third greatest threat to listed species—after water development and human recreation.

Belsky, who has written the tracts on which the anti-grazing activists most rely, has called her own scientific credibility into doubt with her absurd assertions that elk avoid cattle, that range plants are not adapted to heavy grazing, and that regrowth is dramatically less than the forage that was "originally" there. An abundance of data show that elk prefer cattle pasture. In fact, some wildlife-management areas use cattle to prepare pasture for elk. Anyone who lives in Montana or Wyoming has seen elk herds grazing in the same pasture with cattle. The elk population is exploding, and most of those animals winter on private ranchlands. That is why all western states have programs to assist ranchers in keeping their lands open to hunters.

Range plants are absolutely adapted to multiple defoliations. Before white settlement the range was heavily grazed and trampled by 10 to 60 million bison; in some parts of the West the prairie was ground into dust, and the first trappers' horses starved for lack of grass. The wallows of these bison still pockmark the landscape today.

As to the welfare of elk and deer before white settlement, we know that the Shoshone Indians were starving in Idaho when Lewis and Clark arrived because of a lack of wild game—probably owing to a population crash, part of the natural cycle. We have more of these game animals right now than at any time since European settlement of the West began. In fact, one of the most degraded riparian areas in the country is the Lamar River Valley, in Yellowstone National Park, where elk—not cattle—have eaten almost all the willows in the riparian areas. There never has been any magic "balance of nature." Nature is a place of extremes; species proliferate and then diminish. What is natural is a boom-and-bust cycle.

THE NOVEMBER ALMANAC

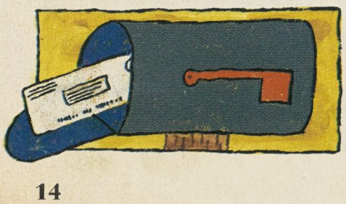


Food

Turkey sales peak this month; so do sales of vegetarian alternatives, such as tofu and wheat-based "turkeys." It is estimated that more than 170,000 meatless turkeys will be consumed on Thanksgiving. The market for such items has recently soared: one manufacturer, for example, has seen sales double each year since 1992. The rise is due in part to the growing popularity of soy products, increasingly prized for their health value, and in part to sentiment (many who shun meat are nostalgic nonetheless for traditional holiday foods). Producers have come up with a number of tactics to make these products resemble real turkeys. One brand is molded into the shape of a bird; another has a covering that turns dark and crispy when baked, like turkey skin; yet another has a tofu-jerky wishbone inside.

Demographics

November starts the busy season for college applications. Admissions officers may still be recovering from last season, which saw the highest volume in the nation's history. The peak resulted from the number of high school seniors, members of the so-called Baby Boomlet (it is estimated that 2.8 million graduated this year, close to the record 3.2 million in 1977), coupled with the high proportion who set out to attend college (67 percent today, as compared with 50 percent in 1977). In recent years the process has been heating up earlier than usual, partly because of the growing popularity of early-action options, especially at top-rated schools: for example, in 1998 Harvard University accepted nearly half of its incoming class by early action. The Internet has also increased applications activity: students have begun adding multimedia components to their applications, electronic services have reduced the cost and work of applying to several schools at once, and some colleges let students confirm the receipt of their applications online. However, one rite remains sacred: acceptance and rejection letters still arrive by regular mail.



Arts & Letters

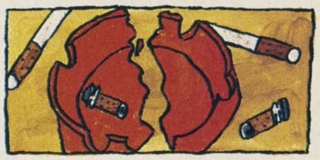
The American artist Norman Rockwell—long scorned by critics as sentimental and a mere "illustrator," and omitted from many art-history texts—gains an important measure of respectability in the art world this month with the opening of the most comprehensive exhibit ever of his work. "Norman Rockwell: Pictures for the American People" starts a nationwide tour at the High Museum of Art, in Atlanta, on November 6; it will travel to Chicago; Washington, D.C.; San Diego; Phoenix; Stockbridge, Massachusetts; and New York City. The exhibit contains more than 70 oil paintings and all 322 of Rockwell's covers for *The Saturday Evening Post*. It pairs the nostalgic pictures for which Rockwell is famous with lesser-known works relating to complex social developments—for example, the civil-rights movement—and also contains sketches and other items that document his meticulous methods. Its catalogue will include critical essays about Rockwell—the first time such a collection has been published.

Government

November **1**: As of today the four major networks and their affiliates must begin high-definition digital broadcasting in the nation's top 30 television markets. This is the second phase of a Federal Communications Commission mandate that will eliminate traditional, analog broadcasting by 2007. (The first phase, implemented in May, required the addition of digital formats in the top 10 TV markets.) The switch not only is big business—high-definition TVs typically cost between $4,000 and $10,000—but also has medical implications. Last year about a dozen heart monitors at Baylor University Medical Center malfunctioned when a Dallas TV station tested the high-definition technology over the same broadcasting band used by the hospital (no patients were harmed). During the transition years, when stations will be broadcasting in both formats, there will be fewer frequencies available to hospitals—which bear the responsibility for steering clear.

The Skies

November **6**: Saturn reaches opposition—it is on the other side of Earth from the Sun—and is at its brightest in more than 20 years. **13**: The crescent Moon hangs just above Mars in the southwest at dusk. **17–18**: The Leonid meteor shower peaks tonight. Though notoriously unpredictable, the shower may bear watching this year: many believe that this might be the last chance in several decades for a spectacular display. **23**: Full Moon, also known this month as the Frosty or Beaver Moon or the Moon When the Bucks Lose Their Horns.



Health & Safety

November **18**: The Great American Smokeout, on which day the American Cancer Society urges smokers to refrain. They may do so at some peril: British researchers who reviewed 10 years' worth of statistics found a rise in workplace accidents on Britain's No Smoking Day (the second Wednesday in March). They attributed the accidents to deficits in concentration and coordination from nicotine withdrawal, and recommended that abstainers take other forms of nicotine on such days.

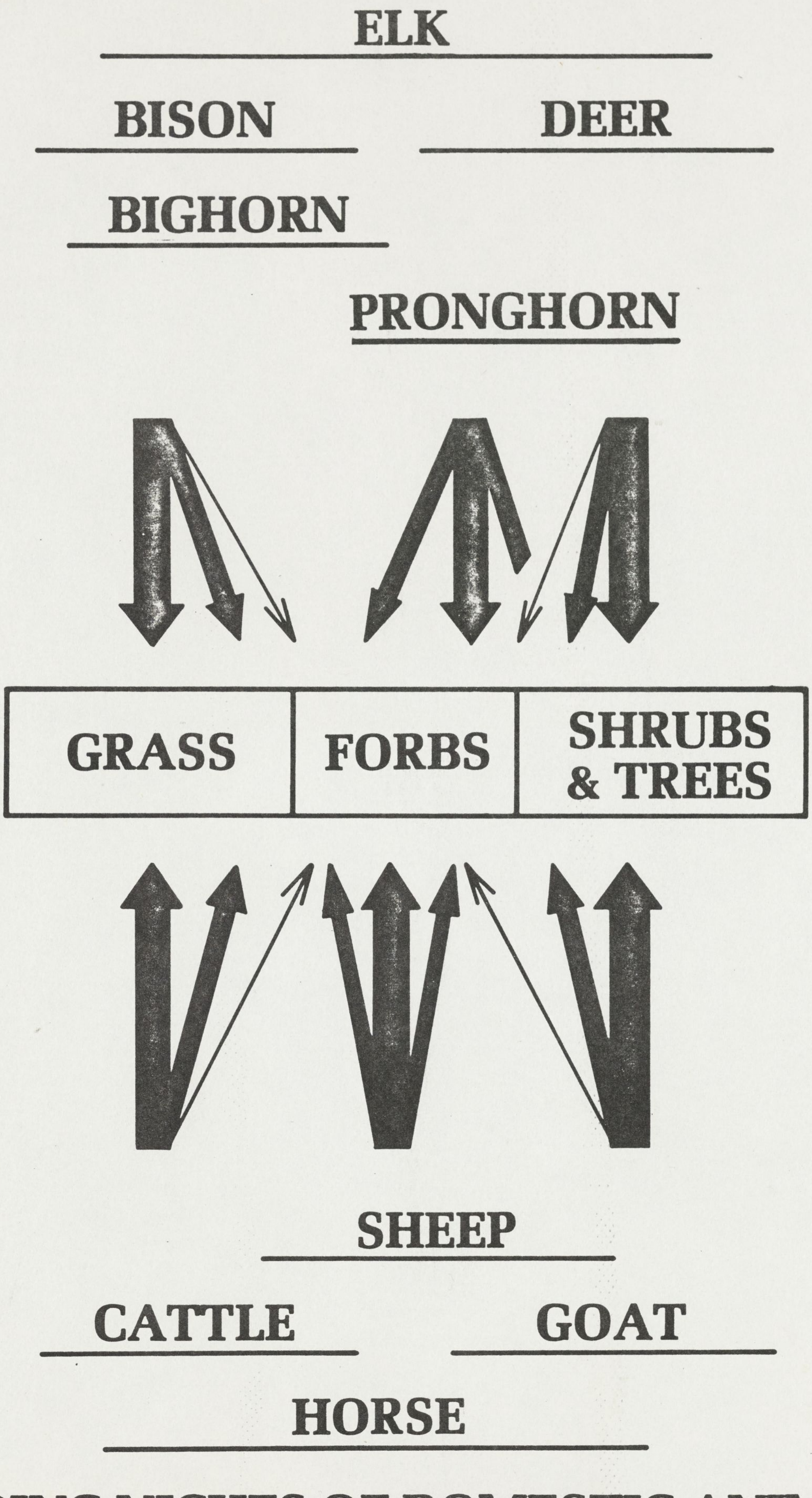
50 Years Ago

Bertrand Russell, writing in the November, 1949, issue of *The Atlantic Monthly*: "The savage . . . lived a life in which his initiative was not too much hampered by the community. The things that he wanted to do, usually hunting and war, were also the things that his neighbors wanted to do, and if he felt an inclination to become a medicine man he only had to ingratiate himself with some individual already eminent in that profession. . . . The modern man lives a very different life. If he sings in the street he will be thought to be drunk, and if he dances a policeman will reprove him for impeding the traffic. His working day, unless he is exceptionally fortunate, is occupied in a completely monotonous manner. . . . When his work is over, he cannot, like Milton's Shepherd, 'tell his tale under the hawthorn in the dale,' because there is often no dale anywhere near where he lives, or, if there is, it is full of tins."

Illustrations by Esther Watson

Date Unknown

FEEDING NICHES OF WILD UNGULATES



FEEDING NICHES OF DOMESTIC ANIMALS

R. B.

EFFECTS OF LIVESTOCK GRAZING AND THE LIVESTOCK INDUSTRY ON WILDLIFE

by Frederic H. Wagner
College of Natural Resources
Utah State University
Logan, Utah

INTRODUCTION

In recent years, wildlife biologists, like other ecologists, have been increasingly adopting a systems perspective. Wildlife resources exist as interrelated parts of ecological systems. More often than not, the influences which affect wildlife populations do so indirectly by affecting other parts of the system with which they interact. Increasing (or reducing) numbers of a particular species must take into account the forces operating on the system, and reduce (or increase) their influence. The major human uses of the land -- agriculture, forestry, grazing, urbanization -- have sweeping impacts on the character of the landscape. In the case of game species, no amount of protection from hunting will produce abundance in the face of these changes if they are detrimental.

Some wildlife biologists will suggest that this is no new perspective, that we have long known that suitable habitat is a sine qua non of wildlife abundance. This is of course true. What is new, however, is the emerging perspective we are beginning to adopt in confronting land-use decisions. We are increasingly viewing a given piece of land as a resource system having the potential for producing an array of goods and services. More often than not, production of any one resource competes with the others. Hence, there is an array of choices as to the mix of goods and services, the production of which will be the management goal set forth for a given land area. The decision on a goal or particular mix within the spectrum, is a societal one which must weigh all the interests and values of society, and recognize the desires of the majority, yet somehow make provision for the minorities. The responsibility of the resource scientist is to predict and make explicit the spectrum of mixes so that decisions can be made with a knowledge of all the alternatives, and the consequences and trade-offs inherent in a decision for any given mix.

For these reasons, I have attempted to make this chapter an analytical one without advocating any course of action or recommending for decision any mix within the spectrum. The wildlife biologist is in the best position to analyze and know the consequences of human action on wildlife resources. But his values and desires are only one set in the complex of societal values, and there is no particular reason why they should take precedence over other societal values and desires, as long as society is aware of the consequences of its choices.

At the same time, there are numerous advocate groups for wildlife in our society today, and hence wildlife values are not likely to go unconsidered. The most valuable function the wildlife scientist can contribute in this day and time is to provide objective analysis, or a reliable body of information on which decisions can be made. In a complex society, with numerous vocal interest groups, such information which all groups will acknowledge as trustworthy, is a vital need. If the scientist adopts a strong advocate's posture, he runs the risk of subconsciously biasing his own analysis; and of damaging his credibility in the eyes of the interest groups, whether in fact he has been objective or not.

This review then, is an attempt at analyzing the various effects of the livestock industry on wildlife resources. I will make a crude attempt at defining the limits of the array of livestock and wildlife mixes, and a few reference points within the array.

The subject is a complex one and needs to be limited to some degree. Consequently I have directed attention to the 11 western coterminous states. These states comprise somewhere between a third and half the area of the coterminous 48, and are the major region for the range livestock industry. Other livestock effects on wildlife -- the dairy industry in the Midwest and East, beef-cattle rearing in the South, and the feed-lot business in the Midwest -- are simply not considered.

The emphasis here is also on game species and particularly on big-game mammals. This is in part a reflection of the research data base available for review; in part a function of where the public interests currently lie; in part a function of the obvious, strong relationships between domestic and wild ungulates; and in part a function of the breadth of the subject and the need to limit.

MODES OF EFFECT

Direct Interspecific Competition for Annually Produced Forage

The ecologist classifies the interactions between pairs of species in an ecosystem according to a spectrum of effects. These may range from negative or deleterious to one or both species, through neutral influences, to positive or favorable effects. The interactions between livestock and wild animals constitute several of these effects, depending on the kinds and numbers of livestock and wild-animal species involved, and depending on the time scale.

The first and most obvious interaction is that of interspecific competition. This is generally defined as the interaction in which two species require the same resource. If, in obtaining it, the two species inhibit each other's growth and/or population increase below what they would be without each other's presence, interspecific competition occurs.

The important requisite here is the population effect. Two species can use a common resource and not necessarily compete. Only where it is used to the point of being in short supply, and the populations are affected as a result, does competition occur. For these reasons, it is not always possible to infer competition when two species co-exist. The critical proof can only be obtained when one species is manipulated and the other responds. Hence, the discussion which follows must be considered in the context of this reservation.

Herbivorous animal species, whether domestic or wild, are specialized to some degree in their dietary needs or their feeding niches. They differ in the structure and physiology of their gastro-intestinal systems, in the microorganisms which inhabit those systems, in their abilities to break down or tolerate the protective chemical compounds which plants synthesize in their tissues to discourage herbivores, and in other ways. Consequently, each animal species feeds on only a portion of the total vegetation spectrum available to it.

Accordingly, each large herbivorous species comes to be known as a grazer (if it feeds primarily on grass and forbs) or a browser (if it feeds primarily on woody vegetation). Some species have narrow feeding niches, specializing largely on grass, or forbs, or browse. Some have broader niches, feeding to some degree on two or more of these major life forms of vegetation.

I have depicted schematically the feeding niches of several important wild ungulate species and the major domestic herbivores in Fig. 1. This is a highly generalized representation and should not be taken as precise or without exception. The actual feeding patterns of animals are complex, varying with the geographic location and vegetation in which they occur, with the time of year, and with the plant subspecies involved. Thus cattle are characteristically known as grazers, but will take some browse. Deer are generally stereotyped as browsers, but this is most true in winter, with substantial amounts of forbs taken in summer and some grass during the early growing season. Elk, considered to be substantially browsers in the central Intermountain region but more inclined to graze farther north, are everywhere considered to be among the most broad-spectrum feeders. The Rocky Mountain subspecies of bighorn sheep is mostly a grazer, but the desert subspecies is substantially a browser.

Hence the scheme in Fig. 1 is considerably generalized, and should be taken most literally as a comparative scheme for animals feeding on the same vegetation. Competition is most likely to occur when two species with essentially similar feeding niches occur in the same ecosystem. That likelihood is shown by the size and dark shading of arrows in Fig. 1, a heavy dark

Figure 1. Diagrammatic representation of the feeding niches of wild and domestic ungulates, and the potential degree of competition between them represented by the strength of the arrows.

arrow indicating the potential for direct competition. Where they occur together, cattle are potential direct competitors of bison and bighorn, and only slightly less directly of elk. Domestic sheep may be substantial competitors of pronghorn, and to a lesser degree of bighorn, elk, and deer in the same system. Goats, which occur in significant numbers only in Texas, are direct competitors with deer. The horse, with its broad feeding spectrum, is a potential competitor with nearly all the wild ungulates with which it coexists.

Feeding niches of wild ungulates may be narrower and more inflexible than those of their domestic counterparts. While this has not been thoroughly explored for North American wild mammals, several studies in East Africa show that the two dozen or so grazing animals which coexist in the savannahs of that region have well-defined and subtly different niches (cf. Talbot and Talbot, 1963). Each may feed on different plant species, or if two use the same species, different plant parts will be eaten or the plant will be fed upon at different stages of growth. These patterns appear to be rather rigidly fixed. Livestock, on the other hand, through centuries of selective breeding appear capable of shifting diets to a greater degree without as much detrimental effect on their nutrition. Consequently, as vegetation composition is altered through grazing, wild species may be affected detrimentally by slight or subtle changes while the range may still be in quite favorable condition for domestic animals.

Competition is least likely to occur between two coexisting species with very different feeding niches, as with cattle and deer, and goats and bison. This low probability of competition is depicted schematically in Fig. 1 by the slender arrows. However, when a species overutilizes its preferred food plants and reduces the abundance of these, it is forced to feed on less preferred plant species. Thus two herbivorous species which would not compete materially in a healthy, diverse vegetation would tend to converge in their feeding patterns in a degraded vegetation, and would be driven to competition.

The question next arises as to the extent to which competition actually exists. Several instances have been rather strongly inferred. Morgan (1971) concluded that the high level of disease and parasitism, low reproductive rates, and declining numbers of bighorns in the Salmon River region of Idaho were due to malnutrition arising largely from heavy forage utilization by cattle on the sheep's winter range. Russo (1956) and Gallizioli (1976) discuss a number of examples in which bighorns do not occur in areas occupied by cattle in Arizona, and in which competition apparently occurs.

Beale and Smith (1970) found pronghorn food preferences in the Great Basin deserts of western Utah to be similar to those of sheep during the winter grazing season. The suggestion of sheep-pronghorn forage competition recurs a number of times in the pronghorn literature (cf. Quinn, 1930; Griffith, 1962).

One particular form of competition which has concerned wildlife biologists for some time is that of feral burro effects on desert bighorn (cf. Russo, 1956; St. John, 1965). Burros have wide feeding niches and increase on poor ranges, all the while eating rare forage plants preferred by sheep. They may also foul scarce water holes.

Most recently, concern has risen over the rapid increase in wild horses in the West. Horses are among the most broad-spectrum feeders, while at the same time having a large forage demand because of their size. They are potential competitors of virtually all wild ungulates. In Nevada, the 30,000 wild horses estimated for this state have a greater forage demand than the estimated 81,000 mule deer.

Gorsuch (1934) concluded that livestock grazing removed food plants important for Gambel's quail in Arizona. Gallizioli (1976) reported the same effect on Mearn's quail in the same state.

Competitive effects are not confined to food competition. If one animal eats vegetation needed by another for cover, the detrimental effect on the latter is just as real as food shortage. Gallizioli (1976) has reported that wild turkeys in Arizona are less successful in producing poults in grazed areas, apparently because of reduced nesting cover. Jones (1976) voiced the same concern for Mearn's quail. Wallmo (1956) reported detrimental effects on scaled quail cover by grazing removal in west Texas. Busack and Bury (1974) observed reductions in lizard populations on a southern California area subjected to heavy grazing and off-road vehicle use, apparently due to vegetation reduction.

Competition may be behavioral and, in a sense, for psychological space rather than for the food or cover resource. One ungulate species may be intolerant of the presence of another, whether domestic or wild, and simply move out of an area when the other enters. It is usually difficult, in such cases, to know whether the competition has been for food or space. Mackie (1970) reported that Montana elk vacate areas occupied by large numbers of cattle, while Jeffery (1963) observed a similar pattern in northern Utah.

A perspective on competition, different from the above anecdotal observations, may be gained by considering the numbers of domestic animals using the ranges of the 11 western states. The excellent records of the U.S. Department of Agriculture's Statistical Reporting Service provide estimates of livestock numbers for 7 of the 11 states back to the 1860's, and for all of the 11 back to the 1920's.

Sheep were the first class of livestock to reach high numbers, totaling around 40 million animals (including lambs) in the West in the 1920-1940 period. If the trend in the 7 states with records is representative of the total, this level was reached by 1890-1900. This number is double the number I shall present later of wild ungulates inhabiting the region in pre-Columbian times. In addition, there were some 15-million cattle (including calves) in the 1920's. Many of these grazed on the range only part of the year, others were fed in feed lots or small farm pastures year-round, but some obviously grazed the western rangelands.

In total, there may have been twice the grazing pressure from domestic animals on the ranges between 1890 and 1940 as that exerted by wild ungulates in presettlement times. The abundant literature reporting declines in range condition during this period attests to the fact that western ranges were fully stocked and the annual forage used to, or beyond, the allowable limit. In all probability, there was no margin left on which wildlife populations equivalent to those of primeval times could have been sustained. Big-game numbers were low at that time, substantially because of overshooting. But no unoccupied niche existed. In a figurative sense one could say that domestic animals, in fully utilizing the primary production of the western ranges, were outcompeting wild animals in the region.

Today, at least on public lands, grazing pressure is markedly reduced below the 1920-1940 period. But competition of unknown extent still exists, as the examples cited above attest.

Indirect Biotic Effects Through Altering the Ecosystem

The above discussion has mostly considered competitive interactions for forage produced each growing season in unchanging vegetation. Competition, by definition, is an interaction in which the effects on the participating species are negative. Consequently, the effects depicted in Fig. 1 range from direct, highly negative ones in the case of species with similar requirements, to nearly neutral effects in the case of the species connected with slender lines which have very different feeding patterns and do not compete appreciably.

However, the interactions between herbivores using the same vegetation are more complex than direct competitive interactions alone. These more complex effects lie in the influence of herbivorous animals on vegetation structure, in their ability to change that structure, and in the effects of such changes on the other herbivores in the ecosystem.

Plant ecologists have long recognized that the plant species in a plant community exist in a matrix of biotic interactions, particularly competitive (Fig. 2). They may compete for light, space, water, and nutrients. The composition of the community at any point in time is substantially a function of the outcome of that competition; the community may be undergoing change or be static in some form of equilibrium.

Any influence -- weather, disease, or fire -- which has a more harmful effect on some plant species than on others will place those most affected at a competitive disadvantage in the community. As a result, the less affected plant species will tend to increase at the expense of the more affected ones, and the plant community composition will change in ways that it would not otherwise.

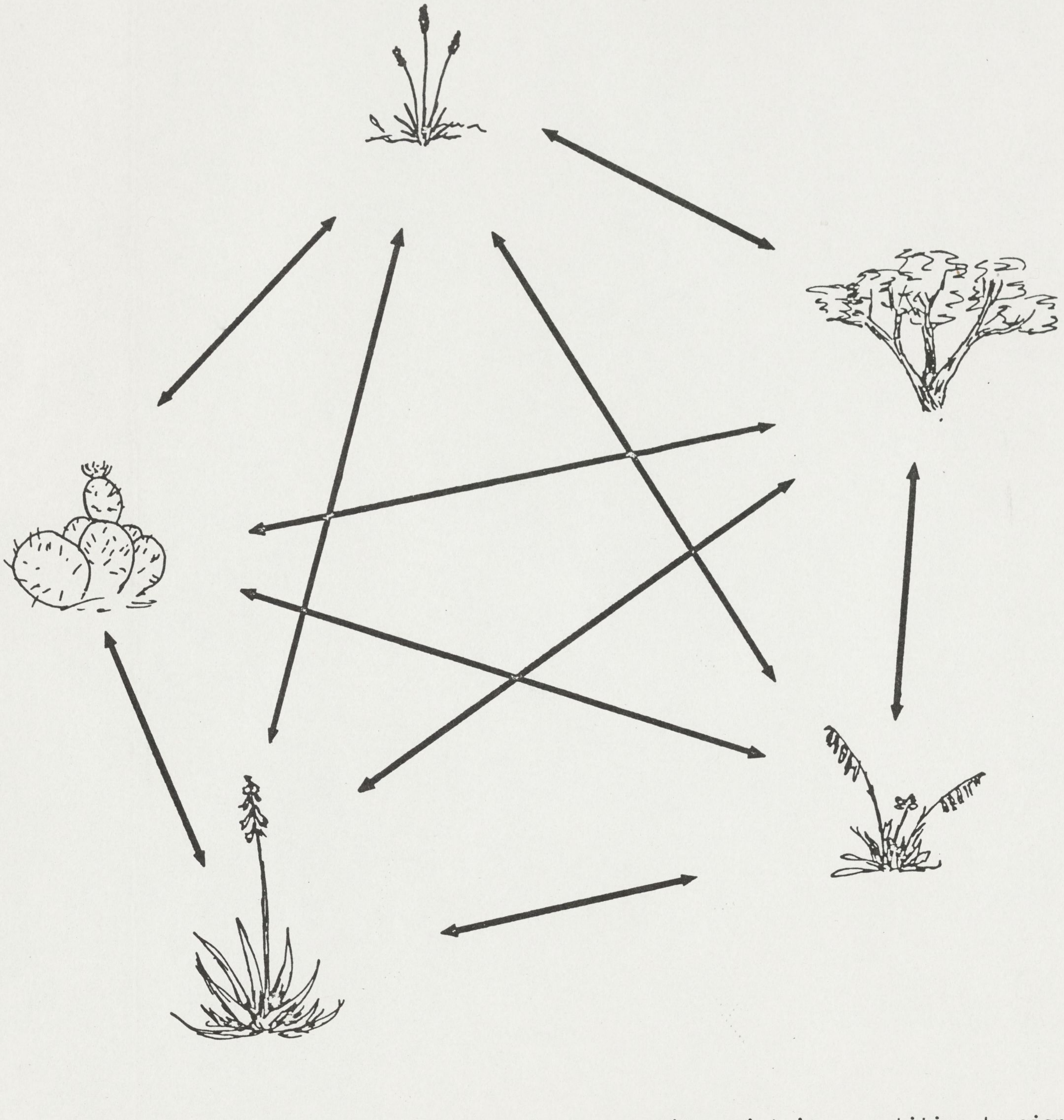


Figure 2. The species of plants in a community exist in competitive tension for water, light, space, and nutrients. The composition of the community at any point in time is importantly determined by this competition. (After Wagner, 1976a).

Feeding by herbivorous animals, whether wild or domestic, is a particularly effective influence in this regard. Since each herbivore is specialized to some degree in its feeding preferences, it will tend to suppress the growth of those plant species which it prefers. The most subtle effects are the suppression of a few highly palatable species from a vegetation not markedly changed to casual view. Thus Leopold et al. (1947) and other authors have described the disappearance of a few, highly palatable browse species from an otherwise unchanged forest vegetation when deer populations increase. Intermediate effects are those in which the species composition of the vegetation may be markedly changed but the general life form of the vegetation is unaltered, as with changes in the species composition but not the form of shrub deserts. The most dramatic effects are those in which the major life form of the vegetation is changed, as when grassland is converted to shrubby vegetation. At the extreme, the soil-holding capacity of the vegetation is impaired and soil is lost to wind and water erosion.

For herbivorous species with closely similar feeding niches, these changes constitute a form of competition. Where cattle graze on grasses and convert a vegetation to shrubland, they reduce the carrying capacity for their wild, grazing analogs such as bison and bighorn. Hence the dark arrows in Fig. 1 represent not only the direct competition for annually produced forage, but also the competitive effect of vegetation alteration.

This is probably the more profound effect on some wildlife species than direct competition for annual forage production. If a decision were made to favor certain wildlife species in a land-use plan, it could be accomplished simply by reducing the number of livestock in those cases where direct competition alone is the constraint. But in those cases where vegetation has been drastically altered, no wildlife response could be expected until long-term vegetation recovery.

Numerous examples have been demonstrated, or are postulated over the West. Morgan (1971) concluded that grassland range for bighorn sheep in central Idaho had been reduced by sagebrush invasion, and that cattle were competing for the remnants of bunchgrass. Paradoxically, the shrub increase had promoted increases in mule deer which were now competing with sheep for that portion of the sheep diet made up of browse. There is a widespread view among wildlife specialists in the West that these kinds of changes were significant influences in exterminating bighorns from much of their former range, and placing them in an endangered status in the remnant areas still occupied.

In the semi-arid plains and valleys of the Intermountain region, the steppe-like vegetation has apparently undergone changes in species composition (Holmgren and Hutchings, 1972). That change has favored species less palatable and nutritious to sheep as well as to pronghorn (Buechner, 1961) and sage grouse (Rasmussen and Griner, 1938; Schneegas, 1967). The latter two species now exist in remnants of their pre-Columbian numbers, particularly in the northern Intermountain region. The conversion of desert grassland in the Southwest to desert shrub type has indefinitely eliminated the pronghorn from much of its previous range.

Consideration here has so far been directed to the better-chronicled game species. But equally profound changes have undoubtedly occurred in other components of the fauna. Buttery and Shields (1975) have discussed grazing effects on songbird populations.

One concern which is coincidentally arising in a number of quarters is that for riparian ecosystems. Stocking rates on public lands are often set in terms of the allowable, animal unit months (AUM's) on a grazing unit, and the appropriate number of animals introduced into that unit according to its total area. But cattle do not distribute themselves evenly over all terrain, tending to prefer moderate topography and ready access to water. A stream bottom is especially attractive to them, and tends to acquire AUM's far in excess of what it should. The result is heavy grazing on stream-bottom vegetation, overuse on stream-bank plants, and erosion and trampling of stream banks into the streams. Jones (n.d.) expressed particular concern for the loss of riparian trees and shrubs in New Mexico which provide habitat for a unique and rich bird fauna. A. S. Leopold (1974) in California and Michael Gaufin (Personal Communication) in Utah have both voiced concern for the deterioration of stream conditions and the loss of trout stock.

An important implication of the indirect competitive effect through vegetation alteration is that a range degraded for a given class of livestock is also likely to be degraded for its wild analogs. This is the case with the Great Basin sheep and pronghorn described above. Or, stated positively, a range in good condition for certain domestic species must also be in good condition for their wild analogs. As an example, the federal agencies have for some years been reducing stocking rates on the public lands of the West in the interests of improving range conditions. In Figs. 3 and 4 I have summarized livestock numbers on the western national forests, and the U.S. Bureau of Land Management lands in the 11 western states. These show rather marked reductions over the past 30-40 years. There is a widespread view that mountain ranges in particular have improved in the Intermountain West in terms of grass and forb vegetation. Smith (1949) and Wagner (1969) discussed the reversion of brushy, foothill ranges to the original bunchgrass type.

A number of responses have been observed or inferred in some wildlife species. Wayne Sandfort (Personal Communication) told me of elk population increases in Colorado, apparently in response to range improvement. Michael Gaufin (Personal Communication) suspects similar elk responses in Utah. Patterson (1952) reported that once livestock numbers were reduced from the excessive stocking levels around the turn of the century in Wyoming, sage-grouse populations increased in that state.

The greater complexity of the vegetation alteration effects lies in the fact that they involve not only the negative, indirect competitive influences of domestic species on wild analogs, but also <u>positive</u> influences between noncompetitors. If an herbivore changes vegetation from one form to another, it has produced an environment for an entire fauna adapted to the new conditions. Cattle and sheep may convert grassy vegetation to a shrub type which is optimum for a different fauna adapted to that vegetation form. These positive effects are depicted with the slender arrows in Fig. 1.

The classical example of this in western game species has been the effects of livestock grazing on deer range. Wildlife biologists generally agree that deer were scarce over much of the western United States at the time of European settlement. Following growth of the livestock industry in the last century, grasslands were invaded by brushy species and deer food was produced thereby. In most of the West, deer populations increased in the first half of this century to levels that were probably unprecedented.

By the same token, moderate grazing is thought to encourage the growth of forbs which supply food for several southwestern quail species. A. S. Leopold (1977) reported that some livestock grazing is desirable to maintain habitat for California quail in humid areas of the Bay State that would otherwise grow up to dense chaparral or forest.

A number of southwestern authors (e.g. Norris, 1950; Wood, 1969) have described increases in rodent and lagomorph numbers coincident with the conversion of desert grassland to desert shrub type. The desert vegetation produces high densities of annual forbs, the seeds of which supply rodent food. The high small-mammal populations may now be a major deterrent to recovery of the climax grasses (Wagner, 1976).

An important implication of these positive, symbiotic effects is that, in the case of two noncompetitors, range degradation for one may be range improvement for another. And conversely, range improvement for one may be detrimental to another. The suspicion exists in a number of quarters in the West that the same range improvement (from the standpoint of livestock and possibly elk) achieved by reducing livestock numbers on public lands may have worked to the detriment of deer, and be involved in the region-wide decline of mule deer populations. In a particularly lucid account, Salwasser (1976) described the sequence of events affecting the Devil's Garden Interstate mule deer herd in California and Oregon. Original increases in the herd followed logging, fires, and heavy grazing around the turn of the century. But reduction in logging and grazing, and fire protection have prevented the regrowth of browse plants needed to replace the dying, senescent plants produced by the first cycle of disturbance. The result was a lower nutritional plain for the animals, declining fawn survival, and a failing herd. Longhurst et al. (1976) have postulated this same pattern for California deer herds in general.

Indirect Effects from Human Action

Up to this point we have been considering the biotic interactions between livestock and wildlife, whether direct through competition, or in indirect ways which involve other components of the ecosystem. There are other effects of the livestock industry on wildlife populations which result primarily from actions taken by people in behalf of livestock. Some of these effects are inadvertent or indirect, but others involve decisions directly affecting some wildlife species. I shall discuss three of these before attempting to place the overall effects of the industry on wildlife into some sort of perspective.

(1) Range improvement programs. As vegetation has been changed over the past century by livestock grazing, those changes have acted to the detriment of livestock much as they have to their wild, competitive analogs. Pinyon-juniper forests have invaded grass-covered foothills of western mountain ranges. Sagebrush and shadscale have replaced grass, forbs, and more desirable shrubs in the Great Basin valleys and plains. Creosote-bush desert has replaced grassland in the Southwest. The result has been reduced carrying capacity for livestock as well as for wildlife.

As concern for the condition of the western range developed in this century, consideration has been given to rehabilitating ranges which had changed from the earlier, more productive state. An ecosystem can rehabilitate itself through natural processes if freed of disturbance. And to this end, the public agencies have been reducing livestock numbers on the national forests and National Resource lands (Figs. 3 and 4).

But the recovery process may be slow, particularly in arid and semi-arid lands where the sequence may require a century or more (Wagner, 1976a). Consequently, a number of techniques have been adopted to rehabilitate rangelands artificially. These include mechanical, fire, and herbicidal removal of woody species. Areas thus treated may then be left to natural grass regrowth; or in cases where grasses and other desirable species are too few to reproduce themselves, grasses and desirable shrub species may be seeded artificially

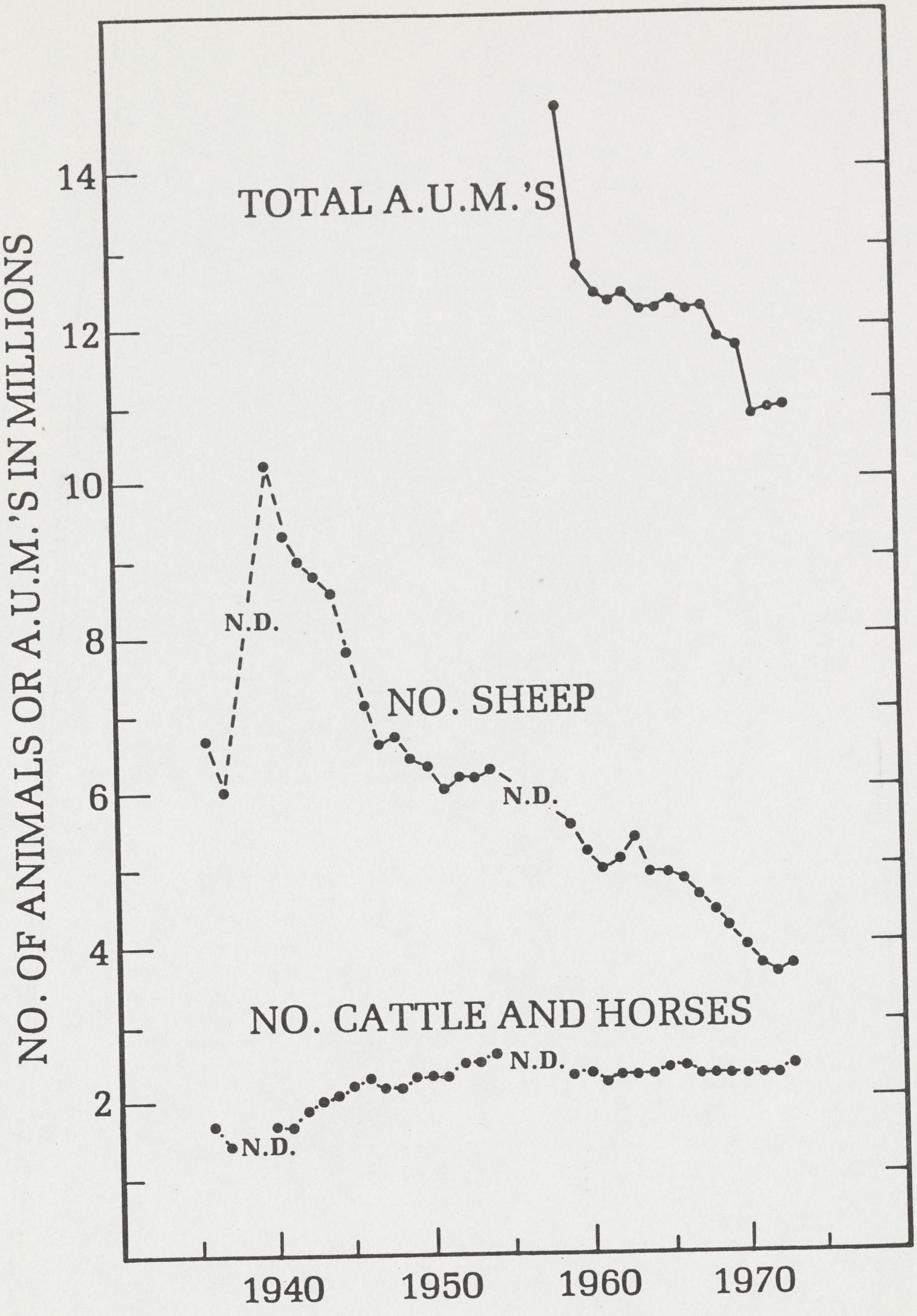
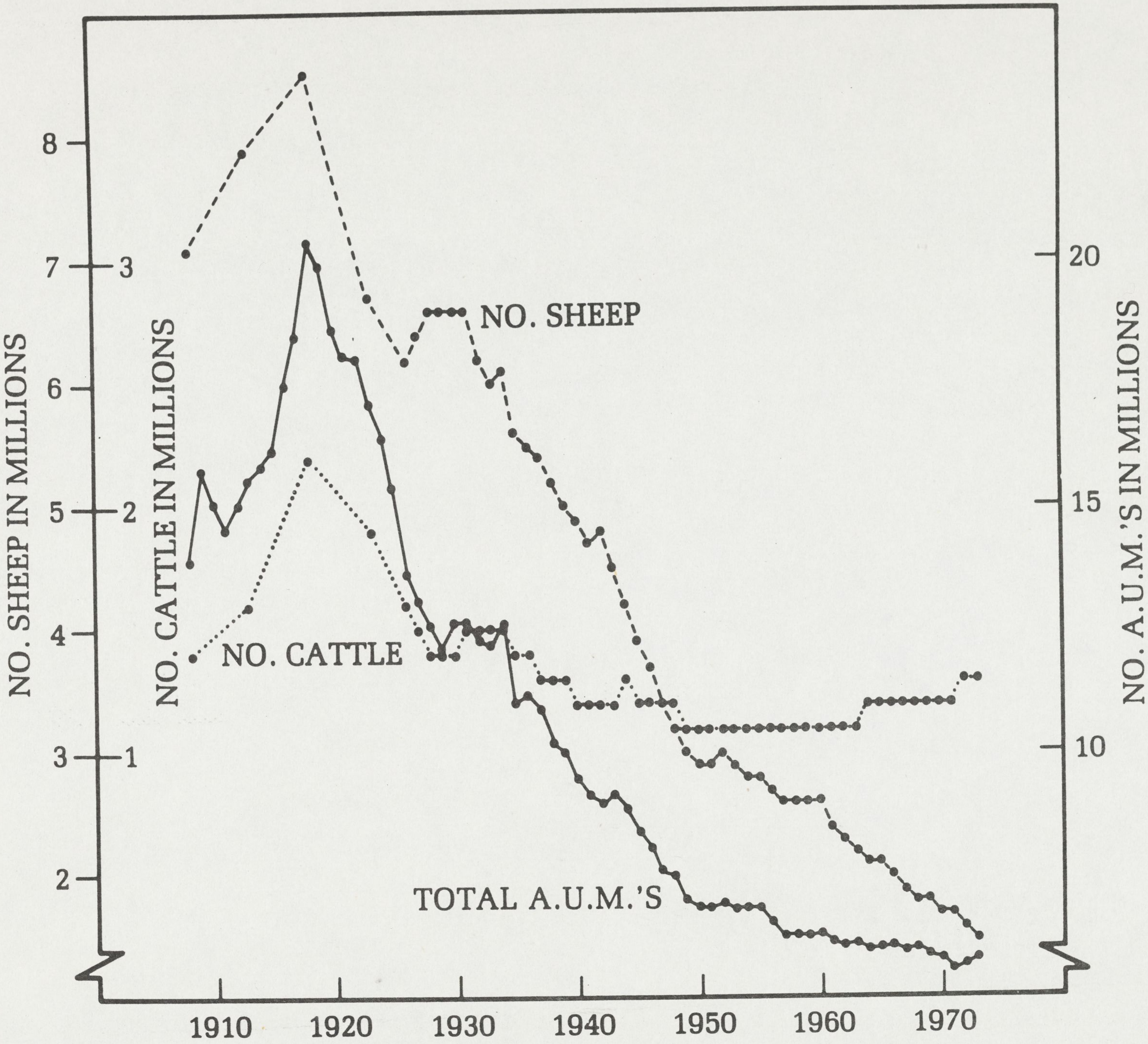


Figure 3. Chronological trends in sheep and cattle numbers and animal unit months (A.U.M.'s) of grazing on the western national forests. Data from U.S.D.A. Forest Service annual reports.

Figure 4. Chronological trends in sheep and cattle numbers and animal unit months (A.U.M.'s) of grazing on the public grazing lands (Natural Resource Lands). Data from the Public Land Statistics published annually by the U.S. Department of Interior.


NO. SHEEP IN MILLIONS
NO. CATTLE IN MILLIONS
NO. A.U.M.'S IN MILLIONS
NO. SHEEP
NO. CATTLE
TOTAL A.U.M.'S
8
7
6
5
4
3
2
3
2
1
20
15
10
1910
1920
1930
1940
1950
1960
1970

to speed up the process. Millions of acres in the West have been treated in these ways over the past 30-40 years.

Wildlife specialists in a number of areas have become concerned over these practices, especially in connection with two or three game species. One is mule deer, and the concern is directed to pinyon-juniper removal and to sagebrush control.

Heavy pinyon-juniper stands often have a depauperate understory vegetation and little browse production. Yet juniper itself, while not a preferred species, is often eaten by deer in considerable amounts. This, plus limited browse production around the edges of, and within small openings in, a stand plus cover afforded by the forest, often combine to produce at least low-density deer populations. The fear is that converting such plant communities to grassland will make them even less productive of deer than the admittedly poor pinyon-juniper type. The early rehabilitation programs were in fact directed only to livestock, and seeding confined almost entirely to grass. In more recent years, the management agencies have included shrub and forb seeds with the grass in order to provide for deer as well as livestock.

A number of research projects have attempted to evaluate the effects on deer populations with, in my opinion, inconclusive results. Most show a strong increase in deer use in the seeded grass. But none has, to my knowledge, demonstrated a population response in terms of higher fawn production, survival, and population growth. The observed responses could be redistributions of stationary populations without actually increasing their numbers.

Concern over sagebrush control has been much the same as that for pinyon-juniper removal. As with juniper, palatability of big sagebrush to mule deer is intermediate at best. But in vegetation where the more palatable species have been browsed out, sagebrush is consumed in large amounts and becomes the staple dietary item. Hence, herbicidal or mechanical removal, and conversion to grass in deer wintering areas are viewed with alarm by wildlife biologists. But here again, I am not aware of any study which has conclusively analyzed the impact.

The same alarm has developed over the effects of sagebrush control on pronghorn (Deming, 1963) and sage grouse (Patterson, 1952; Schneegas, 1967). Both species browse on sagebrush foliage, and most authors consider sagebrush vital to supporting sizable populations. However, both species browse other shrubs and consume large amounts of forbs. Hence, ideal habitat for both appears to be an interspersion of sage (preferably young plants), other shrubs, forbs, and perennial grasses (Rasmussen and Griner, 1938; Patterson, 1952).

Over much of the range of these species in the Plains and Great Basin, livestock grazing has reduced grasses, forbs, and more palatable shrubs and converted the vegetation to impoverished stands of mature sage. Such vegetation can sustain remnant numbers of pronghorn and sage grouse much as the sterile pinyon-juniper forests sustain low deer numbers.

In many cases, range rehabilitation programs have sprayed sagebrush with herbicides to encourage grasses. In many thousands of acres, sagebrush has been plowed and the land seeded to exotic, perennial grasses such as crested wheatgrass. From the standpoint of pronghorn and grouse, this alteration appears to swing too far to the opposite extreme and creates a barren monotype unfavorable for the wildlife. Here, as with pinyon-juniper removal, aid to both livestock and wildlife would seem to lie in preserving an interspersion of sagebrush (or pinyon-juniper) while seeding a diversity of grasses, forbs, and other shrubs (Deming, 1963).

One of the most recent effects reported for seeding projects which establish monotypes of exotic grasses is on the prey base for raptors (Howard and Wolfe, 1976; Wagner, 1976). Crested wheatgrass seedings contain lower densities of rodents and lagomorphs than the native brushlands. Concern has developed that if prey populations are reduced over a large enough area, they could lead to reductions in raptor numbers. Once again, the solution would seem to lie in vegetation diversity.

On the whole, we do not have a total evaluation of the effects of range rehabilitation, both favorable and unfavorable, on wildlife. A starting point would be a compilation of the total acreage of rehabilitation over the West subdivided by the kinds of treatment and their ages. Seedings do not persist indefinitely, tending to return to shrublands within a few decades. In some cases, the shrubs may be rabbitbrush and other species less desirable than sage. The entire ecology of reseeding ecosystems needs to be studied.

Rest-rotation grazing systems are another set of range-improvement practices particularly in vogue at present, and planned for increasingly extensive use on public lands in the years ahead. A variety of systems are in use which prescribe grazing on any given tract of land in alternate months, alternate seasons, or alternate years. The idea is to give the vegetation rest periods during which it can regrow foliage, increase carbohydrate reserves, and increase the volume of root systems rather than subject to continuous grazing which saps the vigor of the plants.

The planned expansion of rotation systems requires extensive fencing of public lands in the years ahead. Each grazing allotment will be fenced into subunits which will constitute tracts used by any given permittee (stockman) in his rotation plan. In effect, the public lands will be extensively subdivided into pastures if these plans are carried out.

There has long been some alarm over the possible effects of fencing on pronghorn antelope populations in the Great Plains. These animals are highly nomadic, moving freely over long distances like so many inhabitants of arid and semi-arid regions to areas of rainfall and forage production. At the same time, antelope are runners rather than bounding animals like deer, and do not leap fences readily. They have learned to go through and under fences in many cases, but where snowbanks develop on fences in severe winters, antelope are sometimes confined and die. While antelope do exist in fenced areas, the overall effects of fencing on their populations have never been adequately evaluated.

Recently, the possible effects of fencing for rotation systems on deer has caused some alarm. While deer can jump most fences nimbly, they occasionally catch their feet in the wire, become entangled and die. Presumably the more fences there are, the more of this kind of mortality we can expect. It adds one more source of attrition to wildlife populations which are already hardpressed by other factors.

(2) Predator control. Ranchers and personnel of the U.S. Fish and Wildlife Service's Division of Wildlife Services (formerly Division of Predator and Rodent Control) suggest that the Division's institutionalized predator-control program in the West is in behalf of wildlife as well as livestock. While this may be true, the fact remains that the effort was instituted during World War I for the purpose of increasing food production (Wagner, 1972). And it is questionable whether we would have had a program of its magnitude over the years, if any, if the sheep industry had not provided two-thirds of the funding while simultaneously applying political pressure for the lesser fraction of funding from the federal government. Thus, it is reasonable to suggest that the effects of predator control on wildlife are indirect effects of the livestock industry on wildlife.

Following the landmark paper of Leopold et al. (1947), it became part of conventional wisdom in wildlife management to attribute the deer population increases in this century to the trilogy of habitat alteration (forestry in the East, grazing-induced brush increase in the West), predator control, and restrictive hunting laws. Numerous textbooks in ecology and wildlife management have cited the deer irruption on the Kaibab Plateau in Arizona as the classic example of the role of predators in constraining deer populations, and the effects of releasing that constraint with predator control.

At the beginning of this decade, Caughley's (1970) refreshing reanalysis of the Kaibab story provided us with one of these cleansing acts we periodically need to dispel the intellectual fogs in which we allow ourselves to become entrapped. Caughley pointed out the inconsistency of the primary data on which the Kaibab story had been built, the uncertain validity of the original inferences drawn from those data, and the manner in which those inferences were modified and institutionalized by subsequent authors into what became an archetype of the relationship between predators and ungulate populations. He proceeded to the generalization that ungulate eruptions are largely a function of change in food and habitat, and by implication that predation is not a very significant limiting influence on ungulate numbers.

This implication marches with the findings of other authors who have concluded that predation does not play a significant role in limiting some ungulate populations (cf. Talbot and Talbot, 1963a; Pimlott, 1967; Hornocker, 1970). Elsewhere (Wagner, 1972), I have pointed out that deer population increases in the West occurred in the first half of this century and peaked in the 1940's or early 1950's. The toxicant techniques developed for coyote control were not put into use until the late 1940's or early 1950's, and the resulting reductions in coyote populations not evident until the 1950's.

Hence, the deer increases in the West took place in the face of heavy coyote populations which were probably affected very little by the mechanical control methods available before the late 40's.

Yet one should not swing the pendulum too far to the categorical extreme of viewing predation as having no effect. Some authors have shown predation to be an effective constraint on some ungulate populations (cf. Mech, 1966; Hirst, 1969). And Trainer (1975) and Salwasser (1976) have reported coyote predation to be a major source of fawn mortality in mule deer. The unfortunate fact is that we have so few conclusive data on which to form judgments. The answers undoubtedly differ with the ungulate and predator species, their relative numbers, and other aspects of the ecological context. My own inclination at this point in time is to view predation as a deer-herd constraint which, in most cases, is secondary to food and habitat conditions, but one which may be locally important to some herds.

The same question has arisen with regard to the value of coyote control to pronghorn and sage grouse. The evidence in the case of these species is more fragmentary than that on the deer question. Arrington and Edwards (1951) and Udy (1953) presented findings on the positive side while Griffith (1962) expressed doubts about the contributions of predator control to antelope herds. Patterson (1952) questioned its value for sage grouse.

The discussion so far has considered the implication that predator control has positive benefits for herbivorous wildlife populations. A number of the critics of predator control have raised questions about its negative effects. There is convincing evidence that coyote populations in the 1950-1970 period were reduced below the pre-1950 era (Wagner, 1972). The extirpation of wolves from much of the West and, I suspect, the reductions in bear and mountain lion populations are also consequences of a generalized mind set against predators which has pervaded the thinking of much of our populace since frontier days. To those who attach positive values to these species, these reductions are undesirable.

Critics of predator control have also claimed that the programs are too indiscriminate, and lead to the reduction of non-target carnivorous species. This claim may be contrary to fact (Wagner, 1972, 1975). Bobcat, red fox, badger, and even skunk populations appear to have increased in the 1950's and 60's in a number of areas subject to heavy coyote control. The response may lie in competitive tensions between the medium-sized carnivorous species, with the coyote being dominant. When its numbers are reduced, the others may increase to fill the competitive void. Such tensions are well known in other groups of vertebrates, notably rodents (Grant, 1972) and birds (MacArthur, 1972; Cody, 1974), and reductions in one species are followed by population increases in others in a process termed "density compensation" by avian ecologists.

Critics have also challenged predator control on the grounds that reducing coyote numbers removes a constraint on rodent and lagomorph populations allowing them to increase to undesirable numbers. There are almost no conclusive data to substantiate or deny these claims. While one would be unwise to hold any sweeping hypothesis that predation is never a material constraint on these species, their numbers, like the ungulates', must be importantly determined by food and habitat. Furthermore, western predator control concentrates largely on coyotes while rodents and rabbits are typically preyed upon by a community of avian, mammalian, and reptilian predators. The coyote is only one of a complex of predatory pressures. If we add to this the possibility that coyote control may promote the increase of other mammalian predators -- species which may be more effective rodent predators than coyotes --

one cannot escape scepticism over the suggestion that coyote control has produced generalized increases of rodents and lagomorphs in the West.

(3) Industry pressures to limit ungulate populations. Historically, livestock grazing has been the major land use over much of the West. Stockmen, businesses in support of the livestock industry, and agencies which manage the one-half of the West which is public land, have been major components of the western economy and social millieu. It is quite understandable that the values and desires of the industry have long permeated political process in the region, and have influenced attitudes and land-use decisions of the government agencies. For much of the history of the West, a considerable fraction of public-land management has been concerned almost entirely with range management for the industry. From the standpoint of big-game values, this ubiquitous political influence has had both positive and negative effects.

Until the last decade or two, there have been almost no social or economic forces concerned with maintaining very large deer populations in much of the West. The livestock industry, and supporting socio-economic groups in the Intermountain West were, if anything, concerned about possible competition with livestock for forage. Wildlife biologists were concerned about what excessive deer populations would do to their own range. Sportsmen, enjoying high hunting-success rates and not understanding that those rates would be followed by lower success in the future, were sanguine about the situation. Consequently, there was through much of the West until the last few years, a rather general attitude in favor of liberal deer harvests. Unlike midwestern states, where the resort industry has been a political force in favor of large deer populations and conservative hunting regulations, the western states readily invoked large hunting removals in the 1940's, 50's, and 60's when the deer herds had reached such high numbers. In this situation the industry was an ally of the wildlife biologists.

In the Great Plains, ranchers have been generally tolerant of, and sympathetic to, high pronghorn populations (Patterson, 1952). These animals are small, do not appear to compete with the cattle industry in that region, and are a part of the western heritage. Their presence is definitely enriching to the environment.

But the real, if intangible, political pressures of the industry have had their negative effects as well, primarily in connection with those species which pose a real competitive threat to livestock. The elk is the prime example. In pre-settlement times, elk were numerous in western mountains and valleys. As European man began to occupy the region, develop cities and agriculture in the valleys, and a livestock industry on non-arable lands, elk became a nuisance. They are large, aggressive, and can wreak havoc upon fences, farm haystacks, orchards, and golf-course greens. In Utah, a State Board of Elk Control was established in the early 1900's to control nuisance animals. This control, plus overshooting, nearly extirpated the animals from the State, and present populations derive largely from re-introductions from Yellowstone National Park.

But these populations today are low, numbering around 13,000 animals. It is fair to ask why, in a state over 80,000 square miles in area, and with over 2 million head of livestock and several hundred thousand head of deer, there are not more elk. The answer lies in a considered policy of stabilizing the herds at their present level through sustained-yield hunting removal. Admittedly, we may not be able to tolerate pristine numbers of this free-spirited animal, but I have asked agency personnel why populations are not allowed to double or perhaps quadruple. The answer has been that we can hardly allow elk populations to increase at a time when we are asking the livestock industry to reduce its quotas on the public lands. Both Utah Division of Wildlife Resources and U.S. Forest Service officials have told me that much of the resistance to elk increases is in the Forest Service, and that this amounts almost to an unwritten policy.

It would be unfair to suggest that the pressures against elk are solely of livestock-industry origin. Elk are nuisances in many ways, and a headache for agencies which have the responsibility for managing them. But it can surely be said that industry pressures are a significant part of the overall resistance to elk increases.

It is perhaps not entirely facetious to suggest a somewhat similar situation for bison. A number of the western states have token free-roaming bison herds. All are maintained at carefully controlled low numbers, some by limited sport hunting. No respecters of interstate highway fences, plate-glass windows, or even automobiles, large numbers of bison would be an even greater problem than large elk herds. But there would also be a strong disinclination to allow their herds to increase and compete for forage with livestock, plus expose cattle to the high incidence of brucellosis which bison appear prone to develop.

MAGNITUDE OF EFFECT

Wildlife Resources in Pre-Columbian Western America

In the several hundreds of millenia during which man has existed as a species, he has obviously had profound effects on the wildlife resources of the earth. But those effects have probably been of recent origin, namely the last ten or so millenia during which he has had domestic plants and cultivated agriculture, and domestic grazing animals. While the western hemisphere was occupied by man throughout this period, the fact that agriculture and pastoralism failed to develop to any degree saved its "pristine" character from the effects which eastern landscapes were experiencing. For a well-intentioned American environmentalist, critical of European man's impact on his continent's landscapes, a trip to North Africa, the Middle East, or India can be a sobering experience.

Hence in 1492, human technology had had little impact on North American ecosystems. The one possible exception is Martin's (1967) hypothesis that the arrival of man in North America in Pleistocene times occasioned the extirpation of many species of North American large mammals.

In the ecologist's terminology, an ecosystem undergoes a sequence of change following disturbance called "succession." If an area is denuded of plants and animals, and then released from disturbance, it will heal itself by growing a sequence of plant and animal communities until some stable end point is reached. In the ecological lexicon, that end point is termed the "climax." Climax communities are best recognized by their vegetation, and tend to reflect the climates in which they have developed: forests, in moist areas, grasslands in mesic or semi-arid climates, and deserts in arid areas.

Because severe, extensive disturbance was lacking in North America in pre-Columbian times, the ecosystems were at or near a climax state. There were localized patchy disturbances such as floods, landslides, fire (both lightning and man-caused), insect outbreaks, and others. But these did not alter the general pattern in which the eastern third of what are now the 48 states was cloaked in deciduous forest and the central third in grassland.

The western third of the U.S. was biotically the most diverse region in North America. The far western mountain chains of what are now Washington, Oregon, and California, and the Rockies on the east served as barriers to moisture from the Pacific and Gulf of Mexico, and enclosed the West in an arid to semi-arid climate. The mountains themselves -- including the many smaller ranges within the western regions -- and the northwest coastal region did receive moisture and consequently were covered with mantles of evergreen forests. As a result the valleys and lowlands of the West were covered with climax grassland, shrub desert, or combinations thereof while the mountains were wooded. On the highest peaks, the severity of the climate promoted tundra or Arctic-like conditions.

The successional process applies to animals as well as plants, and the North American ecosystems included climax animal communities: forest-dwelling forms in the East; grassland species in the midlands; and an array of mountain, grassland, and desert inhabitants in the West.

Estimates of wildlife numbers in pre-Columbian America exist for only a limited number of species, primarily the large grazing mammals. These estimates are, of course, highly speculative but are of some interest for comparison with contemporary numbers of the same species and of domestic grazing animals. With heavy reliance on Seton's (1929) estimates for the North American continent, I speculate that the numbers for the 11 western states were of the following orders of magnitude:

bison: 5-10 million

pronghorn and antelope: 10-15 million

bighorn sheep: 1-2 million

mule and blacktail deer: 5 million

elk: 2 million

Seton (1929) estimated 60 million bison in North America prior to settlement, McHugh (1972) 30 million. Many of these occurred in Canada, and highest densities were east of 100th meridean. Most of the 5-10 million suggested here probably occurred in the plains of Montana, Wyoming, and Colorado, although they occurred widely in the Intermountain valleys, and surprisingly widely in the mountains themselves.

Nelson (1925) estimated 30 million pronghorn, virtually all west of the 100th meridean and most in what is now the U.S. I have reduced the number to exclude the animals between the 100th meridean and the 11 western states, plus the Canadian herds. Pronghorn are tolerant of very arid conditions, and were common in the Intermountain valleys, deserts, and desert grasslands. In his archeological investigations of three caves along the Nevada-Utah border which had been inhabited for centuries, Jennings (1957) concluded that pronghorn had been the most common source of meat for the desert-inhabiting Indians of the region.

Seton (1929) estimated 1.5 to 2 million bighorn sheep in North America, not including the thin-horned species of the North. Many animals doubtless occurred in Alberta, British Columbia, and possibly Saskatchewan, and so the number for the 11 western states perhaps should be reduced below the estimates I have given. However, sheep were evidently quite widespread in the West. Lewis and Clark reported that they were locally abundant, while Osborne Russell's (1955) journal indicates that sheep and bison were the common sources of meat for the trappers in his group during their travels in western

Montana and Wyoming, Idaho, and northern Utah. Jennings' (1957) cave remains showed sheep second only to pronghorn as a meat source. And the prevalence of sheep and sheep-hunting scenes in the petroglyphs and pictographs of southern Utah and Colorado, and northern New Mexico and Arizona surely suggests the prevalence of these animals. If any of Seton's estimates are conservative, it might be the sheep estimates.

The most difficult estimates to rationalize are Seton's estimates of 10 million mule deer and 3 million blacktails. There were, of course, some deer present. Russell (1955) describes them in his journal along with the other wildlife forms. And Longhurst et al. (1952) describe large numbers of blacktails in the chaparral areas of California, particularly areas subject to periodic burning. But deer are intermediate successional animals which thrive on disturbance. A large amount of evidence, much of it episodic to be sure, points to relative scarcity in pre-settlement times. Early settlers found them scarce in numerous states. Jennings (1957) did not find a single piece of deer remains among the food items in his caves. Most wildlife specialists believe that deer have increased in the present century to unprecedented numbers following alteration of forests through logging and increases of brushy plant species into previous grassland. Had Seton been privy to our modern-day understanding of deer ecology, he might have tempered his estimates. I have listed the above numbers for the 11 western states, but suspect that they could very well be high. They exceed the number of deer occurring in the same region today, and most wildlife biologists believe that deer today are more numerous than they were in presettlement times.

Seton's map of primeval elk distribution was similar to that for bison. Yet their lesser numbers in the Plains, and proclivity for forest edge suggest lower numbers than of bison, and hence his estimate of 10 million. If we reduce that estimate by allowing for Canadian animals, those of the eastern two-thirds of the U.S., and for the large area of arid and semi-arid lands, my speculative 2 million might or might not be a reasonable order of magnitude.

In sum, we might postulate an aggregate big-game resource numbering somewhere between 20 and 30 million animals. Most of these were animals which we consider today as climax species. Bison and bighorn are primarily grass feeders, as described earlier.

Pronghorns, perhaps the most abundant ungulate between the Rockies and Sierras in pre-settlement times, are forb and shrub feeders. In the Plains, they undoubtedly fed on shrubs and forbs produced by the disturbance of bison grazing on climax grass. Thus, in this region the two species were virtual symbionts. In the semi-arid to arid Intermountain zone, vegetation is scant and shrubs and forbs can be considered part of the climax. But shrubby vegetation has its own successional patterns. And food-habits studies have shown pronghorns to select those shrubby and herbaceous species which succeed in relatively undisturbed situations. Hence, pronghorns can be considered climax over much of the region.

The rest of the fauna undoubtedly matched the advanced successional status of the larger animals. Sage grouse have habitat and food requirements very similar to those of pronghorn antelope, and were numerous over much of the same western plains and Intermountain region as antelope. The Columbian sharp-tailed grouse, a species of the more mesic, grass-covered Intermountain valleys was sufficiently abundant in parts of the Great Basin to serve as an emergency food source for early settlers. In the Southwest, several species of quail and wild turkeys were numerous, a number of these apparently needing abundant, perennial-grass ground cover for escape and nesting.

Chronology of Livestock Numbers in the West

The chronology of early livestock build-up in the West varied regionally, depending particularly on Spanish settlement. Spanish settlements began in California in the 1700's and there were already more than 1 million sheep in areas of the Spanish missions as early as 1825 (Longhurst et al., 1952). Hastings and Turner (1965) point out that Spanish settlers had sizable numbers of domestic animals in early Arizona well before the arrival of immigrants from the eastern states and territories in the later 1800's. Doubtless the same was true of New Mexico. L. B. Leopold (1951) summarized comments in early journals about the scarcity of grass near some of the New Mexico settlements in the early 1800's. To the north, settlement came later, and the initial build-up in livestock numbers occurred in the latter half of the 1800's.

But despite the differing dates of first settlement, livestock build-up gathered real momentum in the last 3 decades of the 19th century, and with no more than a decade or 2 variation between the 11 western states. Thus the trends shown in Fig. 5 represent not only the general trend for the West, but reflect the curve for each state fairly well. The only significant exception is California which had reached peak sheep numbers before 1870.

January 1 sheep numbers had reached a level of nearly 20 million by 1895, varied between 20 and 30 million for the next half century, then declined by two-thirds to three-fourths in the period after 1945. Cattle numbers rose more slowly, but have risen continuously from post-settlement numbers to the current all-time high.

Largest numbers of livestock occurred in the West during the half century when the sheep industry was at its maximum. This number dropped slightly in the 1950's when sheep numbers declined, but the cattle build-up in the past years has nearly maintained livestock numbers at the level reached by the turn of the century.

In terms of food need, the picture is somewhat different. A cow eats about five times as much forage as a ewe. The Animal Unit Month (A.U.M.) is the standard range-science unit of livestock food demand, and equates to 1 cow feeding for 1 month, or 5 adult sheep feeding for 1 month. I have converted the numbers in Fig. 5 to combined A.U.M's for the sheep and cattle, and these depict a continuously growing livestock food demand throughout the century for which data are available. Food demand for western livestock today is at an all-time high. The trend is set primarily by growth in numbers of cattle which have five times the food need of sheep.

However, this demand should not be equated directly to pressures on the range. In particular, a large fraction of cattle in the West are fed hay, grain, silage, and crop wastes in feed lots and farm fields for varying portions of the year. This tendency has increased over the years and undoubtedly has absorbed a major fraction of the increase in A.U.M's, although I was not able to ascertain what this fraction is. In addition, the development of the range-management art has tended to mitigate the effects of sheep numbers. Today we fence, water, rotate, control the season of grazing, and otherwise distribute grazing pressures in ways not known 75 years ago.

There also are circumstances which tend to increase the significance of these figures. Don Dwyer has pointed out to me that the average cow around the turn of the century weighed about 800 lbs. Today, the average cow weighs 1,000 lbs., suggesting that the forage demand has increased some 25 percent per animal.

Secondly, range carrying capacity today must be lower than it was 75-100 years ago. Rangelands have been pre-empted by farms, orchards, urban development, impoundments, highways, state and national parks, and industrial complexes.

In addition, most observers agree that the remaining ranges are producing at less than capacity. Hence, for a number of reasons we have less carrying capacity today than in the past, and whatever grazing pressure on the range is implicit in the numbers of Fig. 5, that pressure is directed to a smaller range base than the pressures exerted 75-100 years ago.

Effects of Grazing and the Livestock Industry on Western Ecosystems

Vegetation and herbivorous animals have co-evolved for eons, and plants are physiologically constituted to sustain some feeding removal without significant damage to their function and without profound ecological change. This statement is borne out by the climax state of western ecosystems in pre-Columbian times which carried some 20-30 million wild grazing animals. There is, in fact, considerable evidence that the functioning of range vegetation is enhanced by some grazing removal (Wagner, 1976a).

In an effort to gain some impression of the pressure applied by native animals, I converted the big-game numbers listed above to A.U.M.'s. Bison were each assigned a single animal unit, as were elk (notwithstanding Forest Service's puzzling assignment of 2 units), and multiplied by 12 to calculate A.U.M.'s. Antelope and bighorn numbers were divided by 5, and multiplied by 12. The total for these four species -- roughly 80 million A.U.M.'s -- constitutes a highly speculative estimate of the grazing pressures applied by climax big-game animals on western ranges in presettlement times. I assume that deer were scarce and did not include them in the total.

There are of course physiological and ecological limits, and when these are exceeded changes occur. The tolerance limits of western systems have been exceeded by the livestock pressures applied to them, and changes have occurred. While the effects of grazing have not been anywhere near as influential in altering the biota as has agriculture in the Midwest, grazing has surely been the most ubiquitous influence for change in the region. Those changes have been rather drastic in some areas, in others fundamental though not recognizable to the untrained eye, and some areas subtle and perhaps not fully recognized even by the professional observer.

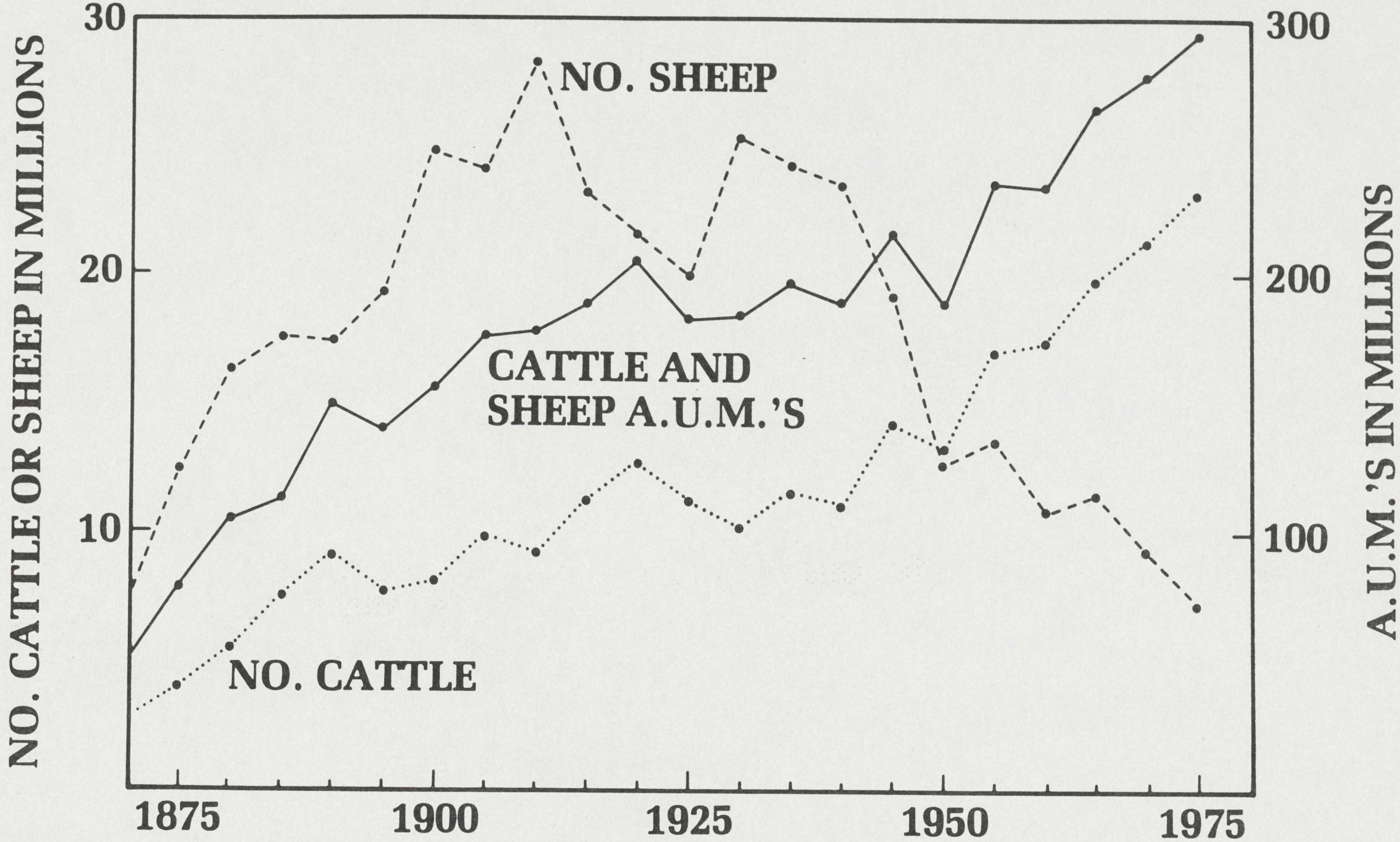
The changes began in the late 1800's. Box et al. (1974) reviewed a number of early reports of range damage prior to the turn of the century, and as mentioned above L. Leopold (1951) summarized similar accounts from journals of trappers, military men, and other individuals. There is a tendency among some observers to conclude, partly on the basis of these kinds of reports, that most of the damage to American ranges was suffered prior to 1900.

Although we probably will never envisage the history of change clearly and assuredly, I am not convinced of this pre-1900 theory. The kinds of reports summarized by Box et al. and Leopold tend to be based on localized and anecdotal observations. The impact of large, localized livestock herds may be spectacular in limited areas, and color one's judgment about what has happened over the range at large. But it is difficult to gain a statewide or regional perspective of trends over hundreds of thousands of square miles.

Livestock did not reach their maximum numbers in the West until the decade before 1900 (Fig. 5), and then remained at this level for the next half century. In an effort to convert these numbers to pressures on the range, I have attempted to calculate A.U.M.'s of range use from them. Since most sheep spend the full year on natural vegetation, I calculated sheep A.U.M.'s by dividing the total sheep in Fig. 5 by 5 and multiplying by 12. The results (Fig. 6) suggest sheep pressures on the ranges continuous from about 1890 to 1940.

Calculating cattle pressures is more speculative. Prior to 1940, most cattle were finished on the range and there were no sizable feed-lot operations.

Figure 5. Chronological trends in sheep and cattle numbers and total livestock forage need (A.U.M.'s) in the 11 western states. Data on animals from the U.S.D.A. Statistical Reporting Service. A.U.M.'s were calculated by the equation: A.U.M.'s = $(\frac{\text{sheep}}{5} \times 12) + (\text{cattle} \times 12)$.



NO. CATTLE OR SHEEP IN MILLIONS
A.U.M.'S IN MILLIONS
30
20
10
300
200
100
NO. SHEEP
CATTLE AND
SHEEP A.U.M.'S
NO. CATTLE
1875
1900
1925
1950
1975

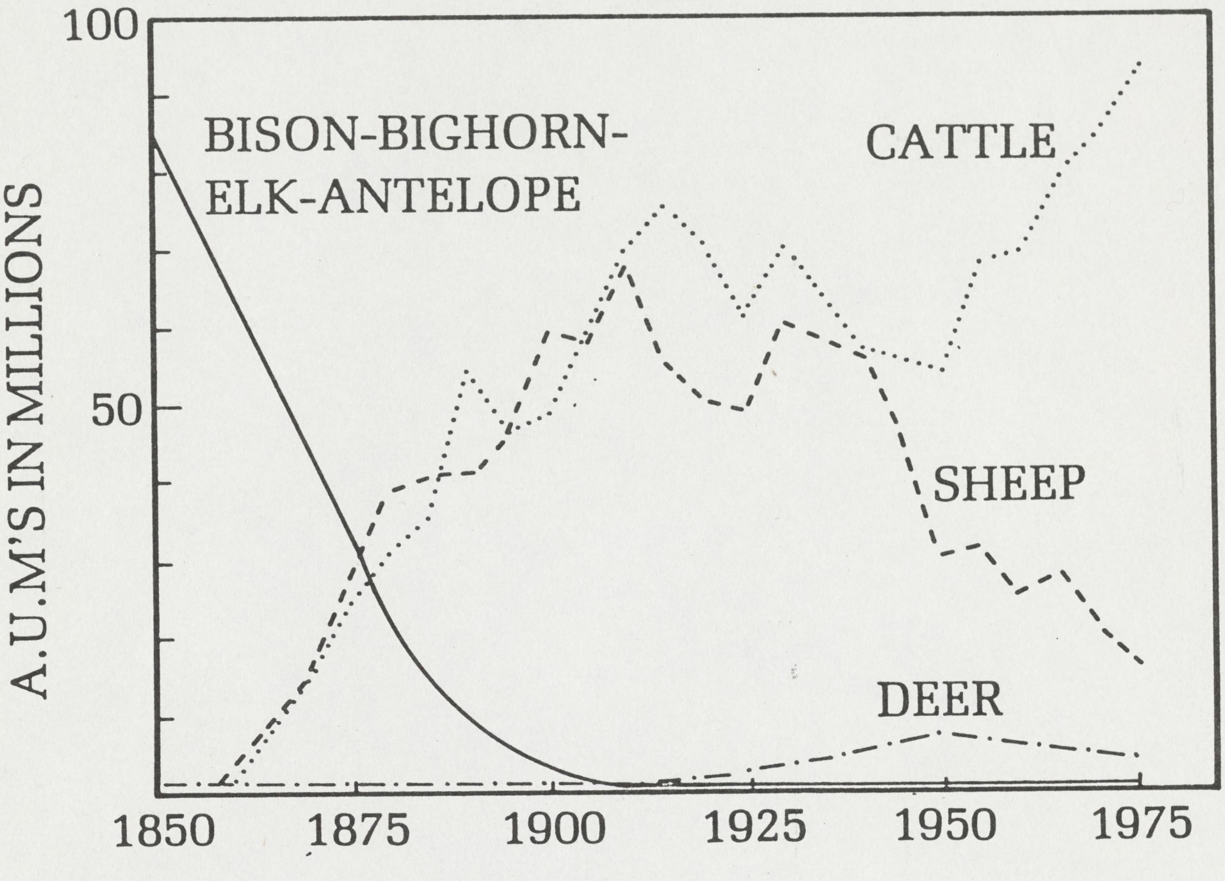


Figure 6. Conjectured A.U.M.'s of wild and domestic grazing pressure on rangelands in the 11 western states. See text for calculations.

As a conservative estimate, I halved the number of cattle in Fig. 5 for the years up to 1940, multiplied these by 12 to convert to A.U.M.'s, and assumed that the result reflects the cattle pressures on the range (Fig. 6). The annual totals are quite similar to sheep A.U.M.'s.

Collectively, the results in Fig. 6 suggest rather continuous, total pressures on the ranges between 1890 and 1940, applied about equally by sheep and cattle. The totals of both suggest annual pressures around 120 million A.U.M.'s, or half again the primeval pressures applied by wild animals. If my reduction of cattle numbers to half is conservative, then livestock pressures were more than half again the earlier wild-animal pressures.

There evidently was some limited redistribution of these pressures due to reductions on the national forests starting around 1920 (Fig. 3). A.U.M.'s were reduced on the forests from around 20 million in 1920 to around 10 in 1940, and those animals must have been shifted elsewhere. But they only constituted about 5 percent of the total livestock A.U.M.'s in the West during this period (Fig. 5) even though they constituted half the A.U.M.'s on national forests.

Reductions on the Public Domain lands were begun around 1940 following passage of the Taylor Grazing Act in 1934 and formation of the Grazing Service (later the Bureau of Land Management). But these animals, too, constituted a relatively small percentage of the total livestock in the West (Fig. 4).

If range damage occurred before the turn of the century, I find it difficult to come to any conclusion other than that the damage continued unabated, and perhaps at greater intensity, until about 1940. The one exception is the eased pressures on the national forests between 1920 and 1940.

What the trends have been since 1940 in both grazing pressures on the range and trends in range condition are almost impossible to ascertain to any full extent. I have, in Fig. 6, calculated highly speculative, post-1940 cattle A.U.M.'s on the ranges by using one-third of the cattle shown in Fig. 5. But this is sheer guess since, to my knowledge, there are no data as to what fraction of the A.U.M.'s shown in Fig. 5 are provided by irrigated pastures and cropland products.

There is a widespread view that the livestock reductions on public lands have effected some range improvement, but some critics hold that these reductions have still not been sufficient to halt deterioration in some areas (cf. Gallizioli, 1976). I have not been able to find records of livestock numbers or range conditions on private lands. But the steady increases in A.U.M.'s, even with due allowances for increased feeding from croplands, make one wonder if private lands have sustained continued or even increased pressures during this century. One half the area of the West is private land.

One conclusion does appear warranted from the data in Figs. 3-5. Because each livestock species is specialized in its feeding patterns to a degree, each applies a different kind of pressure to the vegetation. Obviously the particular kinds of pressures applied by sheep are markedly reduced today below what they were a half century ago. On public lands, cattle numbers are also down somewhat from earlier numbers. But they have been roughly stable since about 1950, and overall have not been reduced as drastically as sheep. The particular pressures applied by cattle, therefore, continue with some intensity. And if my suspicion is correct that cattle numbers are at an all-time high on private lands, their impact obviously continues. Longhurst et al. (1976) have pointed to this same shift in the nature of grazing pressures, and speculated on its effects on California deer herds.

The extent of change which has occurred in western ecosystems may be an inverse function of precipitation. The change from the desert grasslands to desert-shrub type in Arizona, New Mexico, and Texas may be the most extreme. In some areas, it has been accompanied by the loss of up to 3 inches of topsoil due to sheet erosion, and by severe gullying.

Humphrey (1958) attributed this change to cessation of prehistoric fires, as did Leopold (1924) in part. But Hastings and Turner (1965) challenged this, and attributed the change to a combination of climatic change and grazing. From their Arizona vantage point, the climatic change which they implicated consisted of a decline in <u>winter</u> rainfall along with higher temperatures over about the past century or more. But the southwestern grassland extended into New Mexico and west Texas, both of which are <u>summer</u> rainfall areas. Paulsen and Ares (1962) report a 100-year rainfall record for southern New Mexico which indicates more years of above-average summer rainfall between 1882 and 1943 than of below-average years. York and Dick-Peddie (1968) rather firmly implicate livestock grazing as the source of change, as did Leopold (1924).

Next in degree of aridity is perhaps the Great Basin desert where much of the change in vegetation appears to be a shift in species composition (Holmgren and Hutchings, 1972). More palatable, perhaps climax, shrubby species have been replaced by the less palatable shadscale. In this region, the Bureau of Land Management has been severely self-critical of its program in Nevada, in effect conceding that it has mismanaged the public range.

In the Plains, and in the bunchgrass valleys and foothills of the Intermountain region, grasslands have experienced invasion or increased densities of various perennial species: sagebrush and juniper in the north; cacti, mesquite, tarbush, creosote, and various succulents of the lily family in the south. The extent of change, of course, varies locally.

Little is known about the influences of grazing on high-altitude biotas. The general view is that the effect is less, and that these ranges have been improved through management more than any other type (Box et al., 1976). Yet I cannot help suspecting that subtle changes in understory vegetation have occurred when I see rather sparse ground cover under aspen stands; rather sterile, monotypic brome meadows; and heavy infestations of pocket gophers which are commonly thought to be disturbance animals.

Box et al. (1976) attempted to quantify the magnitude of these changes, summarizing several reports on the condition of the western, public rangelands. The first attempt at quantifying the condition of western ranges was associated with passage of the Taylor Grazing Act. The results, published in 1936 as Senate Document 199, 74th Congress 2nd Session and entitled The Western Range, concluded that 57.5 percent of the public ranges were in a condition of severe or extreme depletion. Only 16 percent were in reasonably good condition. In 1968, a national range inventory used somewhat different criteria, but Box et al. concluded on the basis of the data collected at that time that three-fourths of the western ranges were producing at less than half their potential.

"Potential" in range terminology implies at or near climax for a given site. Thus, climax plant species had been reduced by more than half over three-fourths of the West, according to this estimate. Intermediate or early successional species had presumably increased in their place. According to Box et al., reports of range condition since the 1968 report generally do not contain sufficient data to permit inferences about range trends since the 1960's.

Without measures of the structure of western ecosystems prior to rise of livestock numbers, we will probably never understand fully the nature and magnitude of changes which have taken place. Even today, our efforts at measuring western vegetation are so inadequate that we will not have an accurate picture of changes in the next 50 to 100 years unless those efforts are extensively increased.

Effects on Wildlife Populations

The extent of changes in wildlife populations are a function of the magnitude of these ecological changes, and the wildlife species concerned. I have summarized the most recent fish and game department estimates of big-game numbers in each western state (Table 1). Comparison of these numbers with the pre-Columbian numbers given earlier will convey some idea of the changes in these species.

The climax species -- bison, bighorn sheep, and pronghorn antelope -- have declined the most, perhaps existing today at less than 5 percent of their primeval numbers. Elk can succeed in a range of vegetation types, and while definitely fewer than in primeval times, are not reduced as severely as the climax species. In total, there are obviously far fewer ungulates of these species today than in primeval times.

The initial reductions in all of these species occurred substantially through overshooting. At the turn of the century, they were thought to have been on the verge of extinction. It was at about this time that a network of federal, big-game refuges was established to preserve remnant herds.

With protection, some increased in some areas. Pronghorns have now recovered to substantial populations in the Plains States (Table 1) where summer rainfall produces a more nutritional range during the late gestation and early postnatal stages of the life cycle. Presumably these ranges are more resilient to grazing pressure and have changed relatively less than in more arid areas.

Table 1. Current Estimates of Big-game Populations in the Western States[1]

State	No. of Animals by Species					
	M. & B.-t. Deer	Pronghorn	Elk	Bighorn	Bison	Total
Arizona	130,000	7,000	10,000	2,000	320	149,320
California	650,000	4,869	3,392	3,750	-	662,011
Colorado	325,000	32,000	120,000	2,500	-	479,500
Idaho	178,000	13,250	50,600	2,975	25	244,850
Montana	No est.	No. est.	No est.	No est.	No est.	-
Nevada	81,700	5,000	200	4,000	-	90,900
New Mexico	261,600	26,900	27,500	800	-	316,800
Oregon	1,050,000	11,000	107,000	400	-	1,168,400
Utah	275,000	2,500	13,000	450	150	291,100
Washington	373,500	50	60,000	435	-	433,985
Wyoming	280,000	168,000	63,000	3,100	-	514,100
Totals	3,604,800	270,569	454,692	20,410	495	4,350,966
% of Pristine Nos.	>100?	2-3	25	<1?	<1	15-20

[1]These estimates were provided by officials of the fish and game departments in each state.

Herd composition counts have long showed higher late-summer doe:fawn ratios than in Intermountain populations.

Elk have recovered in most areas to some degree. This species, with its broad feeding tolerances, could probably increase more with sufficient protection from hunting. The same could probably be said for bison.

Intermountain antelope and bighorn sheep in nearly all areas have not recovered to any great degree. I suspect that this is largely a function of vegetation changes and low vitality.

Those same vegetation changes are probably responsible for the increases in deer populations in this century (Fig. 6). The populations appear to have crested in the late 1940's and early 50's, and have declined in the past 20 years, perhaps for reasons I have outlined above.

Virtually no estimates exist for other wildlife species. But biologists generally assume that the same trends have characterized the other species of the climax and intermediate successional stages as those of the large ungulates. In view of the severity of ecological change, some of the severest critics of grazing are in the Southwest. Gallizioli (1976) simply and unequivocally states that livestock grazing is the single most influential factor acting to the detriment of wildlife populations in Arizona. Forty years earlier, Gorsuch (1934) had posed the same generalization for the effects of grazing on Gambel quail in that state.

In Wyoming, Montana, and Nevada, some wildlife specialists are alarmed about range-improvement projects and the strong livestock orientation of the Bureau of Land Management. The concern is about the effects of brush control and grass seeding on deer, and the effects of widespread fencing to facilitate rotation systems on both deer and antelope. Some cases have been reported of industry political pressures being brought to bear on game commission decisions and employees.

In Utah, Colorado, and Oregon biologists are more favorably disposed to livestock grazing. The attitude is strongly colored by the vegetation changes which have been favorable to deer, and the importance of deer as a bread-and-butter hunting species. One Utah official told me: "Grazing is essential to the maintenance of wildlife populations. But it has to be proper grazing."

In general, attitudes are favorable where intermediate successional wildlife species are present, and ecological alteration is not excessive. Attitudes are critical where range is seriously abused and little vegetation remains for any wild organisms, and where range improvement is heavily oriented to livestock and wildlife suffers accordingly. Overall, there appears to be subconscious resignation to the loss of climax species and little consideration to their restoration. The concern is for keeping reasonable populations of disturbance species, primarily deer.

MANAGEMENT NEEDS

Management programs for enhancing wildlife resources obviously must be preceded by policy decisions. Such decisions are no longer made independently for each resource. Because those resources may compete with each other, and interrelate in other ways, we are increasingly making collective decisions for the aggregate resources.

Since each resource is valued by one or more facets of society, the decisions are societal ones. The values of no one facet -- environmentalists, wildlife ecologists, or range managers -- take any particular precedence. Decisions are compromises, and where to strike those compromises among the possible alternatives is a question central to the political art. The role of the resource scientist is, as mentioned at the outset, to provide objective analyses of the array of decision alternatives, and the consequences of each to the various resources affected by it.

Fig. 7 is a crude, schematic attempt to depict the related changes in wild ungulate and livestock numbers on the western ranges since European settlement, and possible changes in the future, depending on two courses of action. Since the numbers on each line above any given point on the X-axis are causally related, each point on the axis and its related livestock and wildlife numbers could be considered a management alternative. Thus, in this sense, Fig. 7 represents an array of decision alternatives.

The left side of the array depicts the situation which would prevail if society were to opt for large numbers of near-climax ecosystems and game species. Its trade-off would be meat and animal products. The long-term gain would be the greatest possible ecological health.

The right side of the array depicts two alternative consequences of further increasing livestock grazing on western ranges. Both cattle and sheep numbers could be increased. And with a considerable amount of primary production going to sizable deer populations, it is not inconceivable that in a future world where starvation was commonplace, a browsing ungulate like the goat would be introduced to utilize the forage now eaten by difficult-to-control deer.

Since most ranges are now overgrazed, increased grazing pressures without greatly intensified management effort would degrade ecosystems further. Carrying capacity for both livestock and wildlife, as represented by the lower right-hand portion of Fig. 7, would decline to fractions of their present levels. This state of affairs has already been reached in most of North Africa and the Middle East where hunting scenes in Roman mosaics attest to once-abundant populations, but where wild ungulates can no longer be found today. These degraded ranges

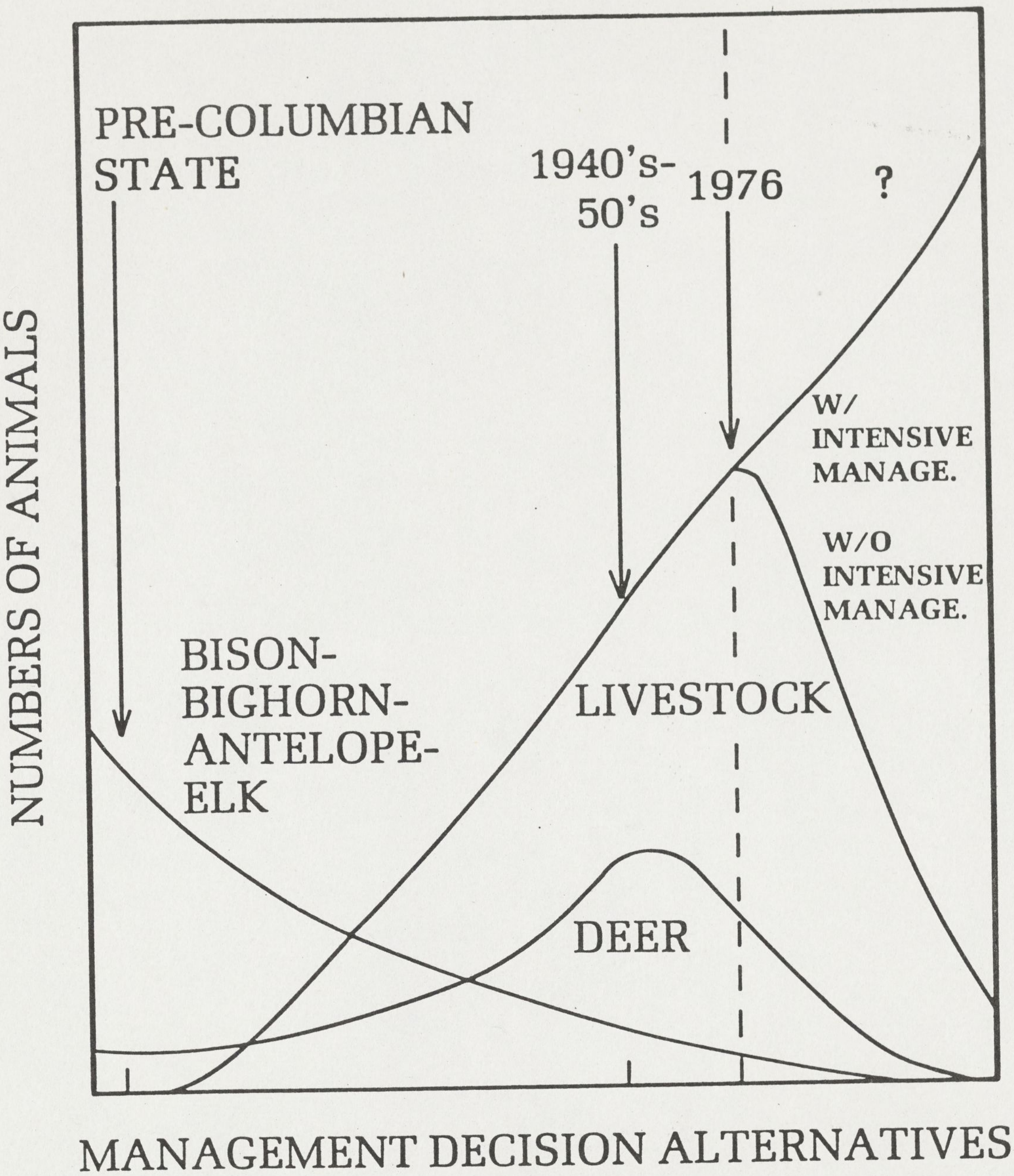


Figure 7. Schematic representation of decision alternatives for various mixes of livestock and wildlife numbers in the western states. See text for explanation.

also carry a fraction of the livestock they could carry if the vegetation were producing at its potential.

Increased livestock production through intensive management is a possible alternative on the upper right side of the scale. The West could be fenced into a mosaic of rotation pastures and planted to exotic grasses palatable only to livestock. Here again, new ungulate species could be added to utilize primary production in areas not suited to planting and plant species not palatable to existing livestock forms. The result would approach the intensity and land alteration of cultivated agriculture which undoubtedly could produce more livestock, but from which wildlife resources would long since have faded as they have in so many of the intensively farmed areas of the Midwest.

At present we are at the 1976 point on the scale. It is difficult to sense which direction in Fig. 7 we are moving today. On public lands we have probably moved both to left and right, depending on the area. Stock reductions in the 30's and 40's, plus some range improvement programs, probably effected some leftward progress. In a large share of the states, public agencies now plan management programs with both livestock and wildlife in mind. Stockmen themselves are becoming more cognizant of livestock effects on other components of the ecosystem. But in some states, according to the concerns of biologists, management decisions are heavily oriented to livestock, particularly cattle.

On the basis of Figs. 3-6, one must suspect that we are moving to the right on private lands. The marked cattle increases shown in Fig. 5 are not taking place on public lands.

Perhaps the most fundamental point to be advocated by the ecologist is the avoidance of irrevocable change. The most basic resource on which the others depend is the soil resource. Any decision favoring a move to the right in Fig. 7 should be made with a clear understanding of the effects on this resource. At the same time, rare and endangered species and sample ecosystems should be preserved in natural areas against a time when reduced populations would permit a partial return to natural conditions.

My own suspicion is that we have moved too far to the right to maintain the long-term productivity and health of western ecosystems. In my opinion, a leftward move to about the midpoint of Fig. 7 is desirable from the standpoint of ecological health.

While Gallizioli (1976) has pointed out, with good reason, that some areas are simply too arid and fragile to sustain any livestock use, a leftward move in the Fig. 7 scheme need not involve permanent, mass reductions of livestock. As Leopold (1924) put it over a half century ago: "Wholesale exclusion of grazing is neither skill nor administration and should be used only as a last resort." The conclusion of Box et al. (1976) that western ranges are now producing at less than half their potential surely suggests that contemporary numbers of animals could be carried and a considerable margin left for wildlife if those ranges were brought to potential with well-executed management.

A large part of the West has moved to the right for both wildlife and livestock by growing up to over-mature, depauperate stands of juniper, sage, shadscale, creosote, mesquite and other species of low or no palatability. Judicious brush removal, accompanied by seeding to native grasses and desirable shrubby species could produce both wildlife habitat and livestock forage. On severely degraded sites, management might need to reach the intensity of rodent control. But at this level of effort, native perennial grass production has been increased by a factor of 4 on the almost totally destroyed, desert grassland of southern New Mexico (Wagner, 1976). As such areas were improved and livestock moved from other areas onto them, the effect would be to ease pressures on the existing remaining ranges.

Other techniques for simultaneous wildlife and light livestock use can be explored. Investigators in my own institution are experimenting with early-spring sheep grazing and fall cattle grazing to apply light pressure on the grasses of range now completely reverted to perennial, bunchgrass type. The goal is to afford some small advantage to forbs and shrubs needed by deer.

The whole point here is that management, if subtle and ecologically well-conceived, does give some hope of producing rangelands which can support goodly numbers of both livestock and wildlife. But that hope does not lie in simplistic, one-shot panaceas like crested wheatgrass monotypes or blanket use of rest-rotation schemes. Nor is there much hope, in my opinion, for continued wildlife resources of any magnitude if livestock numbers are substantially increased, with or without intensive management.

The enlightened, ecologically sound management to which I refer can only be accomplished with large increases in programs. Longhurst et al. (1976) have already alluded to the high cost of such efforts in California. Management agencies today are badly understaffed, their efforts thinly spread over a plethora of responsibilities, while rising operational costs are not being met by comparable budgetary increases. In an era of mammoth federal budgets, management of the resources on which the strength of the nation depends receives a miniscule fraction of those budgets. At the same time, there are large ranks of unemployed youth for whom employment in environmental protection and resource management would be highly prized.

Such management will also require an increasingly sophisticated research data base on which to design programs. That range research programs, small as they are at present, are being reduced is therefore a particular cause for alarm. The valuable, long-term grazing studies on the Forest Service research stations are being reduced or phased out and the personnel who have been associated with these projects for many years, and who know the research findings accumulated to date, are being reassigned to new types of research. There is a real danger that the data which have accumulated over the years, and which have not been sufficiently analyzed and published, may never realize their potential because the investigators most familiar with them are moving on to other assignments. One Forest Service employee told me recently "Range research in the Forest Service is dead."

Not only is our basic research on vegetation-herbivore relationships inadequate, but we do not even have adequate survey information on range condition and trend to make confident statements about them. Data on public lands are extremely weak and those on private lands virtually nonexistent. In essence, we cannot say with any confidence what the condition and trend are on 40 percent of the area of the 48 states.

Heady et al. (1971) report the increased demands which are likely to be made on western rangelands in the decades ahead. U.S. population growth alone is likely to increase the demand for meat by some 30 percent. To this must be added two rising demands. The first is the increasing cost of small grain and growing pressures to move grain into foreign markets and fatten slaughter animals, now finished with grain, on range forage. The second is the rising cost of synthetic fiber made from petroleum products, and consequent growing demand for natural wool.

These changes are likely to exert almost irresistable pressures in the decades ahead for increased livestock numbers on both private and public rangelands. Without intensified management and research effort on this part of our national heritage, it could well follow the path of North African and Middle East grazing lands. Wildlife resources will inevitably disappear in the process.

SUMMARY

Because domestic ungulates, like wild herbivores, have specialized feeding patterns, each species feeds on a limited portion of the total plant community available to it. That feeding constitutes interspecific competition with wild species which use the same portion of the vegetation spectrum, if the plant material in question is in short supply and populations of the wild species are constrained below what they would be in the absence of livestock. Cattle are most likely to be direct competitors of bison, bighorn sheep, and elk; sheep of deer, elk and pronghorn antelope; goats of deer; and horses of nearly all wild species with which they coexist. A number of actual instances of competition for annually produced forage have been inferred. Through much of post-settlement history in the West, livestock have been present in sufficient numbers to compete with some wildlife species for annual forage production.

By altering the competitive tensions between the plant species in a community through selective feeding, herbivores can change plant-community structure. In reducing the plant species on which they feed, domestic animals reduce the food available to their wild analogs, and compete thereby. Such changes have probably affected bighorn, pronghorn, and sage grouse populations. There is considerable concern in the West today about changes in riparian ecosystems.

While some plant species are reduced by herbivory, others not heavily fed upon are increased. Wildlife species which need the increased plant species are benefited by the interaction and become commensals with the herbivore effecting vegetation change. Thus deer, which are browsers, have increased during this century because the shrubby species on which they feed have been increased by cattle and sheep grazing on grass. Increases in forbs in the southwestern desert grasslands have been followed by increases in rodents and lagomorphs. Reductions in livestock numbers in some areas have been followed in recent years, perhaps causally, by declines in deer populations and increases in elk.

Fire, mechanical, and herbicidal methods have been used to reduce shrubby growth invading areas previously favorable for grazing livestock. In many cases this brush control has been coupled with grass seeding, especially exotic grasses, which produce a vegetation unfavorable for deer, pronghorn, and sage grouse. Extensive fencing for proposed rest-rotation grazing systems may be detrimental to wildlife. In some states and in some situations, the commitment of public agencies to livestock management on public lands may be to the detriment of wildlife.

Pre-Columbian western America, in the absence of cultivated agriculture and domestic animals, was in a climax ecological state including the wildlife species. Conjectured population sizes of the large ungulates in the 11 western states are 5-10 million bison, 10-15 million pronghorn antelope, 1-2 million bighorn sheep, 2 million elk, and 5 million (or fewer) mule and black-tail deer. Other abundant species were sage grouse in the western Great Plains, sage grouse and Columbian sharp-tailed grouse in the Great Basin, turkeys and several species of quail in the Southwest.

Although states with early Spanish settlements began to acquire livestock in the early part of the 19th century, large numbers did not build up until the latter part of the century. Sheep numbers essentially built up in the period 1870-1890, remained at high levels from 1890-1940, have declined continuously since to about one-fourth peak numbers. Cattle numbers have risen continuously from settlement times to the present.

In terms of grazing pressures on the range, these accumulated to heavy levels by 1890, and apparently continued to at least 1940. Reductions in livestock numbers began around 1920 on the national forests, on National Resource (B.L.M.) lands around 1940. Since 1940, the continued rise in cattle numbers has more than compensated for the decline in sheep, and total livestock food demand is at an all-time high today. Much of this undoubtedly is supplied from croplands and irrigated pastures, while A.U.M.'s of grazing pressures on the public lands have been low but stable since about 1950. While there are no data from which to judge, one suspects that pressures on private rangelands could be at an all-time high. One-half of the West is private land.

Western ecosystems have been altered by livestock grazing. Much of the southwestern desert grassland has been converted to desert shrub type. Species composition of Great Basin deserts and foothills has experienced increases in less palatable and nutritious shrub species. In a recent estimate, three-fourths of western vegetation is producing at less than 50 percent of its potential, potential here defined as the climax state.

Climax ungulate species, originally reduced through overshooting, may not have been able to recover pristine numbers in part because the vegetation has been changed to their disfavor, in part because of pressure against their competition with livestock. Deer have increased in this century because the vegetation changes have favored them. In the last decade or two, deer numbers have declined, possibly due in part to return of some vegetation toward a slightly closer climax state, in part because of intensive management for, and use by, livestock.

An array of decision alternatives, ranging from a return to pristine conditions to livestock uses more intensive than those of today, exists for society. Society appears already to have opted against the former. The latter would preclude any substantial wildlife resources. An intermediate state would accommodate both large livestock numbers and some wildlife resources, and the potential for both lies in improving the ranges through management so that they can achieve more than their present 50 percent of potential.

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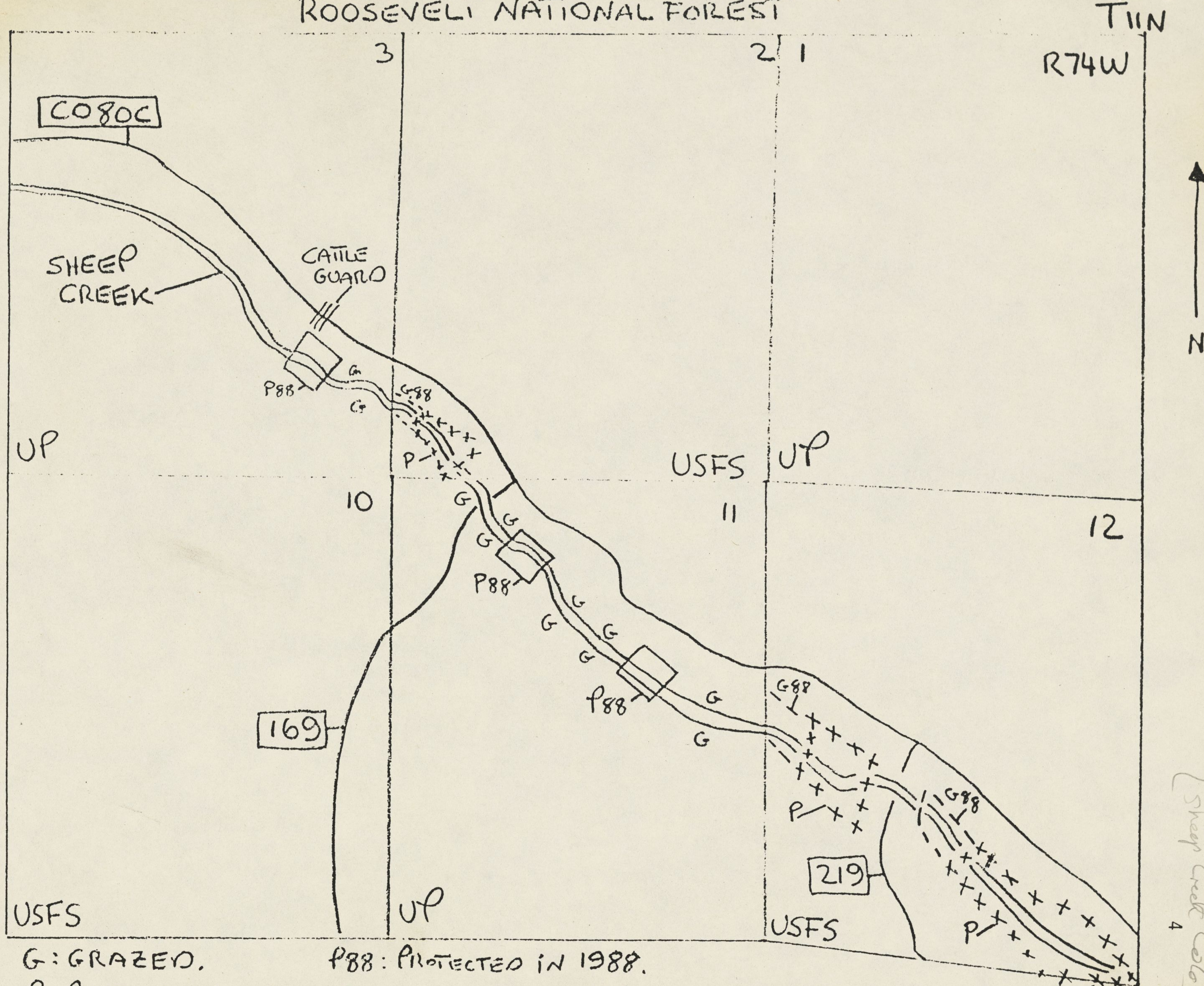
ROOSEVELT NATIONAL FOREST



G: GRAZED. P88: PROTECTED IN 1988.
P: PROTECTED IN 1956. G88: GRAZED IN 1988.

[Sheep Creek Colo]

4

INFORMATION ON SHEEP CREEK ALLOTMENT

AREA:
- 13,200 ac with 2600 ac primary range
- majority of area is lodgepole pine.

RANGE TYPES:
- Sagebrush-grass (Wyoming bunchgrass)
- Mountain meadow (wet areas and adjacent to streams)

RANGE CONDITION:
- Determined in 1964 and 1978
- Condition--fair
- Trend--static to upward

HISTORICAL LIVESTOCK USE:
- Cattle allotment

Early 1900s	1175 AUM
1949-1962	897 AUM
1962-1974	740 AUM
1974-present	456 AUM

GRAZING SEASON:
-June 20 - September 30

PROBLEMS:
- Cattle distribution and use
- Conflict of uses
- Mix of public and private lands

PREDICTION OF RUNOFF AND SEDIMENT IN A RIPARIAN ZONE USING ANSWERS

Mohammad Noor and Freeman M. Smith

Riparian zones are important for maintaining water quality in streams. These areas are often subject to impacts from heavy livestock grazing. Sheep Creek exclosures have a 30-year history of livestock exclusion. Impacts of livestock grazing on soil compaction, infiltration, and vegetation composition have been utilized as input into the ANSWERS model. Predicted impacts of livestock grazing on surface runoff and sediment yield from the Sheep Creek riparian area were simulated. ANSWERS is a distributed and physically based model, and utilizes a single rainfall event for the simulation. Parameters can be measured or estimated.

The riparian study area was divided into 77 square elements. The area is homogenous and flat. The size of each element was 147.6 square feet (0.5 acres). The model simulation provides an estimate of erosion and sediment deposition within the riparian zone. The total sediment load detached in an element is calculated during each time step of one minute. This amount is compared to the transport capacity of the surface flow at that time to estimate the net sediment yield of each element during and immediately after a storm. A continuity equation in backward differential form along with Manning's equation is used to integrate the collective behavior of individual elements on the entire watershed.

The model simulations were run for a 2.48-inch hourly rainfall event. Intensities were taken from a model storm. The model parameters were estimated on site as far as possible. Best estimates were used from the literature for parameters that could not be determined on site.

The ANSWERS simulation predicted only 0.004 inches runoff from the excluded area, and 0.014 inches in the adjacent grazed area (Table 1). The model predicted zero (0) sediment yield from the exclosure, and 6 lbs/acre from the grazed areas. The maximum erosion rate for a grid element in the exclosed and grazed area was 17 and 1300 lbs/acre, respectively. The low runoff and sediment loss from both the sites can be attributed to the following:

1. The soil at Sheep Creek is classified in "A" hydrologic group. The soils in this group have high infiltration rates and low potential for surface runoff. The infiltration rates are high in both the exclosures and grazed areas.
2. The soil at the study site is a clay loam, deep, well aggregated, high porosity, and very high organic matter content (15%).
3. Both grazed and ungrazed areas are relatively flat (3% slope).
4. The vegetation cover is greater than 70% in both the areas.
5. The root systems bind soil particles and reduce soil loss.
6. The transport potential of overland flow was inadequate because of the flat topography and high infiltration to transport the detached sediment off the elements to the watershed outlet.

Table 1. Summary of predicted watershed responses for a 2.48-inch hourly rainfall event.

Hydrologic characteristics	Excluded area (96% plant cover)	Grazed area (80% plant cover)
Infiltration parameters (in/hr)		
FC = steady state rate	5.87	1.64
A = maximum infiltration rate - FC	1.41	0.40
Runoff (in)	0.004	0.014
Average soil loss (lbs/ac)	0	6
Maximum erosion rate (lbs/ac)	17	1300
Standard deviation (lbs/ac)	7	332

Assumption: no overland flow received from the adjacent areas.

TROUT HABITAT, ABUNDANCE, AND FISHING OPPORTUNITIES IN FENCED VS UNFENCED RIPARIAN HABITAT ALONG SHEEP CREEK, COLORADO

Robert J. Stuber

Fencing was used to protect 40 hectares of riparian stream habitat along 2.5 km of Sheep Creek, Colorado, from adverse impacts caused by heavy streamside recreation use and cattle grazing. Fish habitat within the fenced areas was narrower, deeper, and had less streambank alteration, and better streamside vegetation than comparable unfenced sections. Estimated trout standing crop was twice as great, and proportional stock density (PSD) was higher in exclosures than in unfenced sections. There was a higher proportion of nongame fish present in unfenced sections. Projected fishing opportunities within the fenced sections were double those estimated for a comparable length of unfenced habitat along the same stream.

IMPACTS OF LIVESTOCK GRAZING ON NONGAME WILDLIFE POPULATIONS IN A MONTANE RIPARIAN AREA

Terry Tucker Shulz and Wayne Leininger

Bird and small mammal populations were examined in a montane riparian zone in northcentral Colorado following 30 years of cattle exclusion and continued, but reduced, grazing pressure. Strip transects were censused for birds within the riparian zone from May through June, 1986. Wilson's warbler (*Wilsonia pusilla*) was found only inside livestock exclosures, and Lincoln's sparrow (*Melospiza lincolnii*) was twice as abundant in the exclosures when compared with grazed areas. Conversely, the American robin (*Turdus migratorius*) was twice as abundant in grazed areas when compared with numbers observed within livestock exclosures. Other species, such as ruby-crowned kinglet (*Regulus calendula*) and dark-eyed junco (*Junco hyemalis*), appeared to be unaffected ($P>0.05$) by cattle grazing. Small mammals were kill trapped from July through August, 1986. The western jumping mouse (*Zapus princeps*) was the dominant small mammal in the exclosures, while the deer mouse (*Peromyscus maniculatus*) dominated the grazed areas. Exclusion of cattle from the riparian zone led to changes in the vegetation structure, resulting in changes in the species composition of nongame communities, while the level of diversity was maintained.

Important Birds at Sheep Creek

Barn owl
Great horned owl
Mountain bluebird
Wilson's warbler
Lincoln's sparrow
Chipping sparrow
Great-headed junco
Tree swallow
American robin
Ruby-crowned kinglet
White-crowned sparrow
Cassin's finch
Empidonax flycatcher
Mountain chickadee
Clark's Nutcracker
MacGillivray's warbler
House wren
Warbling vireo
Broad-tailed hummingbird
Brown-headed cowbird
Western tanager
Killdeer
Pine siskin
Yellow-bellied sapsucker
Common flicker
Yellow-rumped warbler

Important Mammals at Sheep Creek

Black bear - *Ursus americanus*
Mink - *Mustela vison*
Badger - *Taxidea taxus*
Coyote - *Canis latrans*
Yellowbelly marmot - *Marmota flaviventris*
Richardson ground squirrel - *Citellus richardsoni*
Golden-mantled ground squirrel - *Citellus lateralis*
Least chipmunk - *Eutamias minimus*
Masked shrew - *Sorex cinereus*
Montane shrew - *Sorex monticolus*
Deer mouse - *Peromyscus maniculatus*
Western jumping mouse - *Zapus princeps*
Mountain vole - *Microtus montanus*
Longtail vole - *Microtus longicandus*
Northern pocket gopher - *Thomomys talpoides*
Beaver - *Castor canadensis*
Porcupine - *Erethizon dorsatum*
Elk (Wapiti) - *Cervus canadensis*
Mule deer - *Odocoileus hemionus*
Moose - *Alces alces*
Mountain cottontail - *Sylvilagus nuttalli*

DIFFERENCES IN RIPARIAN VEGETATION STRUCTURE BETWEEN GRAZED AREAS AND EXCLOSURES

Terry Tucker Schulz and Wayne Leininger

The valuable role that healthy riparian ecosystems play in regional diversity of plant and wildlife communities is just beginning to be recognized. Resource managers need to know how degraded riparian areas respond to changes in management, such as reduction or elimination of grazing. Differences in vegetation structure were examined in a montane riparian zone in northcentral Colorado after 30 years of cattle exclusion and continued, but reduced, grazing pressure. Canopy coverage, density, and standing crop of important riparian species were measured in 1985 and 1986 to assess the changes in the riparian community. Total vascular vegetation, shrub, and graminoid canopy cover was greater ($P \leq 0.05$) in the exclosures as compared to grazed areas, while forb canopy cover was similar ($P > 0.05$) between treatments. Exclosures had nearly 2 times the litter cover, while grazed areas had 4 times more bare ground. Willow canopy coverage was 8½ times greater in protected areas than in grazed areas. Kentucky bluegrass (*Poa pratensis* L.) cover was 4 times greater in grazed areas than exclosures, while the cover of fowl bluegrass (*Poa palustris* L.) was 6 times greater on the protected sites. Canopy cover of other important riparian species, such as tufted hairgrass (*Deschampsia caespitosa*), Nebraska sedge (*Carex nebraskensis*), and beaked sedge (*C. rostrata*), was similar ($P > 0.05$) between treatments. Mean peak standing crop over the 2 years of the study was 2410 kg/ha in the exclosures, and 1217 kg/ha in caged plots within grazed areas. Cattle utilized approximately 65% of the current year's growth of vegetation during the 1985 and 1986 grazing seasons.

RESPONSE OF MONTANE RIPARIAN VEGETATION TO FOUR GRAZING TREATMENTS

Carlo A. Popolizio and Harold Goetz

For more than a century, riparian ecosystems in the western United States have been subjected to a large variety of uses. Livestock grazing has been a principal disturbance in most of these ecosystems, and has often resulted in detrimental impacts to vegetation, soils, streambanks, stream channel morphology, water quality, and fish, wildlife, and invertebrate populations. Live vegetation and debris have been found to be directly responsible for providing energy to streams, habitat for fish, wildlife and other organisms, stability to soils and streambanks, shade to the aquatic environment, and retention and transformation of allochthonous materials.

This study was initiated to evaluate the effects of four different grazing treatments on the composition and structure of riparian vegetation. Grazing treatments included: 1) season-long grazing since the turn of the 19th century (G), 2) protection from grazing since 1988 (P88), 3) protection from grazing since 1956 (P), and 4) grazing since 1988 in long-term protected areas (G88). Measurements of foliar cover, species composition, and relative frequency of riparian vegetation, along with density counts of selected forbs and half-shrubs, were measured in early August 1988 and late June 1989, and will be repeated in early August 1989.

Preliminary results shown in Fig. 1, from data collected in August 1988, indicate that grazing treatments had a significant effect on foliar cover and structure of riparian vegetation. Bare ground decreased considerably in treatment P88 when compared to G; bare ground in treatments P resulted from burrowing rodent activity. Grasses and sedges increased in treatment P88 versus G, and decreased in G88 versus P. Litter accumulation was greater in areas protected from grazing since 1956, and was highest in treatment G88 because of removal of foliar cover by grazing. Legume and other prostrate plant cover is inversely correlated with litter accumulation. The species composition of forbs is dominated by dandelion in treatments G and P88; composites are most abundant in P and G88. Grazing favored dandelion; cattle trampling in G88 reduced foliar cover of these composites.

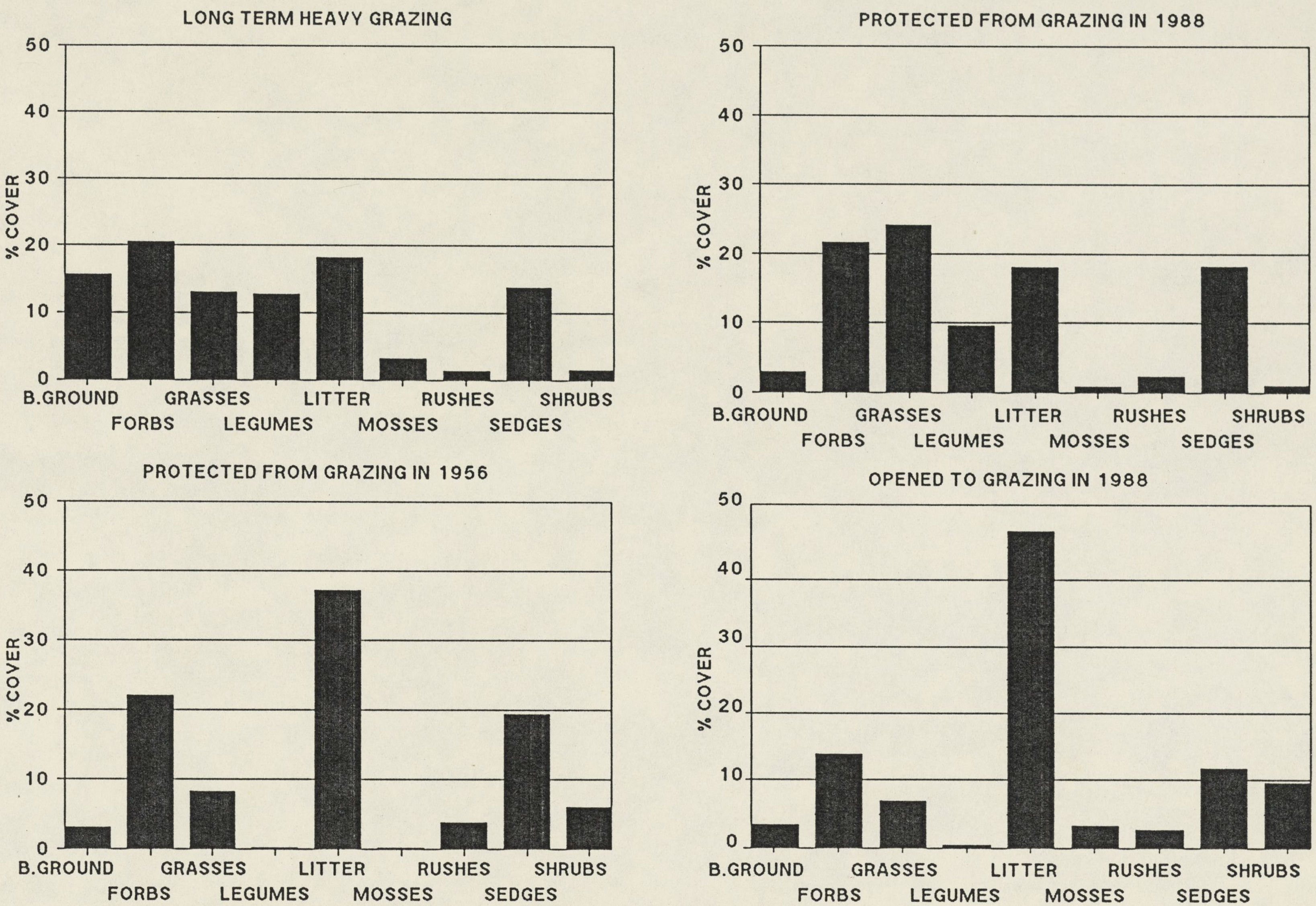


Fig 1: Comparison of % foliar cover for four grazing treatments at Sheep Creek, Colorado.

SOIL-PLANT WATER RELATIONS IN A MONTANE RIPARIAN ECOSYSTEM

Robyn Tierney

Use of montane riparian areas in the western United States by recreationists and livestock operators has markedly altered patterns of riparian vegetative structure and water yield. Grazing has particularly been implicated in the reduction of plant vigor, vegetative cover, and production (Knoph and Cannon 1982). Changes in soil characteristics including increased bulk density and decreased water holding capacity (Marcuson 1977) are also attributed to heavy grazing. These cumulative changes in soil-plant water relations ultimately influence plant community composition, succession, production, and grazing potential (Platts 1982).

Data are being collected to determine water use by eight dominant species (*Salix planifolia, Salix drummondiana, Carex rostrata, Carex nebraskensis, Poa pratensis, Deschampsia caespitosa, Juncus balticus, Taraxacum officinale*) and to predict changes in soil characteristics and community level transpirational losses when grazing induces changes in species composition. Objectives of this study include: 1) determine leaf area for dominant herbaceous and willow species under grazed and protected conditions; 2) quantify transpirational losses and water use efficiencies for dominant species; 3) monitor soil water, soil bulk density, and infiltration rates within grazed and protected riparian sites; and 4) develop a model which can predict plant water use in montane riparian communities. Species specific dynamics in leaf area are being evaluated through the growing season by measuring leaves for area using a portable leaf area meter. Relative cover of herbaceous and graminoid species are estimated from circular quadrats, then clipped, measured for leaf area, and weighed. Regressions between leaf areas and dry leaf weights are then developed for each species. Leaf area index (LAI), or the ratio of area covered by a plant's canopy to the leaf area contained within that canopy, is also calculated from these data.

Reduction of plant litter by the feeding and trampling action of livestock exposes soils to greater radiant energy. Early warming of the soil promotes early germination, emergence, growth, and transpiration. This shift in phenology is supported by differences in water potential (pressure of plant water column) among conspecifics growing on both grazed and exclosed sites (Figure 2).

Transpiration is measured with a null-balance porometer. In an earlier study (Trent, unpubl. 1986), transpirational losses of *Taraxacum* and *Carex* species growing on both grazed and ungrazed sites were higher in grazed areas than in exclosures (Figures 3 and 4). Willows (*Salix* spp.), the dominant shrubs in montane riparian communities are generally considered to be phreatophytes (VanKlaveren et al. 1975). However, lower transpiration rates for planeleaf willow (*S. planifolia*) than for tufted hairgrass (*Deschampsia caespitosa*), Kentucky bluegrass (*Poa pratensis*), sedges (*Carex* spp.), and dandelion (*Taraxacum officinale*) have been observed at Sheep Creek (Figures 5 and 6). *Taraxacum* had the highest mean seasonal transpiration of all herbaceous or graminaceous species in either grazed or ungrazed sites. *Carex nebraskensis*, a sedge most common to ungrazed exclosures, had the second highest mean seasonal transpiration, followed by *Deschampsia* and *Poa*.

Soil cores are being collected and weighed for gravimetric water content and bulk density. Infiltration rates, using a dual-ring infiltrometer in both grazed areas and long-term exclosures, are being measured at the beginning and end of each growing season. Preliminary data indicate that sample distance from the stream does not have a significant influence on soil moisture or willow transpiration, and that the grazed areas are wetter than the exclosures at a 0-5-cm depth, while the converse is true for depths greater than 20 cm.

A simulation model will be adapted and modified from the H20TRANS model developed by Dr. Steve Running (1984). State variables will include soil, stem, and leaf water content, stomatal conductance, and transpiration. Driving variables will include Julian calendar date, precipitation, average day temperature, and daylength. First year measurements of soil water and plant water use will be used to develop the model and parameters for state variables. Data collected in the second year will be used to validate the model.

This research should show that long-term, grazing-induced shifts in species composition and soil characteristics have marked effects upon species phenologies, transpiration, water use, and growth. Information from this study and model may be used by land managers to develop management plans for similar areas.

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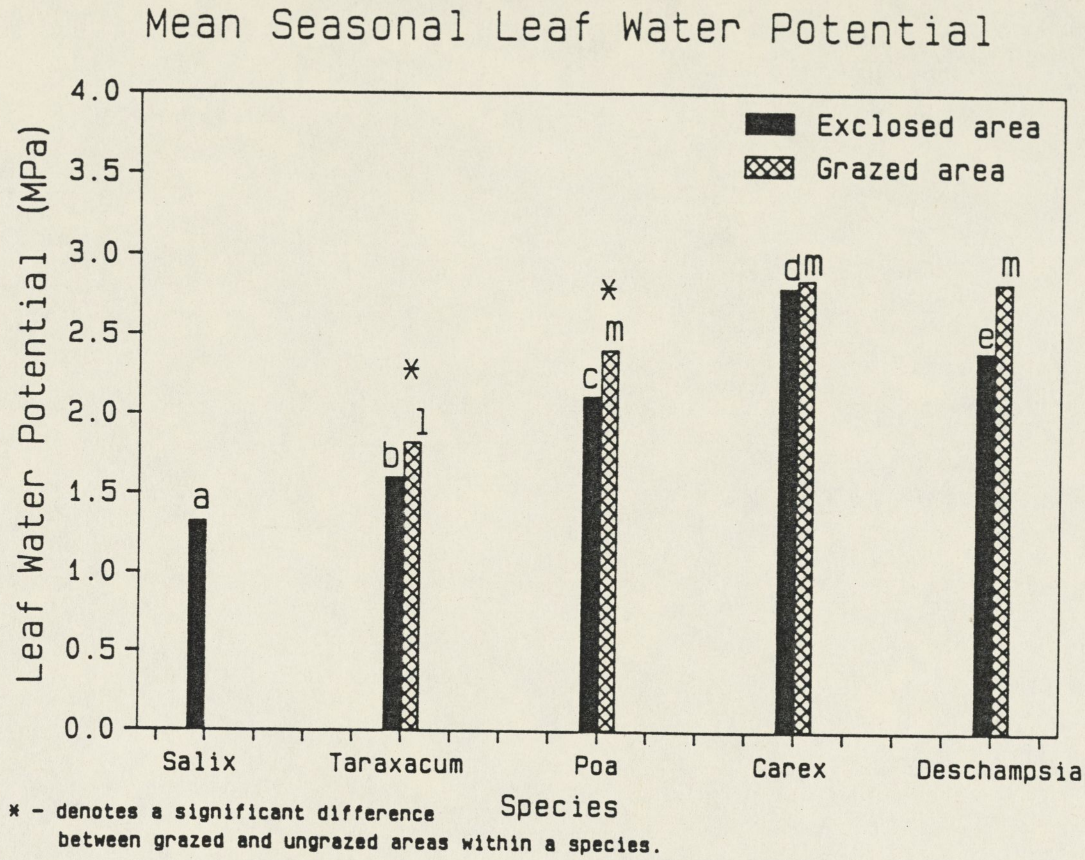

Fig. 2. Summary of two sample t-tests of leaf water potential averaged across sampling dates for 5 study species in exclosed and grazed sites.

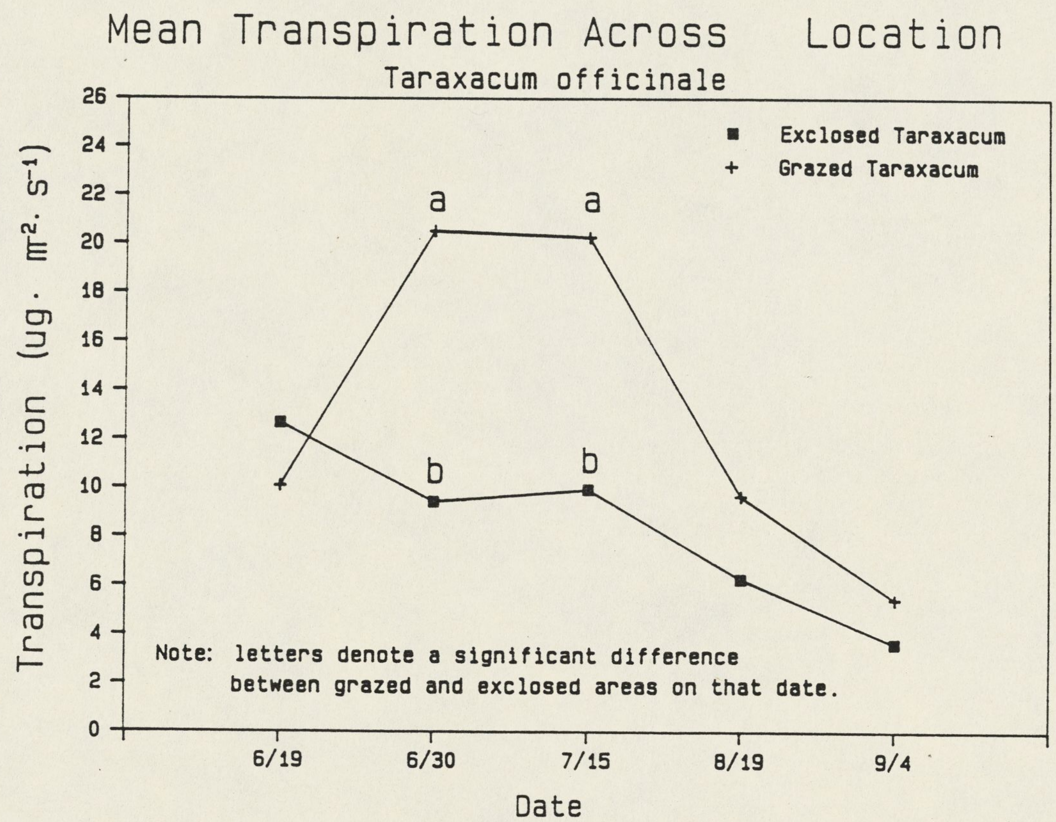

Fig. 3. Summary of two sample t-tests of transpiration from Taraxacum officinale collected on 5 dates in exclosed and grazed sites.

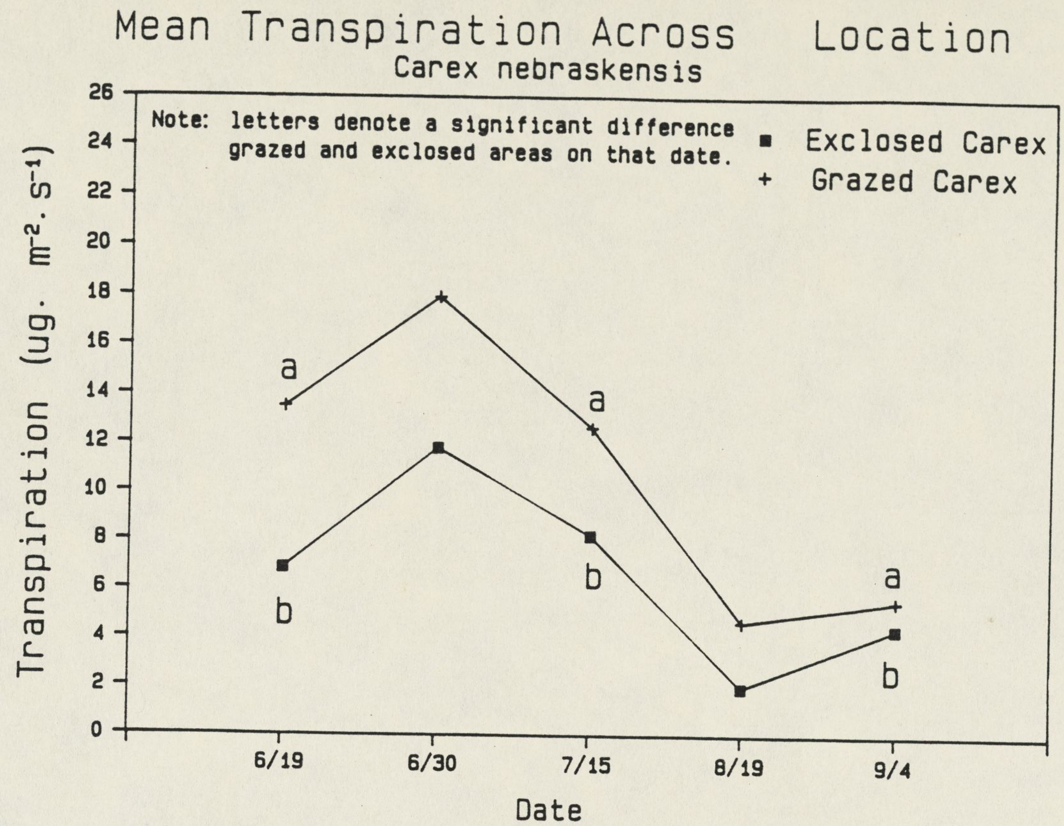

Fig. 4. Summary of two sample t-tests of transpiration from Carex nebraskensis collected on 5 dates in exclosed grazed sites.

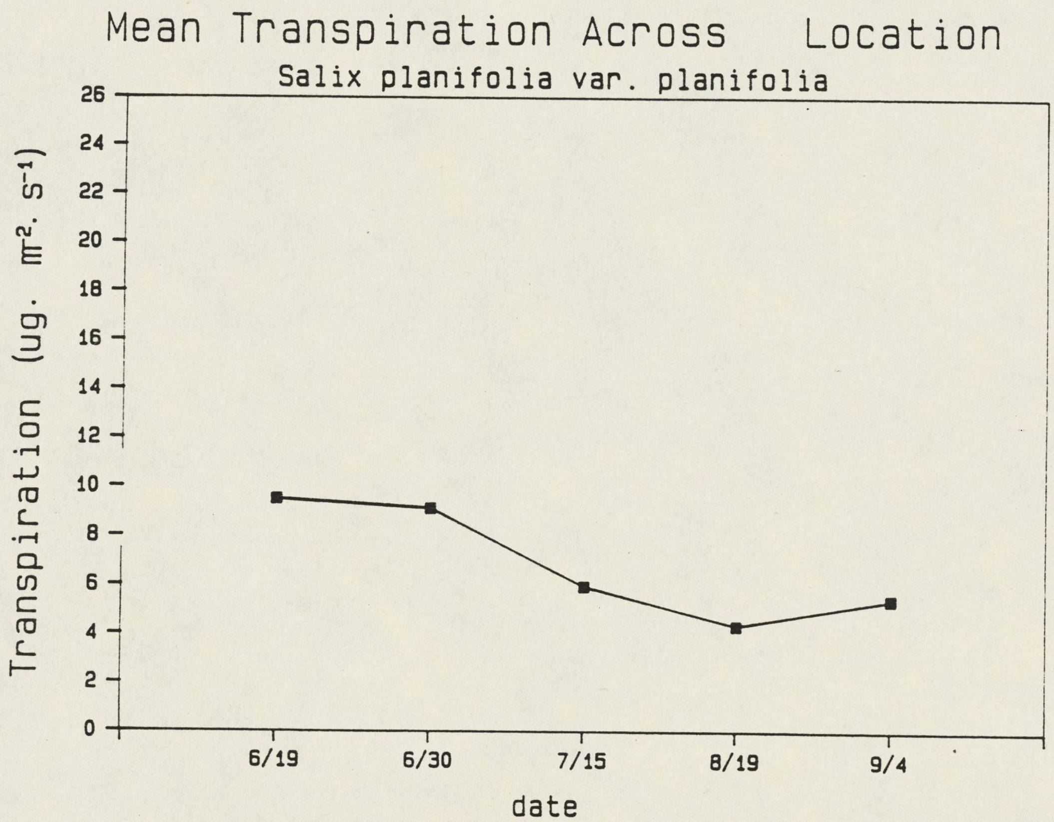

Fig. 5. Summary of mean transpiration values from Salix planifolia collected on 5 dates in the exclosed sites.

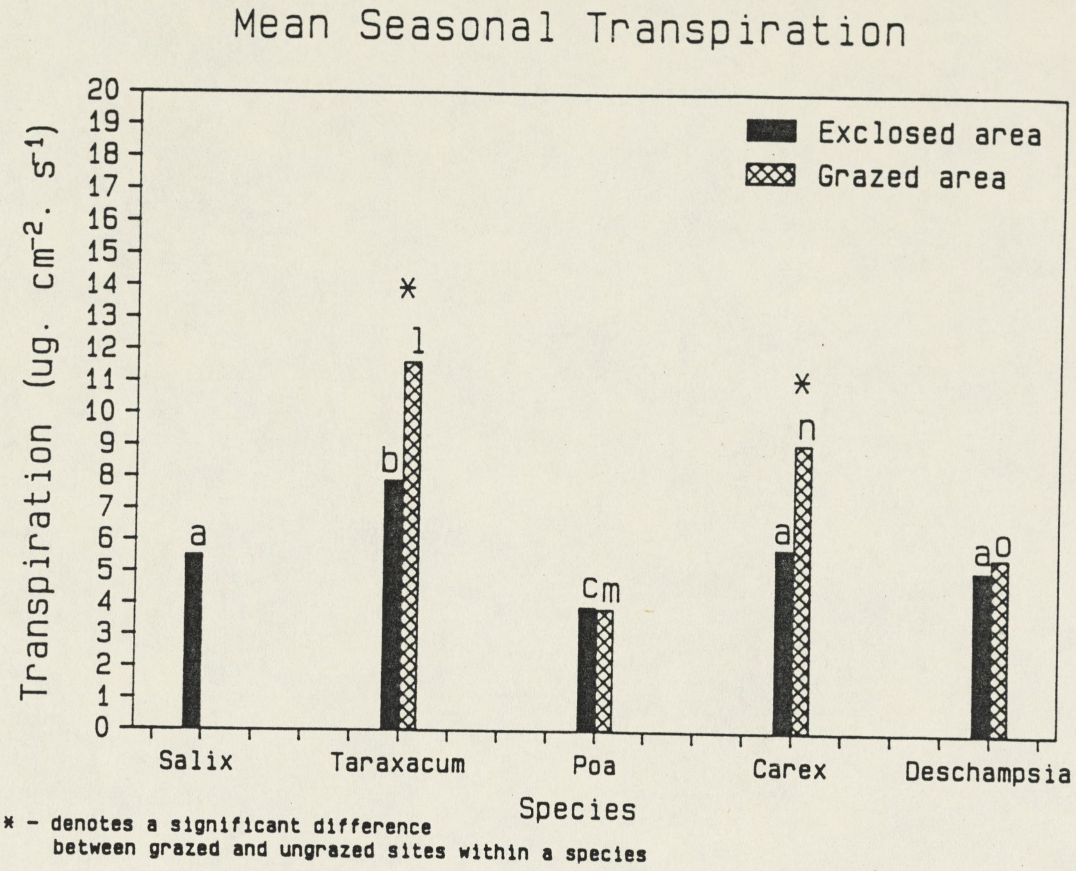

Fig. 6. Summary of two sample t-tests of transpiration averaged across sampling dates for 5 study species in exclosed and grazed sites.

DEFOLIATION OF TWO IMPORTANT MONTANE RIPARIAN SPECIES

Amanda Clements

The riparian zone has many demands placed upon it. Unfortunately, these uses often conflict with each other. For example, use of riparian areas for recreation or livestock grazing may be detrimental to water quality. Land managers need to establish which levels and combinations of uses allow the riparian area to sustain itself and continue to function as wildlife and livestock habitat and a buffer zone for water quality and quantity.

Previous research at Sheep Creek indicated reduced canopy coverage and density of willows (*Salix* spp.) in the grazed areas as compared to exclosures. Nebraska sedge (*Carex nebraskensis*), however, did not exhibit significantly different canopy coverage in response to grazing. In this present research, Nebraska sedge and planeleaf willow (*Salix planifolia*) were selected for study because they have different morphologies and exhibit very different responses to grazing. With respect to water quality, both play a part, as both are important members of the riparian community. Willow's deeply penetrating, woody roots are particularly effective in stabilizing streambanks. Mats of vegetation, such as the rhizomatous Nebraska sedge, reduce erosion and filter sediment from surface runoff.

This study was designed to quantify the effects of timing and intensity of defoliation on planeleaf willow and Nebraska sedge. Plants of both species are being defoliated at four different stages of growth (early leafing, flowering, seed ripe, and senescence) at three levels of foliage removal (approximately 30, 60, and 90%).

Vigor of the treated plants will be assessed through several measurements. For Nebraska sedge, these include measurements at the end of the growing season of leaf length, plant height, number of flowering culms, density of shoots, production, and root total nonstructural carbohydrate (TNC) concentrations. Plants defoliated at senescence (fall, 1988) were more affected by site differences relative to shoot survival than degree of defoliation. The response of planeleaf willow to defoliation will be evaluated through measurements of: current year's growth, changes in morphology, TNC concentrations in twigs, and basal circumference.

This research should indicate the phenological stages at which these species are most vulnerable to defoliation. Furthermore, the data from the different levels of foliage removal should show those defoliation intensities that are most harmful to the plants. We hope this information will contribute to the development of grazing systems suited to montane riparian areas. More knowledge on the effects of timing and intensity of defoliation on key riparian species may also help us use livestock grazing as a tool for management. The riparian areas might then be actively managed in an environmentally sound way to maximize those resources of greatest demand.

EFFECTS OF DEFOLIATION AND NITROGEN FERTILIZATION ON COMPETITIVE ABILITY, BIOMASS ALLOCATION AND CARBOHYDRATES RESERVES OF *Deschampsia caespitosa* and *Carex nebraskensis*.

Maria Bemhaja

Many riparian areas have been subjected to improper use in the past. Several studies have suggested that proper use, including proper grazing management, can provide restoration needed for riparian habitats. The utilization of plants by herbivores should be done in such a way that the use of aboveground production is balanced with the development of root systems.

A greenhouse study is underway to determine how a native perennial grass (*Deschampsia caespitosa*) and a sedge (*Carex nebraskensis*), growing in a soil collected near Sheep Creek, respond to three different factors: 1) frequency of defoliation (2, 4 or 6 weeks), 2) intensity of defoliation (2.5 or 5.0 cm of stubble), and 3) nitrogen fertilization (0 or 100 kg $N0_3$/ha). Plant parameters of above- and belowground biomass, and carbohydrates reserves will be used to access the health or vigor of these two important herbaceous species of mountain riparian communities. Competitive ability and persistence of these two desirable species, either alone or in a mixture (50-50), under the three clipping levels will also be accessed.

Four hypotheses are proposed:

1) A period of 6 weeks between clipping treatments will result in no significant differences in biomass of either species, whereas clipping at 2 weeks intervals will significantly reduce both above- and belowground biomass.
2) A moderate intensity of use (5 cm stubble height) will have no significant effect on measured parameters, but a high intensity of use (2.5 cm stubble height) will cause a decrease in vigor and production of both species.
3) Addition of nitrogen will significantly increase aboveground production of both species.
4) *Carex* will be a better competitor when grown in mixture with *Deschampsia* and will withstand greater defoliation pressure.

EFFECTS OF GRAZING UPON SECONDARY COMPOUNDS IN PLANELEAF WILLOW (*Salix planifolia*)

Nancy E. Hastings

Secondary compounds are substances involved in secondary metabolic activities, as opposed to the better understood primary activities such as growth, development, and reproduction. The actions of these compounds include 1) pollination attractants, 2) allelopathic compounds, and 3) antiherbivore properties. The third property, antiherbivory, is the topic of this study.

Herbivorous activity by mammals can affect the nutritive value of woody plants (Bryant et al., in press). Food quality or palatability can decrease as a result of browsing (Bryant et al. 1983 and 1985, Provenza and Malechek 1983). However, such decreases are not always caused by browsing (Provenza and Malechek 1984, Danell and Huss-Danell 1985). Additional factors that should be considered include: 1) seasonality of herbivory (i.e., whether herbivore is summer defoliation or winter pruning), 2) age of plant (i.e., mature or juvenile), and 3) availability of soil nutrients.

The Sheep Creek study areas has four different treatments that are being examined. Three older exclosures have been closed to grazing for 30 years, and browsing by wildlife appears to be minimal. The newly released areas have been open to livestock grazing since the summer of 1988, and, conversely, the newly exclosed areas have been closed to grazing for the past year. The fourth treatment is open range that has been heavily grazed by livestock since the turn of the century.

Mature planeleaf willow (*Salix planifolia*) leaves are being collected from each of these treatments. These leaves are dried and examined for levels of nitrogen, condensed tannins, and phenolic glycosides. The specific phenolic glycosides will also be determined, as these compounds are different in different species of willow. An in vitro dry matter digestibility (IVDMD) assay will also be performed to determine the inhibitory effects on ruminant digestion.

The hypotheses to be examined in this study are:

1) Levels of nitrogen, that may be an indicator of nutrient levels possessed by the planeleaf willow, will be lower in plants from the old exclosures than in those from the newly released treatment and on the open range.
2) Levels of condensed tannins and phenolic glycosides will be higher in mature plants in the exclosure in comparison with plants in areas now open to grazing.
3) The competition for carbon within the plant in winter-pruned plants will result in decreased levels of phenolic glycosides and condensed tannins.

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PLANT LIST FOR SHEEP CREEK

Alliaceae - Onion Family
Allium geyeri Wats. - wild onion

Boraginaceae - Borage Family
Cryptantha virgata (Porter) Payson - miners candle
Cynoglossum officinale L. - hounds tongue
Mertensia ciliata (James) G. Don. - tall mertensia
Mertensia lanceolata (Pursh) A. D.C. - narrow-leaved mertensia

Cactaceae - Cactus Family
Mammillaria spp. - ball cactus
Opuntia spp. - prickly pears

Campanulaceae - Bellflower Family
Campanula rotundifolia L. - common harebell

Caryophyllaceae - Pink Family
Cerastium arvense L. - field mouse-ear
Cerastium fontanum Baumg.

Compositae (Asteraceae) - Sunflower Family
Achillea lanulosa Nutt. - yarrow
Agoseris glauca (Pursh) Raf. - pale agoseris
Antennaria parvifolia Nutt. - pussytoes
Antennaria rosea Greene - pussytoes
Arnica chamissonis Less. - leafy arnica
Arnica fulgens Pursh. - orange arnica
Artemisia frigida Willd - pasture sagebrush
Artemisia tridentata Nutt. mountain sagebrush
Aster hesperius Gray
Cirsium flodmanii (Rydb.) Arthur
Erigeron formosissimus Greene
Erigeron lonchophyllus Hook.
Liatris puntata Hook. - blazing star
Ligularia taraxacoides (Gray) W. A. Weber
Rudbeckia hirta L - black-eyed Susan
Senecio spp.
Solidago canadensis L. - Canada goldenrod
Taraxacum officinale Wiggers - common dandelion

Crassulaceae - Stonecrop Family
Sedum lanceolatum Torr. - stonecrop

Cruciferae (Brassicaceae) - Mustard Family
Rorippa curvipes Greene

Cyperaceae - Sedge Family
Carex aquatilis Wahl.
Carex festivella Mack.
Carex foenea Willd.
Carex microptera Mack.
Carex nebraskensis Dewey
Carex praticola Rydb.
Carex rostrata Stokes
Eleocharis pauciflora (Light.) Link

Elaeagnaceae - Oleaster Family
Shepherdia canadensis (L.) Nutt. - buffaloberry

Equisetaceae - Horsetail Family
Equisetum arvense L. - field horsetail

Ericaceae - Heath Family
Arctostaphylos uva-ursi (L.) Spreng. - kinnikinnik, bearberry
Vaccinium spp. - blueberry

Fumariaceae - Fumitory Family
Corydalis aurea - golden smoke

Gentianaceae - Gentian Family
Gentianella amarella (L.) Boern. - little gentian

Geraniaceae - Geranium Family
Geranium richardsonii F. & T. - white geranium

Gramineae (Poaceae) - Grass Family
Agropyron trachycaulum (Link) Malte. - slender wheatgrass
Agrostis scabra Willd. - ticklegrass
Agrostis stolonifera L. - redtop
Alopecurus pratensis L. - meadow foxtail
Bromus tectorum L. - cheatgrass
Danthonia parryi Scribn. - Parry oat-grass
Deschampsia caespitosa (L.) Beauv. - tufted hairgrass
Eleocharis pauciflora (Light.) Link
Hordeum brachyantherum Nevski. - meadow barley
Hordeum jubatum L. - foxtail barley
Koeleria cristata (L.) Pers. - junegrass
Muhlenbergia richardsonii (Trin.) Rydb. - mat muhly
Phleum alpinum L. - alpine timothy
Phleum pratense L. - timothy
Poa arida Vasey. - plains bluegrass
Poa interior Rydb. - inland bluegrass
Poa palustris L. - fowl bluegrass
Poa pratensis L. - Kentucky bluegrass
Poa secunda Presl. - Sandberg bluegrass

Grossulariaceae - Currant or Gooseberry Family
Ribes aureum Pursh - golden currant
Ribes inerme Rydb.

Iridaceae - Iris Family
Iris missouriensis Nutt. - wild iris
Sisyrinchium montanum Greene - blue-eyed-grass

Juncaceae - Rush Family
Juncus spp.

Labiatae (Lamiaceae) - Mint Family
Mentha arvensis L. - field mint

Leguminosae (Fabaceae) - Pea Family
Astragalus alpinus L. - alpine milkvetch
Lupinus spp.
Oxytropis lambertii Pursh - Colorado locoweed
Oxytropis splendens Dougl. - showy locoweed
Thermopsis divaricarpa Nels. - golden pea
Trifolium pratense L. - red clover
Trifolium repens L. - white Dutch clover

Liliaceae - Lily Family
Calochortus nuttallii Torr. & Gray - sego lily
Smilacina stellata (L.) Desf. - few-flowered false Solomon's seal
Zygadenus elegans Pursh - death camas

Onagraceae - Evening-primrose Family
Epilobium angustifolium (L.) Holub. - fireweed
Epilobium paniculatum Nutt. - annual willow-herb
Oenothera caespitosa Nutt. - white stemless evening primrose

Orchidaceae - Orchid Family
Corallorhiza maculata Raf. - spotted coralroot
Corallorahiza trifida Chat. - little yellow coralroot

Pinaceae - Pine Family
Abies lasiocarpa (Hook.) Nutt. - subalpine fir
Juniperus communis L. - common juniper
Pinus contorta Dougl. - lodgepole pine
Pinus flexilis James - limber pine
Pinus ponderosa Laws - Ponderosa, bull, or yellow pine

Polygonaceae - Buckwheat Family
Eriogonum subalpinum Greene
Eriogonum umbellatum Torr. - sulphur-flower
Polygonum bistortoides [*Bistorta bistortoides* (Pursh) Small] - bistort
Polygonum viviparum [Bistorta vivipara (L.) S. Gray] - bistort
Rumex occidentalis Wats. - Western dock

Primulaceae - Primrose Family
Androsace filiformis Retz.
Androsace septentrionalis L. - rock primrose
Dodecatheon pulchellum (Raf.) Merrill - shooting star

Ranunculaceae - Buttercup Family
Aquilegia caerulea James - Colorado blue columbine
Caltha leptosepala D.C. - marsh marigold
Delphinium barbeyi Huth - Barbey's delphinium
Delphinium nelsonii Greene
Thalictrum alpinum L. -alpine meadow rue

Rosaceae - Rose Family
Fragaria ovalis (Lehm.) Rydb. - strawberry
Geum macrophyllum Willd. - large-leafed avens
Geum trifolium Willd. - large-leafed avens
Potentilla diversifolia Lehm.
Potentilla fruticosa L.

Rubiaceae - Madder Family
Gallium boreale L.

Salicaceae - Willow Family
Populus tremuloides Michx. - quaking aspen
Salix amygdaloides Anderss - peachleaf willow
Salix drummondiana Barrat in Hook. - Drummond willow
Salix exigua Nutt. - sandbar willow
Salix lutea Nutt. - yellow willow
Salix planifolia Pursh - planeleaf willow
Salix wolfii Bebb in Rothr. - wolf willow

Scrophulariaceae - Figwort Family
Castilleja linariaefolia Benth in D.C. - Wyoming paintbrush
Castilleja sulphurea Rydb. - yellow paintbrush
Mimulus guttatus D.C. - common yellow monkey-flower
Pedicularis groenlandica Retz - elephantella
Penstemon secundiflorus Benth. - one-sided penstemon
Penstemon whippleanus Gray

Umbelliferae (Apiaceae) - Parsley Family
Pseudocymopterus montanus (Gray) C. & R. - yellow mountain parsley

Violaceae - Violet Family
Viola spp.

Fish, Invert.

III. technique

- invert-
  F.S.,
- BCI. ,

- direct dam - destabil - ~~dewag~~ - runoff -

- braid or trench
  depth, vel., cover

- cattle - riparian
  i.

The Final EIS for the White River Dam Project is not to be construed as reflecting the present or future position of any state of the Upper or Lower Colorado River Basin or of the Federal Government with regard to interpretation and application of the treaties, compacts, and laws which do or may affect the allocation of water among the states and among private claimants within each state. In particular, nothing in this EIS is intended to interpret the provisions of the Colorado River Compact (45 Stat. 1057), the Upper Colorado River Basin Compact (63 Stat. 31), the Water Treaty of 1944 with the United Mexican States (Treaty Series 994, 59 Stat. 1219), the decree entered by the Supreme Court of the United States in Arizona v. California (376 U.S. 340), the Boulder Canyon Project Adjustment Act (54 Stat. 774; 43 U.S.C. 620), or the Colorado River Basin Project Act (82 Stat. 885; 43 U.S.C. 1501), or to interpret or reach any conclusions regarding future application of the Federal reserved rights doctrine.

Furthermore, this EIS is not intended to represent the present or future position of either the State of Colorado or of the State of Utah or of the United States with regard to matters concerning the apportionment of the waters of the White River.

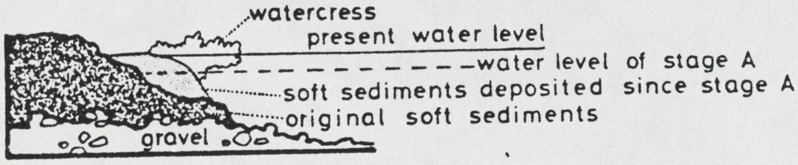
From: White and Brynildson. 1967.

Some stages in natural development of a fertile lowland Wisconsin trout stream from overgrazed (A) to very productive (D-E-F) to overforested (G&H) when protected from grazing. A hypothetical 14-foot wide cross-section plus adjacent bank shown.

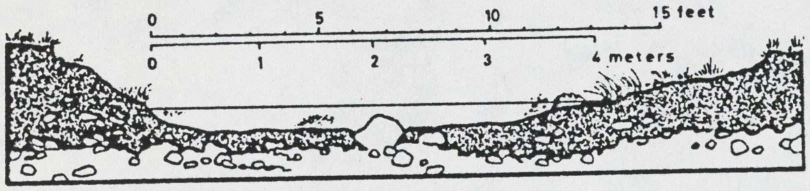
The complete sequence from stage A to stage E-F has been observed on Black Earth and Mt. Vernon Creeks near Madison.

Later succession — stages G and H with many intermediates — is to be seen on other streams. Details of this succession vary from stream to stream, especially after stage E-F, but the passage from predominantly herbaceous to predominantly woody vegetation generally has the same detrimental effects. Good management for trout — and other wildlife — would be control of vegetation to maintain stages D-E-F.

KEY

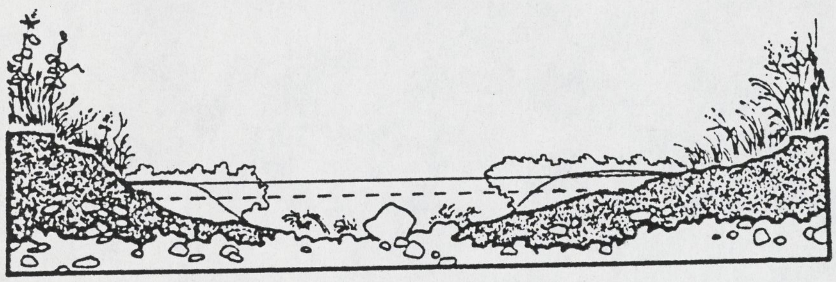


A



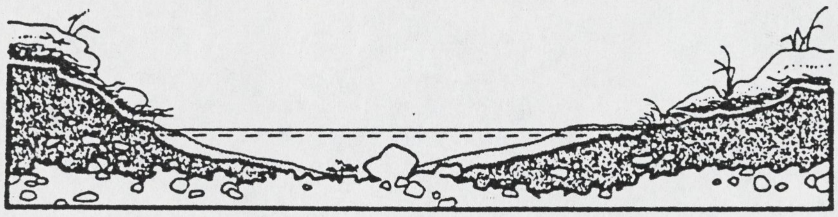
MIDSUMMER CONDITIONS UNDER HEAVY GRAZING BY LIVESTOCK:
Bank vegetation and watercress grazed and trampled. Banks eroding, and stream bed mostly covered by shifting silts. Submergent plants grow poorly. Whole surface of water and stream bed exposed to sun. Greatest depth in cross-section only 9 inches (22 cm). These conditions offer trout no shelter, no place to spawn, little food, and frequently unfavorable temperatures.

B



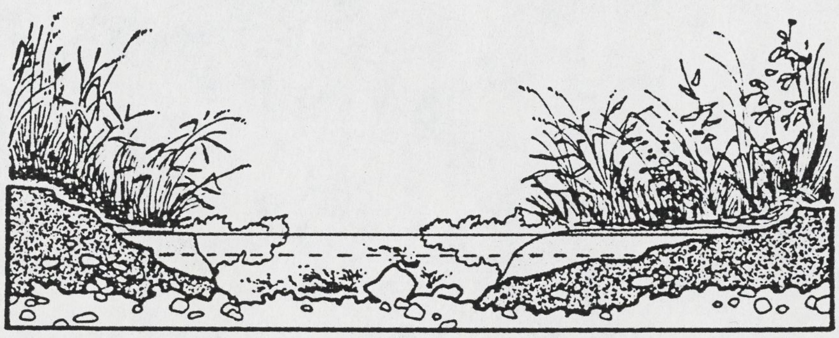
MIDSUMMER CONDITION AFTER 2 TO 4 YEARS OF PROTECTION AGAINST GRAZING:
Bank vegetation forming a turf. Abundant watercress at edges of stream constricts channel, thus deepening and speeding water. Soft sediments scoured from much of stream bed and trapped in cress beds. Submergent plants thriving. Only about half the former stream width exposed to sun. Greatest depth about 20 inches (50 cm). Trout have ample shelter beneath watercress, beside rock, and among submergent plants. Firm stream bed and many plants provide substrate for many animals that trout eat. Newly exposed gravel is a place to spawn.

C

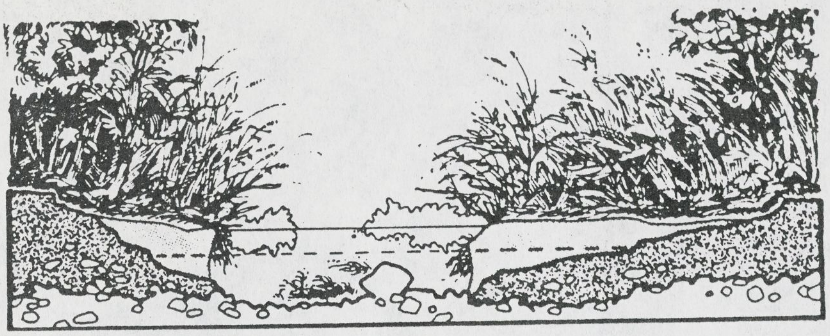


LATE IN THE NEXT WINTER:
Watercress has withered and drifted away. The silts it held slump into the channel, smothering many of the trout eggs buried in gravel and preventing fry from emerging into stream. Food is scarce. Broad surface of water exposed to cold. Shelter for trout almost as poor as at stage A and will not redevelop until May or June.

D

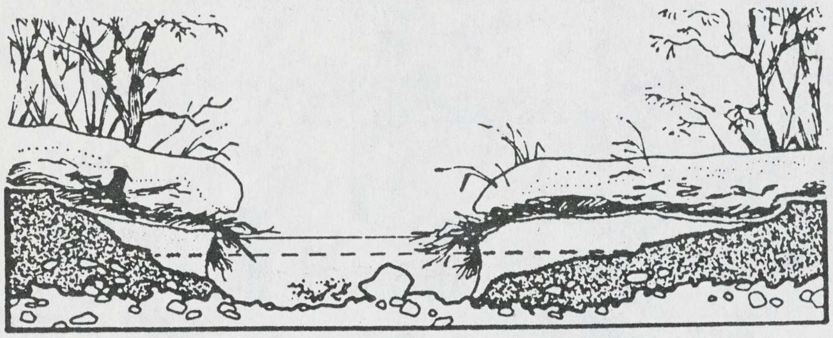


MIDSUMMER CONDITION IN ABOUT 3RD TO 5TH YEAR AFTER GRAZING HALTED:
Further scouring of fine sediments from stream bed. Silt bars at stream edges being tied down by reed canary grass with its tough system of roots and runners. Watercress flourishing, and submergents at peak of development. Only 4 feet of stream width exposed to sky, and this shaded much of day by high grasses. Greatest depth in cross-section about 2 feet (60 cm). For trout, shelter, food, and spawning gravels are ample.



E

MIDSUMMER A FEW YEARS LATER:
Silt bars further stabilized by turf. Channel narrowed by 40% to 50% since stage A. Only 2 feet of stream width exposed; therefore submergents less abundant. Also less volume of watercress due to shade of taller plants. Woody vegetation starting to dominate.

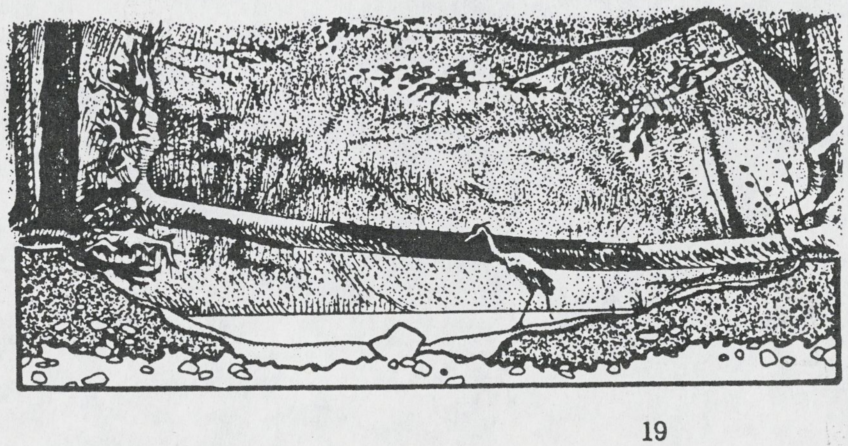


F

LATE WINTER DURING STAGES D AND E:
Turf still holds bank materials firmly. Overhanging fringes of matted grass provide shelter for trout. Gravels remain clean enough to allow normal hatching and emergence of fry.

G

MIDSUMMER 10 TO 20 YEARS LATER:
Alders or other high bushes predominate (saplings of ash, elm or maple at left). Turf completely shaded out. Water level high due to clogging by debris. For trout, food may be scarce, shelter is excellent beneath banks, among roots and fallen branches.
But:
Innermost rows of alders will soon tip into channel, further clogging flow and destroying overhanging bank. The largely vegetational processes of bank-building will not be repeated as long as shade persists.



H

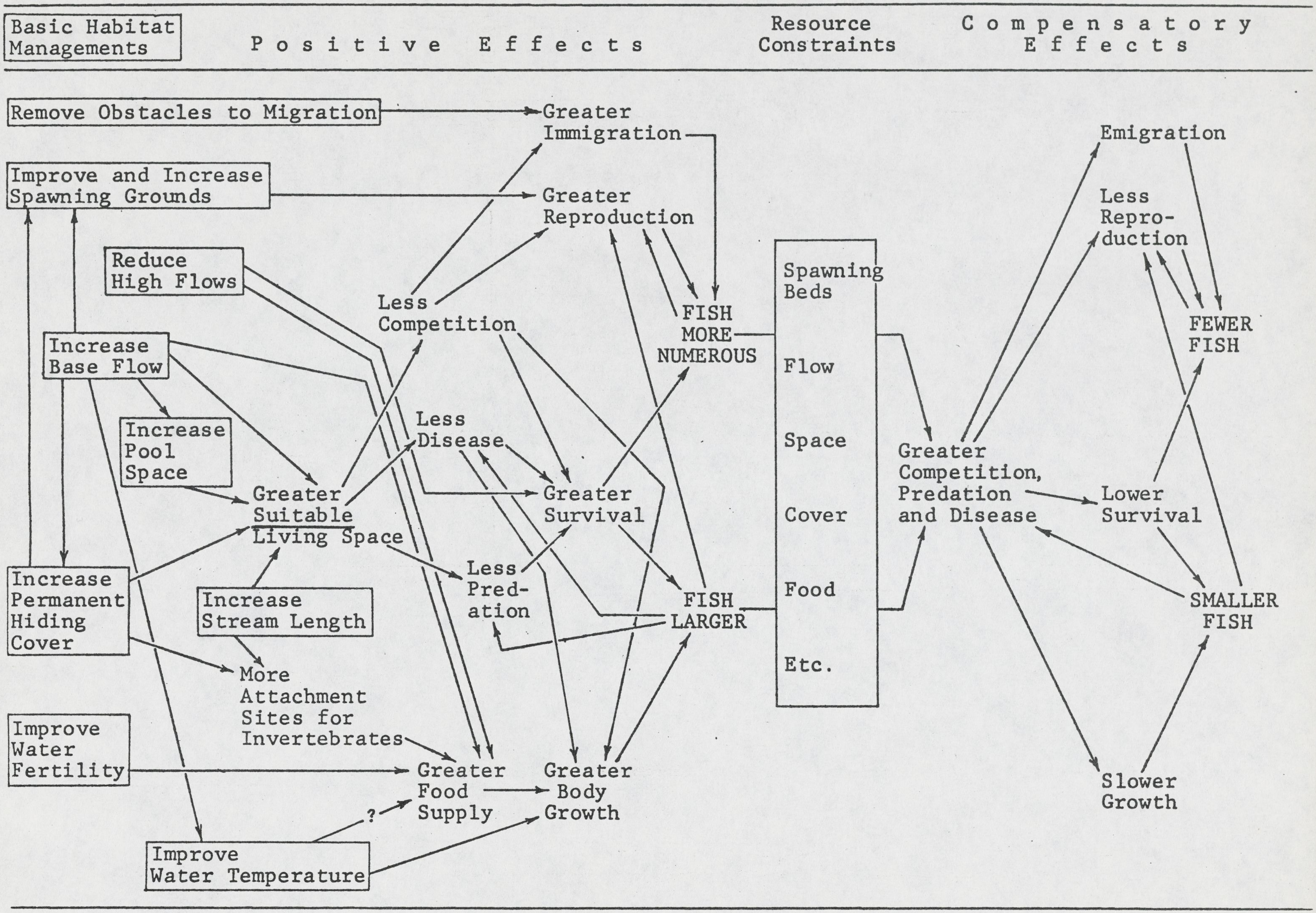
MANY YEARS LATER:
Mature forest . . . Dense shade. Few plants on forest floor. Banks have eroded, channel has spread and silts again cover stream bed. Channel less than 1 foot deep. Little shelter for trout. Even trees undermined by current and toppled across the stream may provide poor hiding cover. Conditions almost as bad as in stage A.

STREAM RECOVERY AFTER FENCING

(AFTER VAN VELSON 1979, OTTER CR., NE)

1. STREAM BANKS REVEGETATE WITH GRASSES (1 YR) AND WILLOWS (2 YR)
2. WATERCRESS ENCROACHES, NARROWING STREAM
3. INCREASED VELOCITY FLUSHES FINES, DEEPENS STREAM, EXPOSES SPAWNING GRAVEL
4. AQUATIC VEGETATION STABILIZES SILT AT MARGINS
5. WATER TEMPERATURE DECREASES
6. RIFFLES AND POOLS BECOME DISTINCT
7. AQUATIC INVERTEBRATES QUICKLY REESTABLISH
8. TROUT SURVIVAL AND REPRODUCTION INCREASE
9. STANDING CROP, ESPECIALLY OF LARGER FISH, INCREASES
10. WARMWATER FISH SPECIES DECLINE

Stream Habitat Managements and Effects



SUMMIT CREEK, IDAHO

(KELLER AND BURNHAM 1982, 4 YR. AFTER FENCING)

	TROUT/HA			TROUT/HA>200 MM		R'BOW LENGTH (MM)		
PAIR	G	U		G	U	G	U	
1	5220	8151	*	965	1869	132	154	*
2	9684	15530	*	568	3100	115	147	*
3	9848	14827	*	571	1202	117	117	ns

* INDICATES SIGNIFICANT DIFFERENCES G VS. U (P<0.05)

Table 1. Published effects on riparian-fishery habitats and fish populations after fencing to eliminate livestock grazing.

Authors	Riparian beneficial effects	Effects on fish population: Increased	Effects on fish population: No change
Berry and Goebel (1978)	X	X	
Buckhouse et al. (1981)	X[a]		
Claire and Storch (1977)	X	X	
Crispin (unpublished)	X	X	
Dahlem (1979)	X	X	
Duff (1977) (1980)	X	X	
Gunderson (1968)	X	X	
Keller et al. (1979)	X		X[a]
Marcuson (1977)	X	X	
Platts (1981a)	X[b]		X
Platts (1981b)	X	X	
Platts (1981c)	X[b]		X
Starostka (1979)	X		X
Storch (1979)	X	X	
Van Velson (1979)	X	X	
Winegar (1977)	X	X	

[a] Insignificant differences.
[b] Small differences.

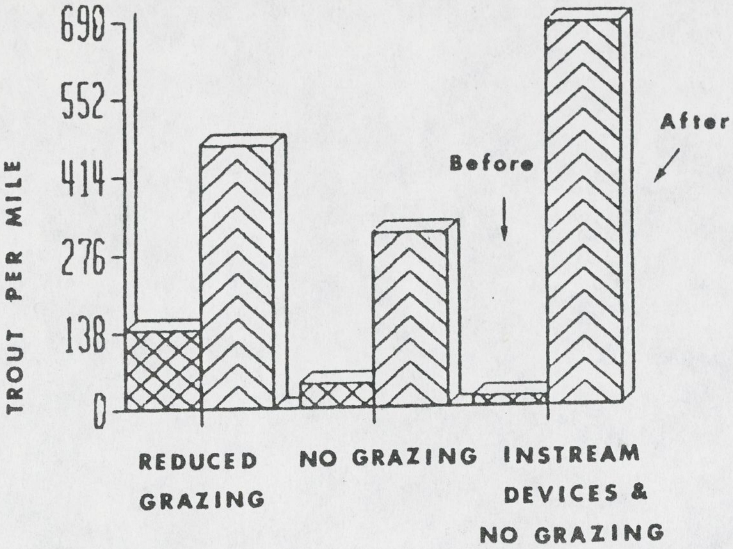


Fig. 1. Response of the Huff Creek trout population to habitat improvement efforts, 1978-84.

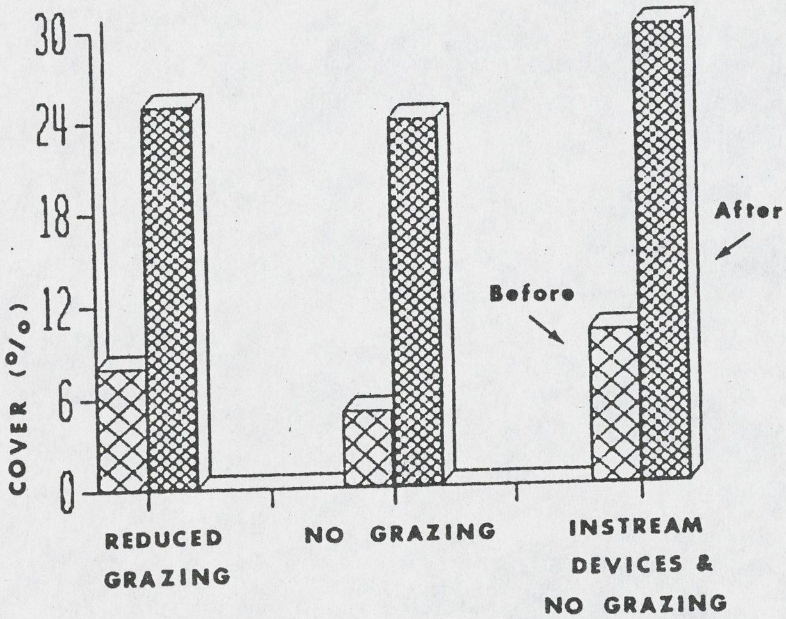


Fig. 4. Cover available for trout in Huff Creek in 1978 and 1984 under three habitat improvement techniques.

From: Binns (1986)

From: Stuber (1986)

Table 1. Comparitive fish habitat characteristics between fenced and unfenced sections of Sheep Creek, Colorado, 1984.

	Fenced	Unfenced
Average width (m)	3.7	5.5
Average depth (m)	0.2	0.1
Width:Depth	18.5	55.0
Streambank alteration (% eroding banks)	Moderate (26-50)	Major (51-75)
Streambank stability (% vegetation)	Good (50-79)	Fair (25-49)
Streamside cover (rating) (dominant vegetation type)	4 (excellent) (shrubs)	2 (fair) (grass/forbs)

Fish Population

Estimated trout standing crop was 97% higher within fenced areas when compared to adjacent unfenced areas (two-year average). Brown trout were the predominant species captured in both fenced and unfenced areas, although some rainbow and brook trout were also captured. Estimated trout standing crop was 96% higher within fenced areas in 1983 (91 kg/ha greater; $P = 0.04$; Figure 2). There was an even larger disparity in 1984, as estimated standing crop was 127% higher (74 kg/ha greater; $P = 0.08$).

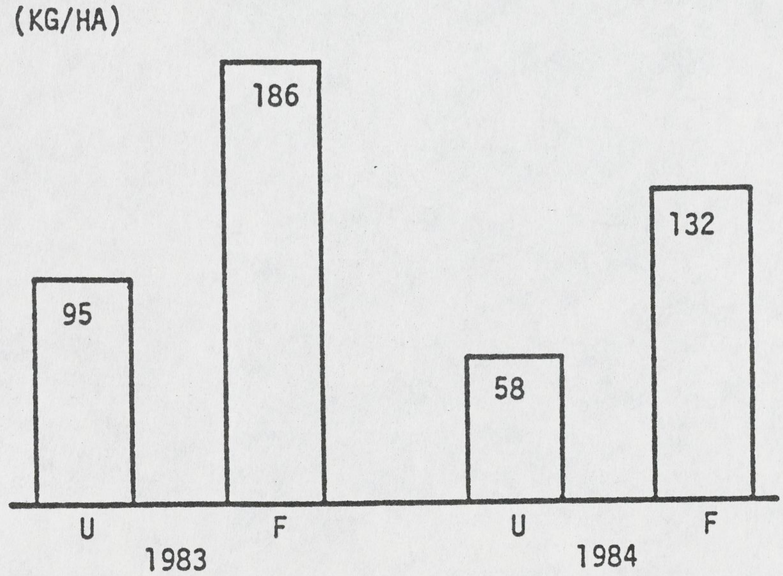


FIGURE 2. Comparative average trout standing crop between unfenced (U) and fenced (F) sections of Sheep Creek, Colorado.

EFFECTS OF GRAZING ON STREAM FISH AND THEIR HABITAT

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Livestock grazing and the aquatic environment

A thorough understanding of relationships between livestock grazing and fisheries is needed to manage range adjacent to coldwater streams

WILLIAM R. MEEHAN and WILLIAM S. PLATTS

LIVESTOCK regularly uses valley bottoms adjacent to streams in the West as grazing and loafing areas. Until recently, the effects of this use on aquatic resources in coldwater streams had not been identified or quantified. As a result, livestock grazing and fisheries generally were and still are managed without a thorough understanding of their interrelationships.

The combined effects of geology, climate, geomorphology, soil, vegetation, and water runoff often result in unstable stream conditions in the natural state. When land uses place additional stress on aquatic habitats, damage usually occurs.

Extent of Range Resources

Rangeland is usually defined as land on which grasses, forbs, or shrubs predominate as the native vegetation. Even commercial forest can be used for livestock grazing. Forest range includes all natural ecosystems that either produce or are

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capable of producing forage (*16*). This encompasses 1.2 billion acres in the 48 conterminous states, 622 million acres in the 11 western states.

In 1970 livestock grazed on 834 million (70 percent) of these forest range acres. This use amounted to 213 million animal unit months (AUM).

Research Interest in Forest Range

Conservation and management of range generally began and focused on the national forests (*59*). National forests resulted directly from the action of leaders who recognized the widespread exploitation and depletion of forest and watershed resources. A system of forest reserves established in 1891 was transferred in 1905 to what has since become the U.S. Forest Service. The areas later were renamed national forests.

Serious concern about national forest land management developed in the late 1920s. The concern focused primariy on grazing lands. Research showed that the degree of soil erosion caused by livestock grazing varied with slope gradient, aspect, soil condition, plant type, vegetation density, and accessibility to livestock (*48*) but demonstrated that soil disturbance was greater in areas overused by livestock (*13*). The susceptibility of soils to erosion increased as vegetation deteriorated. Livestock trampling reduced ground cover density and increased bare soil openings (*39*), which usually resulted in increased watershed runoff and erosion.

Proper grazing use, however, causes minimal, if any, resource damage, and by the mid-1960s new approaches were being considered. Rest-rotation grazing, for example, was found to benefit range conditions (*22*). Livestock grazing research continued to focus on impacts on forage and physical watershed characteristics, however. What these influences meant to aquatic ecosystems did not receive adequate attention.

This changed in the early 1970s, when concern began to grow about the effects of livestock grazing on biotic resources. Severe changes were found in streamside environments from livestock use that could affect the quality of the fishery (*41*). Management officials (*8*) concluded that livestock grazing severely damaged streams in Nevada. The supporting evidence was subjective, however. Nevertheless, researchers began to look at influences on resources other than the land.

History of Range Use

Several documents trace the history of livestock production on public and private ranges (*8, 37, 40, 59*). Before white settlers moved into the western states, wild ungulates grazed compatibly with the carrying capacity of natural ecosystems. If, for some reason, the forage species on a given range became scarce during a particular season or year, wild grazing animals either migrated to more favorable range or increased mortality brought the herds into balance with range capacity.

The grazing potential of the vast rangelands became apparent early in the nation's westward expansion. As man saturated the ranges with livestock and confined them within manmade barriers, drastic changes in vegetation occurred. Livestock trampled and compacted the soil. High quality, deep-rooted plants gradually gave way to shallow-rooted species that were less nutritious and often only of seasonal benefit.

As soil compaction increased, infiltration of water into deep soils decreased and surface runoff increased (*20, 30, 46, 54, 56*). This accelerated erosion (*5, 31*) had two major effects on terrestrial and aquatic productivity. The erosive action of wind and water began to strip the natural ecosystems of their rich top soils, and water quality began to decline (*15, 37*) as the soil was dumped into streams and rivers. Fine sediment smothered spawning beds and altered the habitat of invertebrate and fish populations.

As the livestock industry grew during the 1800s and into the mid-1930s, livestock numbers increased far beyond the carrying capacity of the available range. Many ranges deteriorated badly. In response to the situation, Congress in 1934 passed the Taylor Grazing Act to stop the damage to the remaining public domain, to provide for its orderly use and improvement, and to attempt to stabilize the livestock industry using these lands. While the intent of the act was good, the objectives were not achieved. Grazing privileges were allocated largely on the basis of use prior to the act. Little attempt was made to regulate grazing according to the carrying capacity of rangelands. Also, there was little public interest in rangeland conditions during this period.

By the mid-1960s management by allotment had become an accepted practice. The situation remains essentially the same today. Public awareness of environmental quality, including the condition and use of rangelands, has brought the original goals of the Taylor Act more clearly into focus.

A number of recent publications summarize the literature on various aspects of grazing resources. One lists available material on grazing in the Pacific Northwest (*3*). Another summarizes many of the effects of grazing management and research in Europe and Asia as well as some work in the United States (*1*). Still another lists numerous documents pertaining to the effects of livestock grazing on water quality and associated factors (*37*). In addition, the Environmental Protection Agency prepared an annotated bibliography concerned with animal wastes (*44, 45*).

Effects on Water Quantity

Early livestock growers generally were unaware of the grazing limits of vegetation and soil (*11*). Only recently have these resources been given full credit for their abilities to control water on the land (*14*). Range practices significantly affect water yield, peak stream discharge, stormflow runoff, and associated water quantity factors. Water management and management of rangelands are closely interrelated.

Many studies show that as grazing intensity increases water runoff increases (*2, 21, 27, 28, 30, 31, 39, 46, 51, 54, 56*). The primary causes are soil compaction and resulting reduction in infiltration rate, as well as cover depletion.

Other studies specifically demonstrated that infiltration rates decrease as grazing intensities increase (*7, 12, 23, 35, 47, 49, 58*). In one study (*49*), for example, infiltration rates obtained with a sprinkling infiltrometer over a 2-hour period were five times greater on an ungrazed control area than on a heavily grazed area (12 acres per animal unit), three times greater than on a moderately grazed area (17 acres per animal unit), and two-and-one-half times greater than on a lightly grazed area (22 acres per animal unit).

Effects on Water Quality

Range management practices can alter water quality. Although a half century of research has been devoted to this problem, the true effects on living systems remain unknown. Most studies to date have centered on sediment accrual and increased bacterial concentratons through the addition of animal wastes to streams.

Sediment

Large quantities of fine sediment change the structure of aquatic communities, diminish productivity, and reduce the water permeability of channel materials used by fish for spawning (*9, 34*). In one case increases in fine sediment reduced the biotic productivity of an aquatic environment by 37 percent (*52*). In another case the reduction was 59 percent (*10*).

Stream channel sedimentation caused by soil erosion on rangelands was recognized long ago as a major problem (*37*). The general impacts of sediment from rangelands on water quality have been documented (*11, 15, 18*). The effects on fish of sediment directly attributable to bad range management practices are not well documented, however.

While several studies demonstrate that rangeland abuses result in adverse hydrologic consequences, including accelerated sediment transfer from the land to streams (*5, 6, 17*), evaluations of the effects of grazing systems, such as rest-rotation and deferred-rotation, on instream sediment accrual are lacking. In a study of the grazing effects on watershed hydrology in western Colorado, ungrazed watersheds produced only 71 to 76 percent as much sediment as grazed watersheds (*30*). Soils in this area are poorly developed and generally consist of a shallow, weathered mantle overlying the widely distributed Mancos Shale. Sediments came from both gullies and hillsides, with site-derived sediments more predominant on steeper slopes.

Rangelands account for an estimated 28 percent of the annual sediment production within Region 10 (excluding Alaska) of the Environmental Protection Agency and are second only to croplands in total sediment production (*37*). Depleted plant cover and trampled soils are the factors contributing most to erosion on grazed, particularly overstocked, lands.

Animal Wastes

Considerable research has been done on the effects of livestock wastes from feedlots, pasture, and wildlands on water quality (*32, 36, 43, 55*). Bacterial contamination has been the primary consideration in these studies.

In one of many specific studies on stream pollution from animal wastes, dissolved oxygen stress and high ammonia concentrations killed essentially all the game fish—largemouth bass, white crappie, and channel catfish—in a 45-acre, flood control reservoir (*53*). Inadequately treated feedlot runoff was pumped into the reservoir. At the time of the fish kills, biochemical oxygen demand (BOD) concentration was 86.5 milligrams per liter. This compared with 5 milligrams per liter in a control reservoir. Ammonium nitrogen concentrations were 6 milligrams per liter in the affected reservoir and 0.85 milligrams per liter in the control reservoir.

While land spreading of animal wastes is an effective means of minimizing water pollution because of the soil's natural waste treatment capabilities, direct dumping of fresh animal wastes into streams causes excessive pollution (*50*). Concentrations of animals, as in feedlots or heavily stocked areas, should be located away from streams and other drainageways.

Maintenance of water quality also requires care in the use of cattle manure slurries for irrigation (*4*). Lagoons or collection pools for irrigation runoff must be isolated from natural drainages or flood-prone areas so the wastes do not contaminate runoff or groundwater.

Three groups of bacteria are indicators of pollution by livestock and wild ungulates: the coliform group, fecal coliform bacteria, and the fecal streptococci. In a Colorado study (*26*), concentrations for all three groups in a small, high-elevation stream were highest in the evening and lowest in the afternoon. This cycle apparently related to rising stream levels in early evening that flushed streambanks. Highest concentrations of the coliform groups in cattle-contaminated sites occurred during peak runoff periods in the spring. Fecal streptococci concentrations were highest during mid-summer low flows. Summer storm flows increased the concentrations of all three bacterial groups.

An earlier study involving several Colorado watersheds produced similar results (*25*). Still another study (*38*) identified overland flow from summer rainstorms as the single, most important factor regulating bacterial counts.

While bacterial concentrations do not relate directly to the suitability of fish habitat, they are important to water quality and, therefore, relate indirectly to fish habitat.

Grazing Effects on Fish Habitat

There is a lack of quantitative data in the literature pertaining directly to interrelations between livestock grazing and coldwater fish habitat. Some information has been gathered but remains unpublished (personal communication with Errol Claire, Oregon Department of Fish and Wildlife).

The most detailed, published research was conducted on Rock Creek in south-central Montana (*19*). The quantity of brown trout in pounds per acre was 32.5 percent greater in the stream sections adjacent to an ungrazed area than in the section adjacent to a grazed area. Streamside cover, such as overhanging banks, brush, and debris, was 76.4 percent greater in the ungrazed area than in the grazed area. Other stream parameters in the Rock Creek study were average eroded channel width and average water width (considerably greater in the grazed area than in the ungrazed), percent of total stream as riffles (greater in grazed areas), and percent of total stream as pools and runs (greater in ungrazed area).

In a follow-up study to the initial work on Rock Creek, the pounds per acre of brown trout were 42.3 percent greater in the stream along an ungrazed section than along a grazed section (*33*).

The density of brown trout in central Oregon's Little Deschutes River appeared in a recent study (*29*) to be determined primarily by the physical environment, particularly cover. While the researcher lacked quantitative data relating cover to livestock grazing along the stream, this treatment was an implied source of streamside cover reduction.

On a 40-mile segment of Bear Valley Creek in central Idaho, fish habitat was damaged more along grazed sections, primarily from bank trampling, than along ungrazed sections (*42*).

Grazing Systems and Range Improvements

A grazing system designates a specialized management strategy. Most current systems are based on grazing selected pastures, with certain types and timing of grazing or nongrazing recurring at yearly intervals. The systems vary depending on the livestock operation and the type and condition of rangeland.

Five grazing systems are commonly used to distribute livestock better on the range available and provide better plant growth and vigor. These systems are season-long or continuous grazing, rotation grazing, deferred grazing, deferred-rotation grazing, and rest-rotation grazing (*24, 57*).

Season-long grazing, one of the earliest practices, requires the least range investment. Handling and movement of livestock are minimized. Problems with the system include the concentration of animals at favored locations, especially in riparian habitats; inadequate use of the herbage available; and overuse of more desirable forage plants. This system often disperses livestock use over more stream bottomlands than some of the crowding techniques, such as rest-rotation.

Rest-rotation grazing has some disadvantages because it often requires more livestock movement. This increases the trailing potential in riparian habitat. While trampling may help plant ripened seeds, it also causes streambank erosion and instability. Nevertheless, the system is a popular one. Recent research indicates that rest-rotation grazing may have harmful effects on other land uses.[1] Its effects on

[1]Meiners, William R. 1974. "Rest-Rotation Grazing—A Bummer." Paper given at the 27th Annual Meeting, Society for Range Management, Tucson, Arizona.

aquatic and riparian environments have not been thoroughly documented, however.

Grazing systems are varied to meet the requirements of a livestock operation, promote the growth of forage plants, and match soil qualities. While modern systems promote the growth of desirable plants, research has not determined how these systems relate to the environment.

Many range management practices improve forage resources and their use by livestock (*60*). Fertilization, seeding, undesirable plant and animal control, mechanical soil treatments, water spreading and drainage, prescribed burning, and timber thinning are among the methods used to improve range forage resources. Water developments, fences, trails, and similar improvements permit more effective grazing management. Long-term closure or temporary (3- to 5-year) exclusions of livestock by fencing may be the only effective restoration measure in some cases.

These factors and other management elements, such as kind of livestock, seasons of use, and grazing intensity or stocking rate, must be thoroughly understood before resource managers can manipulate grazing systems to also protect the high quality habitats of resident as well as anadromous coldwater fishes.

Recommendations for Future Study

Further research is needed on both the physical/chemical and biological aspects of livestock grazing and aquatic habitat interrelationships. The resource manager needs this type of quantitative information to make sound land use planning decisions. Physical and chemical considerations include the effects of livestock grazing in valley bottoms on water quality, stream channel morphology, streambed condition, and the riparian zone. Biological information must concern livestock impacts on standing crop and species diversity of fish and benthic invertebrate populations, bacteriological aspects of water quality, and recreational and esthetic values involved in use of the fishery and aquatic and riparian habitats.

Modern grazing systems seek to improve livestock production while protecting range. Resource managers need to know how these grazing systems influence other resources, including anadromous and resident coldwater fish populations.

Before the impacts of such land uses as livestock grazing on fish habitats can be evaluated, researchers need to know what the natural or pristine conditions of streams are or were prior to these uses.

A bull throwing pieces of sod into the air with his head caused this severe streambank damage.

Pristine habitats are increasingly difficult to find. Serious consideration should be given to locating and preserving such stream habitats to serve as study areas and to furnish baseline data on the condition and productivity potential of streams in the western United States.

Once natural conditions are established and the effects of grazing various stream and riparian habitats are known, then researchers will be able to provide resource managers with guidelines for predicting the effects of alternate grazing strategies on the condition and productivity of stream and riparian systems. This information then, will enable resource managers to make decisions more effectively on the use of rangelands with maximum consideration of aquatic resources.

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