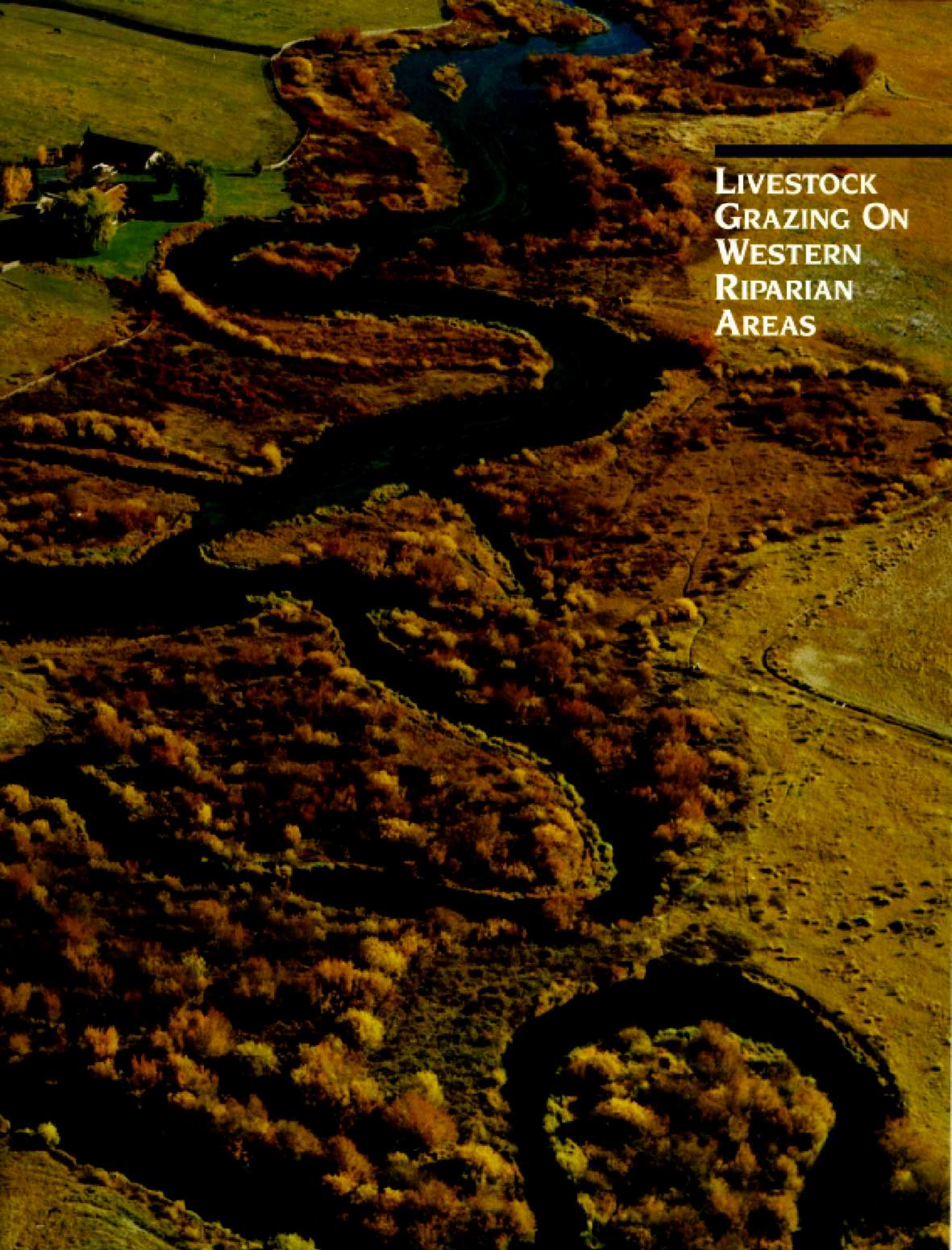
Livestock Grazing On Western Riparian Areas



Livestock Grazing On Western Riparian Areas

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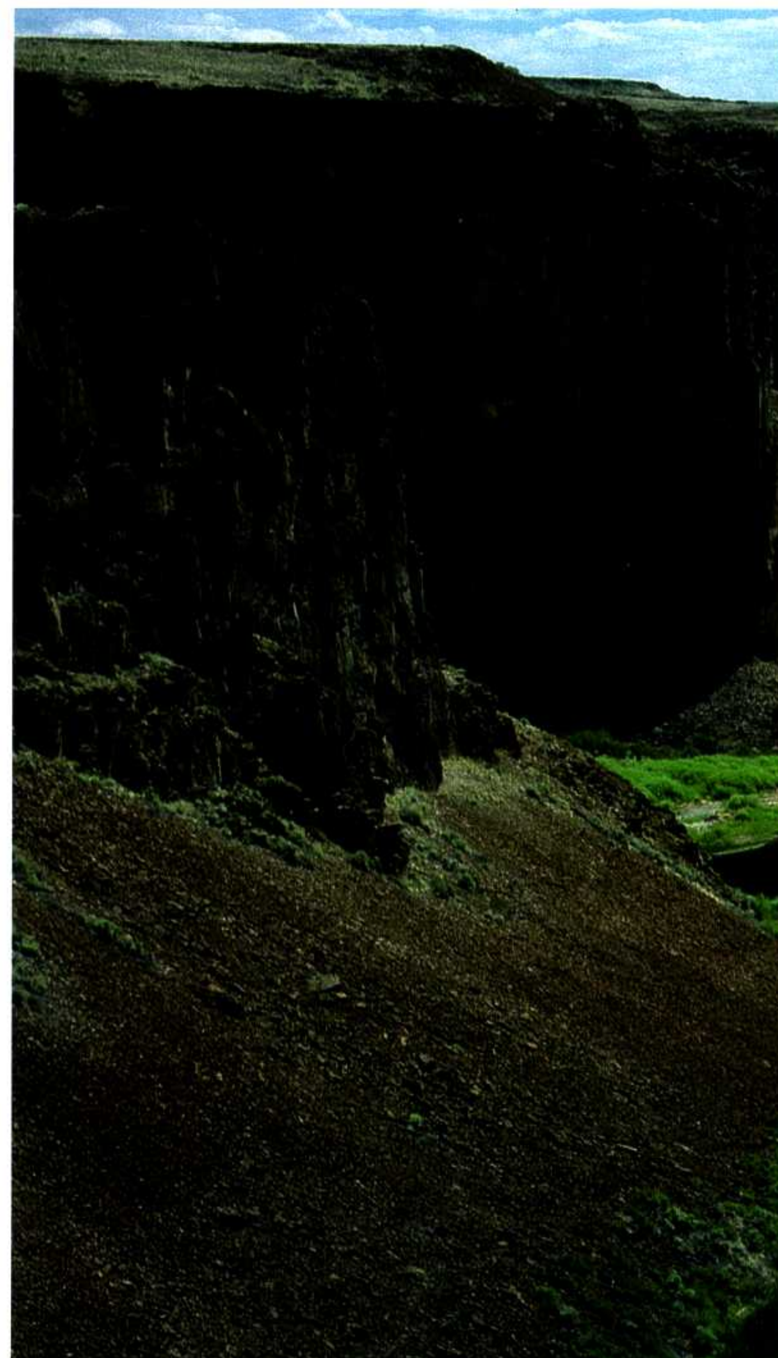
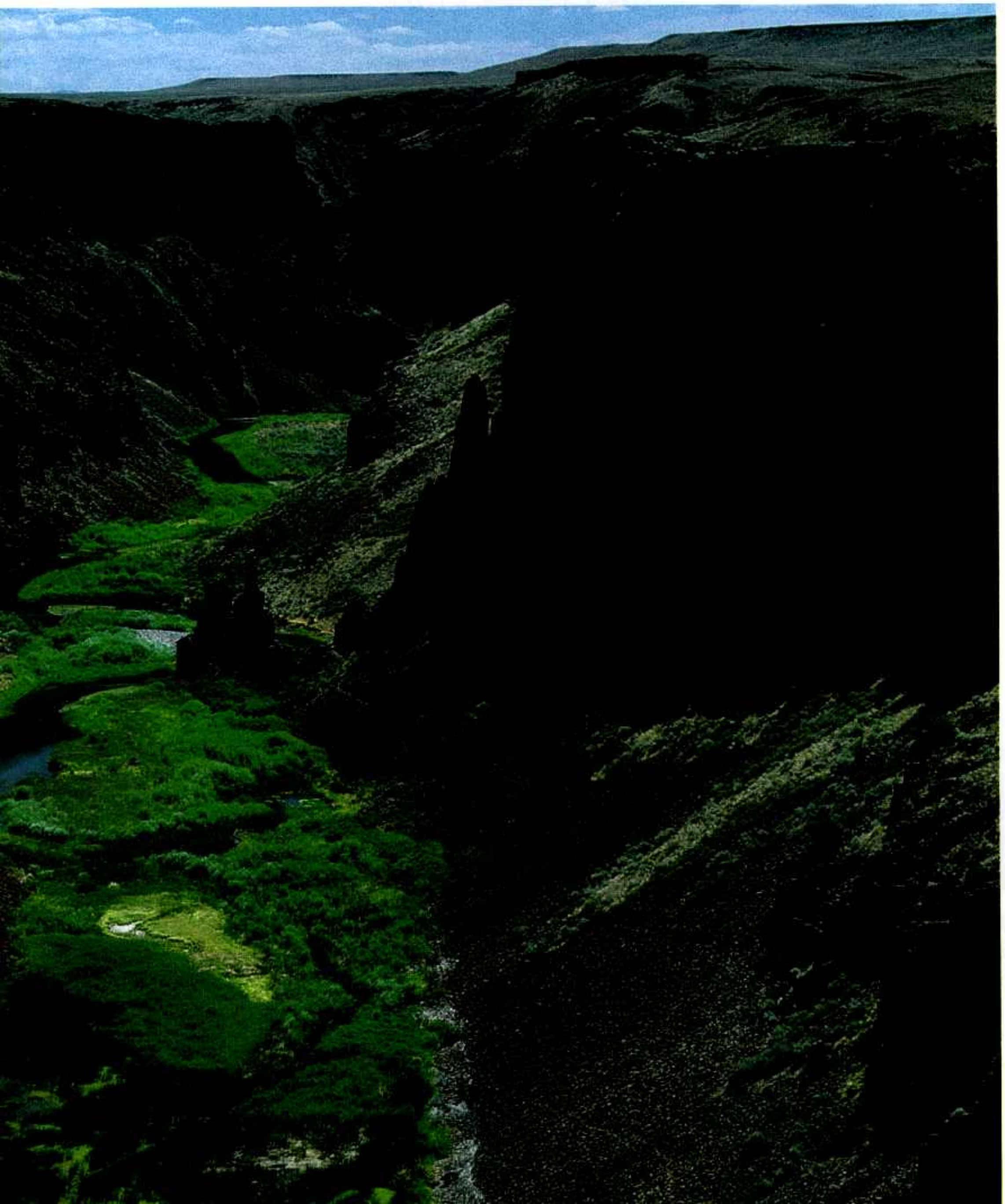


THE national Clean Water Act provides for states to assess nonpoint sources of water pollution from a wide range of land-use activities, and to develop Best Management Practices that will meet state and national water quality objectives.

This document is aimed at the broad and growing audience of people interested in improved management of livestock grazing on western riparian areas and adjacent uplands. Its purpose is to provide general insight into the problems and opportunities. A follow-up EPA publication will provide livestock owners, land managers, state regulatory personnel and others detailed technical guidance for developing grazing strategies to restore and protect riparian areas.



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Riparian Functions, Values and Issues

Riparian areas are lands adjacent to creeks, streams and rivers where vegetation is strongly influenced by the presence of water. Riparian areas may comprise less than 1% of the area in the western United States, but they are among the most productive and valuable of all lands.

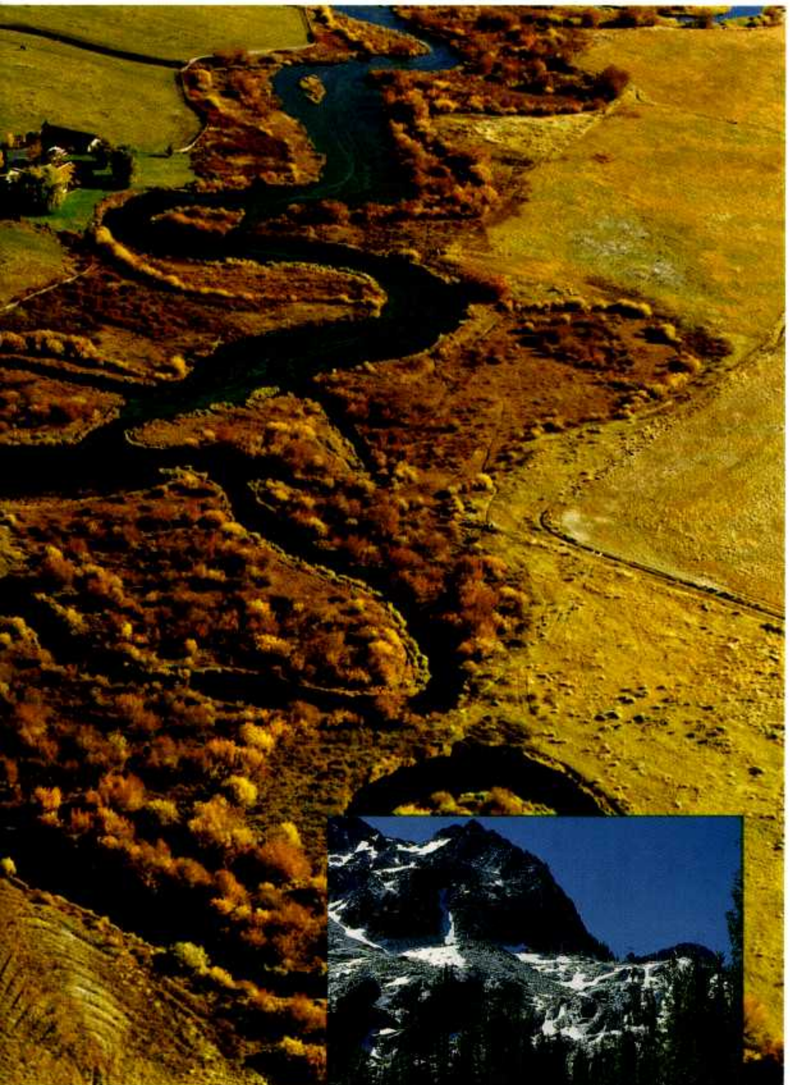
The presence of water and green vegetation makes riparian areas attractive and important to domestic livestock grazing adjacent, drier uplands. Fish, of course, are totally dependent upon the surface waters within riparian areas. These areas are the most important habitat for the majority of western wildlife species, and are essential to many.*

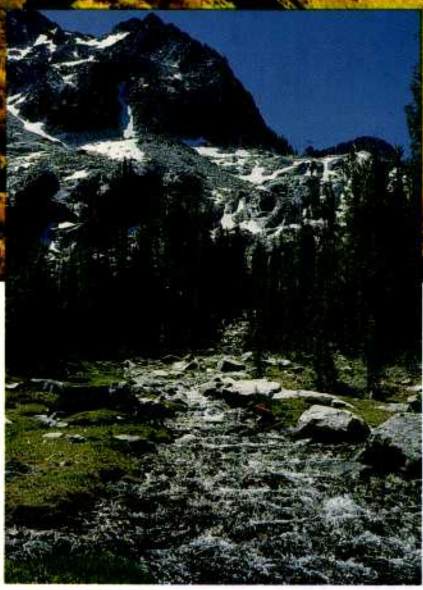
Many other values of riparian areas are not well known, and commonly are misunderstood. While occupying relatively small areas of land, riparian areas can strongly influence how watersheds function. By influencing the timing and quality of water produced, the condition of riparian areas can have significant, far-reaching, economic and environmental consequences.

Diversity of vegetation is an important characteristic of riparian areas in good condition. Woody and herbaceous plants slow flood flows and provide a protective blanket against the erosive force of water. Their foliage shields the soil from wind and sunlight, which keeps soil temperatures low and reduces evaporation. They produce a variety of root systems that bind the soil and hold it in place.

Riparian vegetation filters out sediment which builds streambanks and forms productive wet meadows and floodplains and reduces sedimentation of water supply and hydroelectric reservoirs.

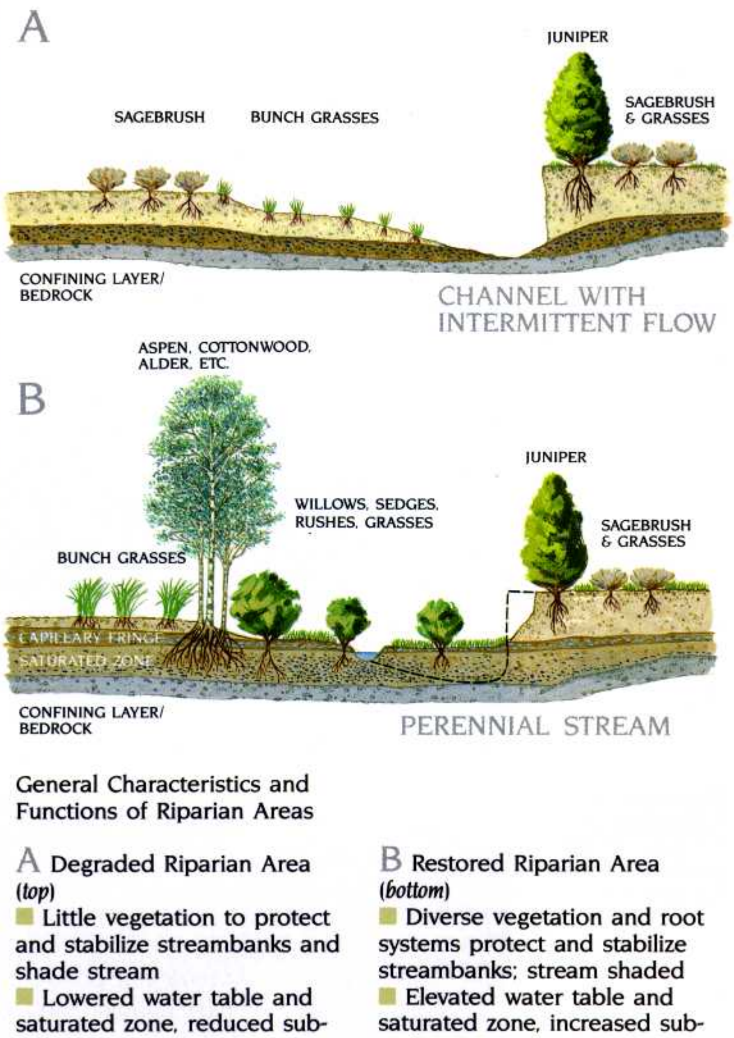
*For example, in the Great Basin of southeastern Oregon, more than 75% of terrestrial wildlife species are dependent upon or use riparian habitats. In southeastern Wyoming more than 75% of all wildlife species depend on riparian habitats. In Arizona and New Mexico, 80% of all vertebrates depend on riparian areas for at least half their life cycles; more than half of these are totally dependent on riparian areas. Riparian areas provide habitat for more species of birds than all other western rangeland vegetation types combined. More than half of all bird species in the southwestern U.S. are completely dependent upon riparian areas.





Riparian areas in good condition slowly release water to stream channels, thus increasing seasonal quantity and quality of water.

The inherent productivity of riparian lands, the proximity of water, and relatively gentle terrain attract a variety of human activities. Consequently, riparian areas are the most modified land type in the West. Riparian functions and values have been widely and severely impacted by cultivation, road building, mining, urbanization, logging, and damming of rivers. Livestock grazing — the focus of this document — has had the most geographically extensive effects. The resulting economic and environmental costs have captured the attention of growing numbers of people concerned about the long-term productivity of western watersheds.



General Characteristics and Functions of Riparian Areas

A Degraded Riparian Area *(top)*

- Little vegetation to protect and stabilize streambanks and shade stream
- Lowered water table and saturated zone, reduced subsurface water storage
- Reduced or no summer streamflow
- Warm water in summer and icing in winter
- Poor habitat for fish and other aquatic organisms
- Poor habitat for wildlife
- Reduced amount and quality of livestock forage

B Restored Riparian Area *(bottom)*

- Diverse vegetation and root systems protect and stabilize streambanks; stream shaded
- Elevated water table and saturated zone, increased subsurface water storage
- Increased summer streamflow
- Cooler water in summer, reduced icing in winter
- Improved habitat for fish and other aquatic organisms
- Improved habitat for wildlife
- Increased quantity and quality of livestock forage

THE nation's wetlands include a wide variety of coastal and inland marshes, prairie potholes, bogs, swamps, river bottomlands and riparian areas, springs and seeps. Together they comprise less than 5% of the land area in the coterminous forty-eight states. But wetlands increasingly are recognized as among the nation's most productive, valuable and threatened natural resources.

Wetlands perform many functions and produce many products of significant social and economic value. Wetland vegetation protects shorelines and streambanks from erosion, slows flood flows, filters out sediment, captures and breaks down nutrients and water pollutants.

Wetlands can store, cleanse and slowly release water, thereby extending the supply and quality of water for agricultural, industrial, municipal, hydroelectric and recreational uses. Wetlands play critical roles in the life cycle of many commercially, recreationally and esthetically important fish and wildlife species.

Most riparian ecosystems — streams and adjacent land they strongly influence — contain wetlands. The Clean Water Act provides jurisdictional wetlands regulatory protection from discharges of dredged or fill materials and other pollutants. Non-wetland portions of riparian areas are outside the regulatory protection of the Act.

Best Management Practices (BMPs) developed pursuant to the nonpoint source provisions of the Clean Water Act provide a mechanism for protecting non-wetland riparian values, and provide additional protection for wetlands.

During the past decade growing national and international attention has been directed to protecting and restoring wetlands.

This document focuses on the effects of improper and improved livestock grazing on stream corridor riparian/wetland areas. Many of the problems and opportunities also apply to lake, pothole, marsh and spring/seep wetlands.

A followup technical field manual will address strategies for protecting and restoring both riparian and wetland values through improved grazing management.

Improper grazing can seriously reduce wetland values.

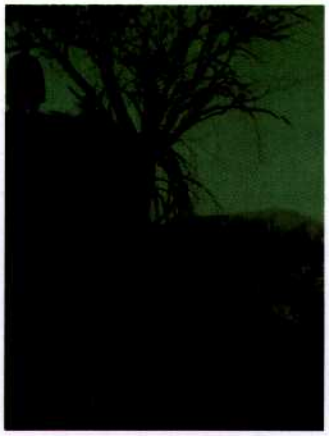
Proper grazing management can protect or restore productive wetland vegetation.

"BEFORE *about* 1880, *the Gila River channel from Santa Cruz Junction to Yuma was narrow with firm banks bordered by cottonwoods and willows, but by the early* 1890s *it occupied a sandy waste from one-quarter to one-half mile wide.*"

— J.J. Wagoner, History of the Cattle Industry in Southern Arizona

"THE *wells are nearly all dried up and have to be dug deeper. At the present time the prospect for next year is a gloomy one for the farmers, and in fact, all, for when the farmer is affected, all feel the effects. The stock raisers here are preparing to drive their stock to where there is something to eat. This country, which was one of the best ranges for stock in the Territory, is now among the poorest; the myriads of sheep that have been herded here for the past few years, have almost destroyed our range.*"

— Salt Lake City Deseret News, 1879



"...DROUGHT *does not cause desertification. Rather, it exacerbates the problem of management of arid lands for sustained production and exaggerates the impact of mismanagement. Drought is, after all, a normal episodic feature of arid regions, just as dust storms and floods are.*"

— H.E. Dregne, Desertification, Resource and World Development, 1987.

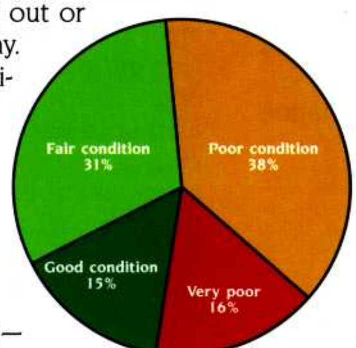
THE extensive deterioration of western riparian areas began with severe overgrazing in the late nineteenth and early twentieth centuries. Native perennial grasses were virtually eliminated from vast areas and replaced by sagebrush, rabbitbrush, mesquite and juniper, and by exotic plants or shallow-rooted native vegetation less suited for holding soils in place. This unleashed natural forces that literally transformed large areas of the western landscape.

Exposed topsoil thousands of years in the making was quickly stripped from the land by wind and water erosion. Runoff was concentrated and accelerated. Unchecked flood flows eroded unprotected streambanks and downcut streambeds. Water tables lowered. Perennial streams became intermittent or dry during most of the year. Formerly productive riparian areas dried out or eroded away. These conditions contributed significantly to desertification — drying out of the land — which has reduced the productivity of an estimated 225 million acres in the West.

In 1980 the United States Department of Agriculture estimated the vegetation on more than half all western rangelands was deteriorated to less than 40% of potential productivity, and to less than 60% of potential on more than 85% of the rangeland.

Rangeland conditions reportedly have significantly improved in many areas since 1980. However, improved upland conditions do not necessarily mean improved riparian conditions. In fact, extensive field observations in the late 1980's suggest riparian areas throughout much of the West were in the worst condition in history.

The deteriorated condition of watersheds represents an enormous economic loss of potential livestock forage forgone. The loss of other values also is high. Many once-productive fish and wildlife populations have been eliminated or greatly reduced over wide areas of land. Degradation of streams and riparian habitats for migratory fish and waterfowl adversely affects economies thousands of miles away.



Rangeland was rated on the difference between the land's present vegetation and the ecological potential of the site. Land rated "good" had vegetation at between 61 and 100 percent of potential; "fair" 41%–60% of potential; "poor" 21%–40% of potential; "very poor" 20% or less of potential. Source: USDA 1981, Resources Planning Act

Erosion-produced sediments reduce the quality and seasonal quantity of water supplies and shorten the economic life of irrigation and hydroelectric reservoirs critical to many western economies.

The legacy of past land abuse and resultant deterioration in overall productivity has important implications for contemporary management: It has made remaining healthy riparian areas both more valuable and more vulnerable.

Their relative scarcity enhances the value of riparian areas for livestock forage, for fish and wildlife, and for regulating the seasonal timing and quality of water yielded from watersheds.

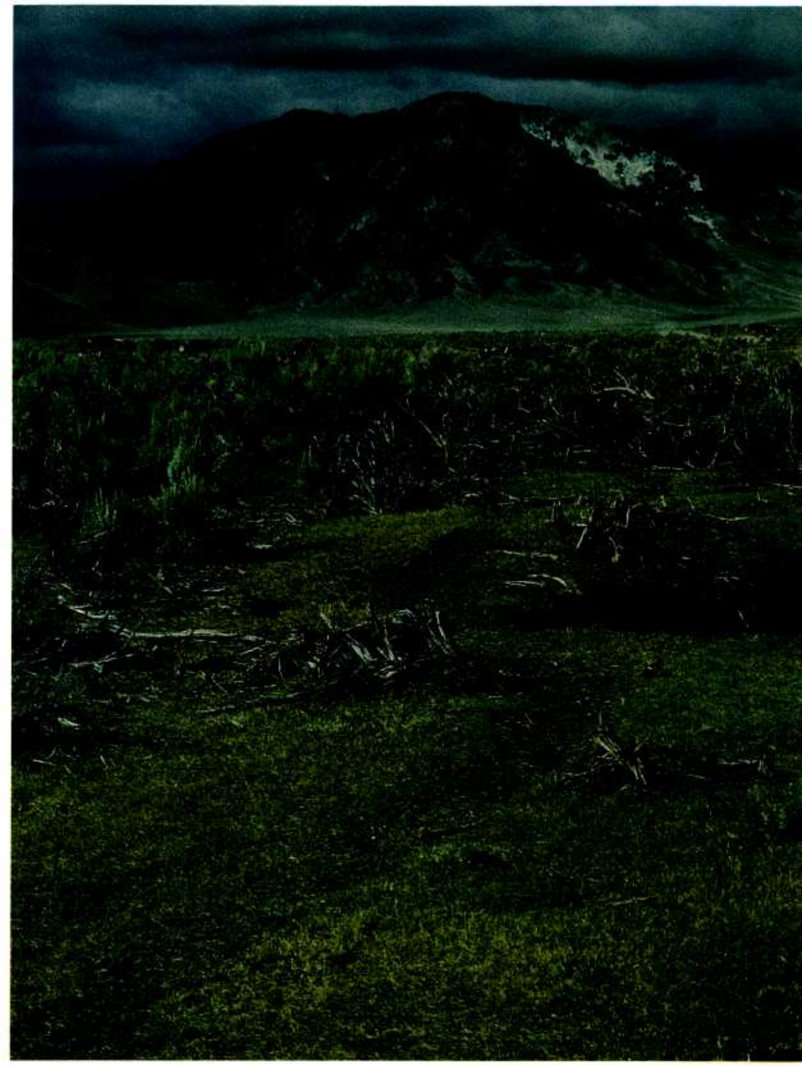
Deteriorated riparian areas are more vulnerable to the increased stress of concentrated and accelerated runoff from degraded uplands. Depleted upland vegetation furthers the natural tendency of livestock to concentrate in riparian areas.

Even riparian areas in good condition are susceptible to damage by concentrations of livestock at the wrong time, in too great a number, for too long, or any combination of these factors.

Moist soils are susceptible to compaction which reduces water infiltration and plant growth. Streambanks can be broken down and eroded. Vegetation critical to the soil's ability to resist erosion and hold water, to slow and filter upland runoff and to provide food and cover for fish and wildlife can be drastically reduced or eliminated by improper grazing.

When riparian areas are in a deteriorated condition they are far more sensitive to improper livestock grazing. Unless the season, duration and intensity of grazing are controlled, damage can be severe, long-lasting and in some cases, irreversible.

Proper grazing management can restore the long-term productivity of most riparian areas and associated uplands. However, grazing tradition, the vast geographical extent of the problem, and the gap between short-term costs and long-term benefits of improved management, all present significant obstacles to the necessary changes in grazing practices.



PROPER *grazing management can restore the long-term productivity of most riparian areas and associated uplands.*

Deteriorated upland vegetative conditions increase runoff stress on riparian areas. When riparian areas also are depleted of protective vegetation, serious damage may result.

Sediment produced from overgrazed watersheds can drastically reduce the capacity and economic life of irrigation, water supply, flood control and hydroelectric reservoirs.

IMPROPER *livestock grazing can result in what are for all practical purposes permanent changes in the landscape and loss of long-term productivity.*

This stream in northern Nevada is representative of conditions affecting a large number of western streams and riparian areas. It once was lined with aspen and willow, flowed year-round and supported native cutthroat trout. ▷

Deterioration of upland vegetation accelerated runoff. Loss of riparian vegetation weakened streambanks. The stream downcut through 15-20 feet of fine material deposited over thousands of years to a layer of coarse, porous material and now disappears into the ground by mid summer.

The once-productive riparian area eroded away or dried out with lowering of the water table. Aspen, willow, forbs and grasses were replaced by sagebrush and other less desirable vegetation.

Stemming the ongoing degradation of streams in this condition must start with improving upland conditions to reduce the erosive power of runoff. Restoring productive riparian areas will be a long, slow process.

Many streams throughout the West are littered with the remains of what were once vigorous aspen groves. Aspen reproduce by sending up shoots from roots. If these young plants are constantly grazed off, eventually the parent trees will die of old age and aspen will disappear from the site. ▷

This transformation of riparian area vegetation is accelerated when deteriorated upland conditions result in downcut or widened stream channels, lowered water tables and drying out of riparian areas.

Case Studies

The Clean Water Act of 1977 established a national objective "... to restore and maintain the chemical, physical, and biological integrity of the Nations waters."

compliance through nonregulatory programs of technical and financial assistance, education, training, technology transfer, demonstration watershed projects, and monitoring.

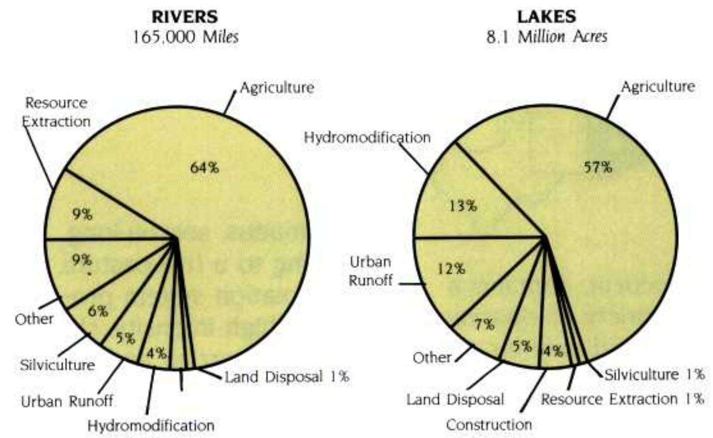
In recent years western riparian areas have been the focus of unprecedented public and political attention. Several factors working together contributed to this encouraging development.

The environmental, economic and social costs of deteriorated riparian areas are more widely understood. The 1987 nonpoint source amendments to the Clean Water Act provided requirements and authorized resources for states to deal with the problem. Perhaps most important to heightened awareness is the work of a growing number of public and private land managers who have conclusively demonstrated improved grazing management can dramatically improve the productivity of riparian areas and adjacent uplands.

The following case studies are representative of broad areas of land in the western United States, and of diverse environmental, political and economic conditions. They broadly illustrate the problems and the promise of improved management of riparian areas and adjacent uplands.

"The objective of this Act is to restore and maintain the chemical, physical and biological integrity of the Nation's waters."

Clean Water Act



Relative amount of state assessed waters impacted by various categories of nonpoint source pollution. Source: Environmental Protection Agency.

The act initially focused on reducing or preventing degradation of water quality by easily identifiable discharges — "point sources" — of pollutants. The act was amended by the Water Quality Act of 1987; section 319 addresses "nonpoint" sources of water pollution.

Nonpoint source pollution is broadly defined as being any human-caused degradation of surface or groundwater quality. This includes all sources not regulated as point sources, such as runoff from construction sites, urban areas, forest lands and agricultural lands — including lands used for livestock grazing.

States are required to identify nonpoint sources of pollution and to develop procedures and practices — Best Management Practices — to achieve state and national water quality objectives.

The current approach to controlling most nonpoint sources of pollution is to seek voluntary

"We have been persuaded to take a path somewhat different from that taken for point sources. States are given flexibility to identify priorities. And based on commitments made in this legislative cycle, it is the expectation of Congress that this program will result in significant improvement in water quality and nationwide reduction in pollutant loadings from nonpoint sources. We will, of course, revisit this question in the next legislative cycle on the Clean Water Act. We will not find this program adequate if real improvement in water quality has not occurred. We are not so much interested in elements of a State program as we are concerned with meeting the goals and objectives of the Clean Water Act."

— Senator Durenberger, Senate debate on nonpoint source pollution amendments to Clean Water Act.

TONTO National Forest— Arizona

The Tonto National Forest in central Arizona encompasses almost 3 million acres of land. This area, just slightly smaller than

Connecticut, contains a wide variety of riparian and upland habitats subject to diverse climatic, grazing and political conditions.

The Tonto Forest has been grazed by domestic livestock since the mid-1800s. Intensive, unregulated grazing in the early years severely depleted uplands and riparian areas of native vegetation. This resulted in the familiar chain reaction of events leading to deterioration of watersheds and loss of productivity.

Grazing eventually was brought under better control, but watersheds and their riparian areas remained in a deteriorated condition.

In the late 1970s the Forest Service took aggressive steps to improve upland vegetation and encourage regeneration of cottonwood, willow and other vegetation in the largely denuded riparian areas.

Grazing strategies were designed to fit specific site potential and condition. A number of grazing allotments were switched from continuous, season-long grazing to a five-pasture, rest-rotation system providing high intensity, short duration grazing and spring-summer rest two out of every three years.

Tonto Creek, 1982

The 34,800 acre Sedow Allotment is at about 5,000 feet elevation. Precipitation is approximately nineteen inches per year, about 60% occurring in winter. Vegetation ranges from semi-desert grasses to chaparral-juniper. In 1978, riparian areas with potential for cottonwood and willow were characterized by a few large, decadent trees scattered along otherwise bare creek banks. In one study area there were no cottonwoods or willows between 0.25 and 25.9 inches in diameter. The Forest Service

Tonto Creek, 1926.

"TONTO Creek was timbered with the local creek bottom type of timber from bluff to bluff, the water seeped rather than flowed down through a series of sloughs and fish over a foot in length could be caught with little trouble. Today this same creek bottom is little more than a gravel bar from bluff to bluff. The old trees are gone. Some were cut for fuel, many others were cut for cattle during droughts and for winter feed, and many were washed away during the floods that rushed down the stream nearly every year since the range started to deplete. The same condition applies to practically every stream on the Tonto."

— Fred Croxen, Senior Forest Ranger, Tonto National Forest, 1926

reduced grazing on the allotment by 50% and implemented the five-pasture, rest-rotation grazing system.

By 1984 upland vegetation had improved. In addition, cottonwood, willow and other riparian vegetation had regenerated in profusion. There were more than 1,000 cottonwoods and 3,200 willows 0.25-25.9 inches in diameter per 100 acres where previously there were none.

In 1987 the livestock permittee remarked that he had been on the allotment for more than fifty years and that the riparian areas had "always looked bad." That areas which had been nothing but sandy draws for decades now had flowing water, and abundant vegetation and wildlife.

The Roosevelt Allotment is located at about 4,000 feet elevation. Precipitation is approximately ten inches per year. Upland vegetation is characterized by semi-desert grasses, prickly pear and cholla. Riparian vegetation is dominated by cottonwood, willow and sycamore.

The permittee on this allotment had voluntarily reduced numbers of livestock without studies or procedural delay because the problem was obvious and he was concerned about the long-term productivity of the land and value of the grazing permit his children would inherit. Upland vegetation benefitted from this stewardship, but riparian vegetation remained in largely deteriorated condition.

Implementing a five-pasture, rest-rotation grazing system resulted in cottonwoods increasing from 20 per 100 acres in 1978 to more than 2,000 in 1984. Willow increased from 28 to 225 per 100 acres. These results occurred concurrent with a 27% increase in the amount of livestock forage grazed from the allotment.

On this site reduced numbers of livestock and a rest-rotation grazing strategy allowed sparse, decadent riparian vegetation to regenerate rapidly and in profusion.

■ Decades of improper livestock grazing on riparian areas reduced woody plants to widely scattered, decadent trees. They provided a source of seed, but continuous heavy livestock grazing eliminated young plants.

■ The Sedow Allotment was so overstocked a drastic reduction in livestock numbers plus a new grazing strategy were required to improve upland and riparian vegetation.

■ The permittee on the Sedow Allotment resisted reducing animal numbers and changing grazing strategy in part because in his half-century on the allotment, riparian areas had "always" looked the way they did in 1978.

■ The necessary changes in grazing management on these allotments were encouraged by the National Audubon Society's concern that improper grazing prevented regeneration of trees essential to nesting bald eagles.

In this area with 10 inches annual precipitation, cottonwoods, willows and other riparian vegetation regenerated quickly under a rest-rotation grazing strategy that concurrently increased livestock forage.

■ On the significantly more arid Roosevelt Allotment, animal numbers were in better balance with available upland forage, but riparian vegetation was severely deteriorated. Implementing an improved grazing strategy produced more livestock forage while restoring riparian vegetation.

■ The riparian healing process began and progressed most rapidly in the upper watershed. Riparian recovery in lower areas was retarded by rapid runoff from deteriorated uplands which were slower to recover than riparian areas.

DUCK Creek/ Henry's Lake — Idaho

Henry's Lake covers approximately 6,500 acres along the continental divide in eastern Idaho.

The lake and immediately adjacent grazing lands are at about 6,500 feet elevation. Annual precipitation averages about thirty inches and comes mainly as snow. Peak runoff in tributary streams generally occurs in mid June. Lakeside pastures have been grazed since the late 1800s from about mid May until early October.

Henry's Lake is fed by numerous large springs. Several small tributary streams provide spawning habitat for cutthroat and brook trout. Juvenile fish migrate to the lake, grow to large size and attract anglers from around the U.S.

The once world-renowned fishery in the lake declined precipitously over the past two decades. Livestock grazing of tributary riparian areas was identified as a significant contributing factor.

Livestock had depleted streamside vegetation and trampled streambanks. Summer water temperatures had increased; streambanks were eroding, and trout spawning gravels were smothered with sediment. Streams carried small but cumulatively significant amounts of livestock manure and urine into the shallow, naturally nutrient-rich lake, accelerating the natural aging process.

The Idaho Department of Fish and Game developed a plan to rehabilitate the lake fishery. Concerned fishermen, summer home owners, local ranchers and business owners formed the Henry's Lake Foundation to raise money and manpower to help revitalize the lake fishery and dependent local economy.

The foundation's most important role was to get fishermen, recreational property owners, business operators and lakeside ranchers working together toward common, mutually beneficial objectives for tributary riparian areas.

The first tributary riparian restoration demonstration project was constructed in the fall of 1985 on private land bordering Duck Creek, an important trout spawning and rearing stream.

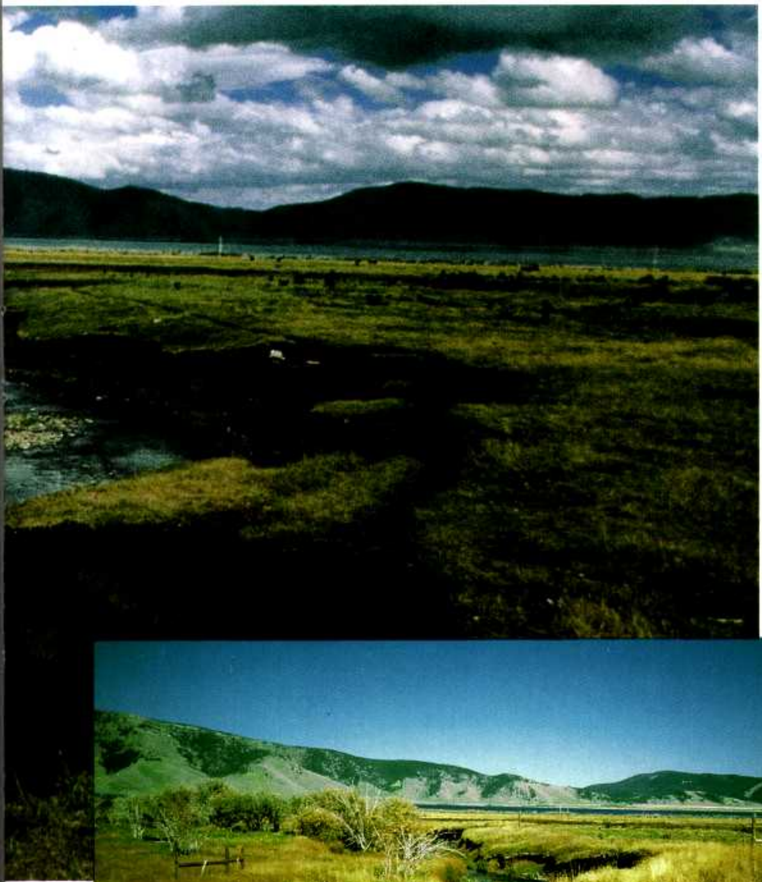
Riparian vegetation was severely deteriorated. Willows were drastically reduced in abundance and there was little regeneration due to constant grazing during their summer growth period. Streambanks were eroding. The stream channel was wide, shallow and full of sediment from trampled and eroded streambanks.

The foundation raised money from its members to permanently exclude livestock from the riparian area along a half-mile reach of stream. Foundation members took time off from jobs and vacations to build the fence to the rancher's specifications. The foundation paid the rancher a modest fee to cover the cost of maintaining the fence.

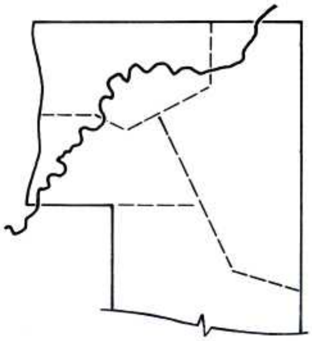
Even after decades of impact from livestock grazing, loafing and trailing, the area fenced from livestock responded dramatically the first growing season.

Vegetation rapidly reestablished on eroded streambanks and began the natural process of trapping sediments and narrowing and deepening the stream channel. The small amount of livestock forage forgone within the exclosure is thought to have been offset by denying livestock their preferred loafing area so they would spend more time eating the abundant irrigated forage outside the fence.

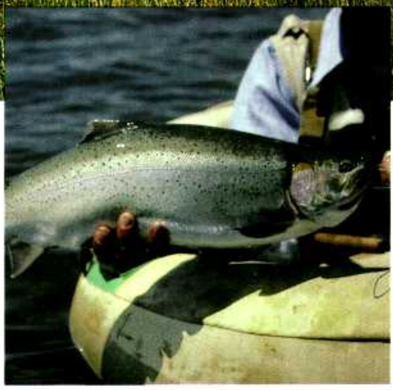
This small pilot project demonstrated the value of fishery interests and livestock operators working together for mutual benefit. The spirit of cooperation proved to be contagious. It led to cooperative screening of irrigation diversions to prevent fish losses, and to construction of additional riparian protection fences on this and other streams around the lake on private, state and federal land.



Duck Creek pilot riparian recovery project, September 1985.



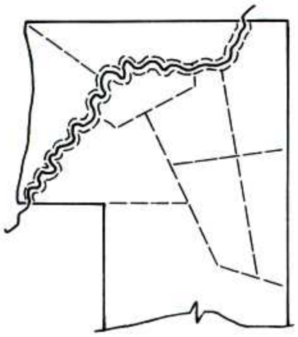
Duck Creek pilot riparian recovery project, September 1986. The initial response of vegetation to rest from grazing was dramatic, but this was just the first step. Full recovery and stabilization of the riparian area and stream channel will take years.



One objective of improved riparian management on Henry's Lake tributaries.

Three years into the pilot project on Duck Creek, the rancher, foundation and Fish and Game Department cost-shared a pasture subdivision project which will provide increased livestock forage production and complete protection for the riparian area and stream channel.

■ The key to success was cooperation among fishermen, landowners and businesses with a stake in restoring and maintaining the overall long-term economic productivity of the area.



The stream corridor fence was integrated into a revised pasture system. Providing more pastures, and separating unirrigated, well- and poorly-drained irrigated pastures allows the rancher to increase forage production while protecting the riparian area.

■ Fishermen with a stake in improved riparian management were instrumental in overcoming traditional barriers between fishery and agricultural interests. The key was their willingness to cost-share mutually beneficial solutions instead of simply blaming riparian landowners for the problem.

■ By forming a mutually beneficial partnership with the private landowner, the Henry's Lake Foundation avoided spending years and many thousands of its members' dollars on studies to "prove" the obvious. Instead they invested their money and energy in implementing solutions which produced quick results instead of paper.

BEAR Creek — Oregon

Bear Creek is located at 3,500 feet elevation in the high desert of central Oregon. Precipitation

averages approximately twelve inches per year. Peak runoff normally occurs in mid to late February and summer thunderstorms are frequent.

This site within the Prineville District of the Bureau of Land Management has been grazed by domestic livestock since the late 1800s.

Prior to 1976 the riparian area was within a single pasture licensed for 72 animal unit months (AUMs) of forage from April-September. (One AUM = the amount of forage necessary to sustain a cow and calf for one month.)

Under this grazing strategy streamside vegetation was low in diversity and productivity. Streambanks were actively eroding. The stream channel was deeply incised and contained medium to high sediment loads. Summer streamflow was often intermittent and low in quality.

In August 1976 Bear Creek was wide, shallow, sediment-laden and warm. The stream was actively eroding the cutbank on the left.

In 1976-78, the BLM partially rested the area from grazing to restore the productivity of the riparian area.

In 1979 and 1980, the area was grazed for one week in September. In 1981-84 it was not grazed. In 1983 juniper trees on adjacent uplands were thinned to improve livestock forage and watershed conditions.

In 1985, the BLM divided the pasture containing the riparian area into three pastures and allowed grazing from the time of spring runoff (mid February) until April 15. Vegetation was allowed to regrow the rest of the year to protect streambanks against high runoff from summer thunderstorms and runoff the following spring. This regrowth also provided livestock forage for the following year.

As a result, streambanks stabilized, reducing erosion and sediment production. This increased stability minimized stream channel damage from a major thunderstorm in 1987 that extensively damaged comparatively poor condition

In August 1986 the cutbank had been stabilized by vegetation. The stream channel had narrowed as vegetation filtered out and stabilized sediment from upstream erosion. (Reduced numbers of juniper in the background are the result of efforts to improve upland ecological condition.)

riparian areas immediately downstream. In some areas one to two feet of sediment from upstream were deposited within the restoring riparian area.

The resulting improvement in water quality and general habitat conditions allowed rainbow trout to be re-established in this reach of Bear Creek.

By 1989, the licensed amount of forage had increased to 354 AUMs, nearly five times the amount previously grazed from the area. The livestock permittee reportedly reduced his annual cost of hay by $10,000.

■ The principal management objective for the riparian area was to protect streambanks against erosion by high flows during spring runoff and during high-intensity summer thunderstorms.

■ The grazing system was designed to improve the riparian area and stream by improving both riparian and upland vegetation.

■ By grazing pastures containing riparian areas early, livestock were less inclined to concentrate on riparian vegetation and better utilized adjacent upland forage.

■ Improvements in upland vegetation were required for full recovery of the riparian area and for the increase in livestock forage.

■ This early season riparian grazing system worked well on this site's sandy loam soils. It might not work as well or at all under different climatic or streamflow conditions, or on soils with high moisture content which are susceptible to shearing and compaction by livestock trampling.

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Mahogany Creek — Nevada

The Mahogany Creek watershed lies at approximately 5,300-6,900 feet

elevation in northern Nevada. Precipitation in the case study area averages about fifteen inches per year and comes mainly as snow. Peak runoff normally occurs in May and June.

Mahogany Creek is approximately eleven miles long. The lower three miles of the stream flow through the Summit Lake Indian Reservation. Six miles of the stream are located on public land administered by the Bureau of Land Management. Two miles of Mahogany Creek plus its major tributary flow through private land.

Mahogany Creek is one of two areas in the U.S. where a lake-dwelling population of Lahontan cutthroat trout reproduce naturally. These fish are listed as a threatened species under the Endangered Species Act. Trout from Summit Lake annually migrate into the creek to spawn. The resulting juvenile fish migrate back to the lake to mature and eventually repeat the cycle.

Mahogany Creek, Fall of 1975.

The area has been grazed by livestock for at least seventy-five years. It was used heavily by both cattle and sheep in the summer. Improper grazing severely degraded the riparian area and surrounding uplands.

The riparian area was virtually stripped of vegetation. Streambanks were badly eroded. Streamflows had declined and increased in temperature and sediment load. Spawning and rearing habitat for the threatened Lahontan cutthroat was severely degraded.

In 1974 the BLM attempted to demonstrate riparian area restoration by simply reducing grazing in the allotment. However, even reduced grazing pressure prevented substantial recovery of the degraded riparian area. In addition, the agency was unable to prevent unauthorized grazing.

In 1976 the grazing permit for the allotment was relinquished by the permittee. The BLM used the opportunity to fence most of the creek and much of the watershed to exclude livestock.

Riparian vegetation responded dramatically to rest from grazing and installation of a few instream structures to improve trout habitat by raising water levels and reducing erosion. Native perennial grasses increased throughout the fenced area. Previously decadent aspen groves expanded. Curlleaf mountain mahogany began reproducing within the fenced area while outside the fence almost no seedlings survived grazing.

Streambanks stabilized and erosion was reduced. The stream channel narrowed and deepened. Summer streamflow increased 400%, and depth of water increased 50%. Water temperatures and sediment load decreased. The improvement in fish habitat resulted in a significant increase in the threatened Lahontan cutthroat population.

■ Simply reducing the number of livestock in the allotment did not allow substantial recovery of the severely degraded riparian area and stream channel; livestock still overused the riparian area.

Mahogany Creek, Fall of 1985.

■ Even where riparian deterioration was severe and a threatened fish species was at stake, it was only after the grazing permit for the allotment was relinquished that the BLM was able to fence most of the creek and adjacent uplands.

■ Long-term rest from grazing was required to overcome the effects of long-term improper grazing.

■ Even under these long-standing, severely deteriorated conditions, ten years of rest resulted in dramatic improvement of riparian and upland vegetation, and increased the quality and quantity of summer streamflow.

■ Achieving similar improvements in the entire Mahogany Creek watershed would require a cooperative effort by numerous federal, tribal and private landowners and grazing permittees.

WEST Rocky Creek — Texas

West Rocky Creek is located at 1,800 feet elevation in the porous limestone Edwards Plateau

region which covers more than 10 million acres in west Texas. Annual rainfall averages about eighteen inches. Peak runoff usually occurs in late spring and fall as a result of thunderstorms.

Prior to the introduction of livestock in the mid 1800s, the landscape of the West Rocky Creek watershed was dominated by native grasses characteristic of the southern Great Plains. The U.S. Soil Conservation Service estimates vegetation was comprised of 85% grasses, 10% forbs and 5% woody plants. Trees and brush were largely confined to riparian corridors due to thick prairie turf and periodic fires which limited seedling survival on the uplands.

Native grasses such as sideoats grama, buffalograss, curly mesquite and tobosa, shielded the soil from the sun and from wind and water erosion. Dense root systems allowed rainfall to soak into the soil to recharge groundwater and keep streams flowing year-long.

Early ranchers didn't understand range ecology and lacked experience in this environment necessary

Representative West Rocky Creek riparian area before upland treatments and improved grazing management.

Representative West Rocky Creek riparian area after upland treatments and improved grazing management.

to predict the effects of overgrazing. By 1885, vegetation within the watershed had been dramatically altered by livestock overgrazing. Removal of the native grasses decreased infiltration of water into the soil. Man's fire suppression activities allowed brush seedlings to establish. The invading brush lowered water tables, accelerated runoff and soil erosion.

Dense stands of mesquite and juniper began to dominate the landscape. These deeper-rooted plants used groundwater below the depth grass roots could reach, depleting water that previously had recharged springs and streams. West Rocky Creek, which once flowed year-round, became intermittent in 1918, and dried up completely in the 1930s. The stream flowed sporadically during periods of above average rainfall. Without the protective cover of grasses, flooding and stream channel erosion increased.

In the early 1960s, five ranchers began a range rehabilitation program on their privately owned land with technical assistance and cost-sharing under the Great Plains Conservation Program. They removed brush, reseeded grasses and implemented a variety of improved grazing strategies on about half the 74,000-acre watershed. Livestock forage increased. Soil erosion and sedimentation of downstream municipal water supply reservoirs decreased.

By 1970, springs that had been dry for decades began to flow again on all five ranches. West Rocky Creek began to flow year-round, yielding from 150–4000 gallons per minute during the severe 1984 drought. Riparian vegetation re-established. Streambanks and the stream channel stabilized. Fish and riparian dependent wildlife re-established.

Improving the productivity of the West Rocky Creek watershed produced significant downstream economic benefits to the city of San Angelo. The quantity and quality of water yielded to water supply reservoirs increased. Reduced sedimentation increased the economic life of reservoirs and decreased water treatment costs. Flooding reduced in severity.

Removing brush, reseeding grasses and good grazing management restored this site to near-pristine appearance and productivity. Continued good grazing management is required to keep it that way.

This nearby site received the same brush removal and reseeding treatments, but was improperly grazed. An improved grazing strategy is required to prevent the site from deteriorating further and eventually becoming reinfested with brush.

Overgrazing and fire suppression created conditions that encouraged thick infestations of juniper and mesquite in the West Rocky Creek drainage.

■ The dramatic decline in the productivity of the West Rocky Creek watershed resulted in largest part from poor livestock grazing practices, notably continuous, year-long, heavy grazing.

■ Extensive, costly brush removal and grass reseeding were required in addition to improved grazing practices in order to repair the damaged watershed and restore streamflows and riparian areas.

■ Proper grazing management is essential to maintain the improved condition and protect the substantial investment in restoring the watershed's productivity.

■ Restoring diverse, more productive upland and riparian plant communities benefitted livestock, fish and wildlife, and downstream water users.

■ Technical assistance with private and public cost-sharing were essential to finance high cost watershed improvements. The economic and environmental benefits extended far beyond the private lands that were restored in productivity.

BIG Creek — Utah

Big Creek rises from springs at about 8,000 feet elevation in the northeast corner of Utah on the Wasatch-Cache National

Forest and flows about twenty miles to the Bear River. Elevation in the case study area is about 6,600 feet. Precipitation averages approximately seventeen inches per year and comes mainly as snow. Peak run-off normally occurs in May or early June.

Beginning about fifteen miles above its confluence with the Bear River, Big Creek flows through land administered by the Bureau of Land Management for about five miles. Down-stream, and for about three miles immediately upstream, the creek flows through private land. The upper two miles of the stream flows through land managed by the Forest Service.

The area managed by the BLM traditionally has been grazed continuously May-October. Consequently, riparian vegetation, stream-banks and water quality were severely degraded.

In the late 1960s the BLM proposed a 1.5 mile riparian improvement project. The objectives were to improve fish habitat and overall riparian conditions, and to demonstrate for livestock operators the rate of recovery and vegetative potential of the riparian area. The proposal was resisted by local livestock interests and the area temporarily fenced off from livestock was reduced to 0.5 mile of streambank. Fish habitat improvement structures were placed in the stream within and outside the fenced area in 1970 and 1971.

Despite occasional unauthorized grazing within the fenced area, riparian vegetation and the stream responded dramatically to rest from grazing.

Grazed area immediately below the Big Creek riparian protection fence, September 1988.

Big Creek inside fence, August 1987. Note heavy sediment load from deteriorated upstream watershed.

Streambanks became more stable. The stream narrowed and deepened. The riparian area widened due to the raised water table.

However, fish habitat improvements within the fenced area were counteracted by poor watershed conditions upstream. Instream structures trapped large amounts of sediment from upstream erosion. Instream structures outside the exclosure ceased to function and were washed out because of unstable streambanks caused by poor grazing management.

■ It was difficult to implement a small demonstration project on this public land site, even though riparian areas and the stream were severely deteriorated.

■ Unauthorized grazing inside the fence was a problem because the permittee was not a cooperator in the demonstration project.

Riparian conditions inside and outside the Big Creek riparian restoration demonstration fence, September 1981.

The deteriorated condition of the watershed and results of the sixteen-year demonstration/research project led to recommendations for short-term reductions in grazing and changes in the grazing strategy for the allotment. These recommendations were not implemented. Riparian areas outside the exclosure continued to be heavily grazed season-long.

■ Sixteen years of research and demonstrated success at improving riparian, stream and grazing conditions were inadequate to overcome resistance to changing the grazing strategy on this allotment.

■ Some riparian and stream management objectives were not achievable because the watershed upstream remained in poor condition due to poor grazing management.

BAD River — South Dakota

The Bad River Basin is the smallest of the major river basins which flow into the Missouri River from western South Dakota. The 3,152

square mile basin is mostly private land and National Grassland Administered by the U.S. Forest Service. The basin is representative of the Northern Shale Plains which covers about 67 million acres in the Northern Great Plains.

Annual precipitation in the Bad River Basin averages approximately fifteen inches with about 80% occurring between April and September. Peak rainfall months are May and June, but intense thunderstorms are common throughout the summer months.

Introduction of livestock and improper grazing practices accelerated the naturally high rate of sheet, rill and gully erosion within the drainage. Overgrazing and livestock trailing to water activated gully erosion and increased runoff from steep, weakly-developed upland soils.

Overgrazing of native grasses reduced water infiltration into the soil and exposed the soil surface to the erosive force of accelerated overland runoff. The increased rate of runoff eroded and downcut gullies and stream channels weakened by livestock trailing and trampling and removal of riparian vegetation.

These conditions intensify the naturally extreme seasonal variations in runoff. Since 1928 Bad River flows ranged from 0 to 4,290 cubic feet per second. Exposed upland and riparian soils produce prodigious amounts of sediment and bedload material which are transported out of the Bad River Basin and eventually into the Missouri River.

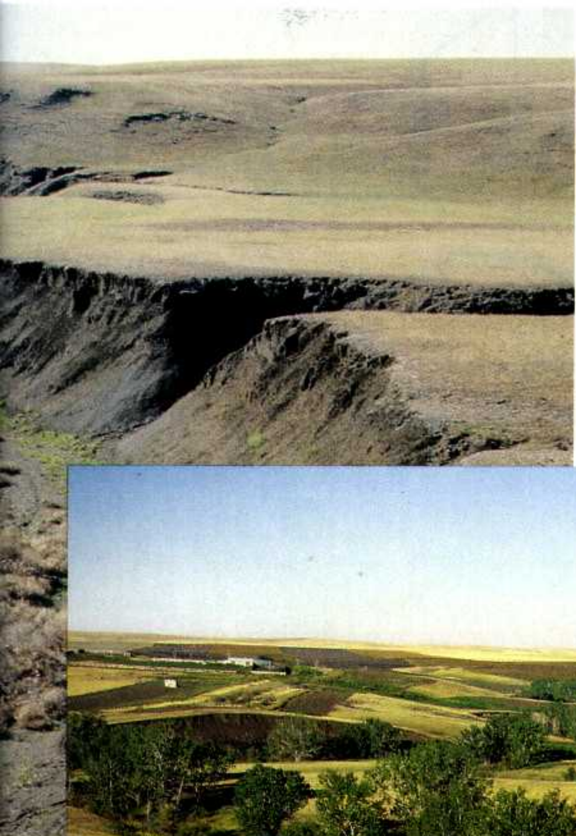
During one extreme event on May 14, 1982, Bad River discharged 949,300 tons of sediment. On the average, each square mile of the basin annually produces 1,418 tons of sediment and bedload material.

Erosion in the Bad River drainage has far-reaching adverse effects. Bad River sediment deposits in the Missouri River restrict the channel. Resulting ice buildups reduce the water release capacity of Oahe Dam. This, in turn, results in reduced generation of electricity and periodic flooding of portions of the city of Pierre.

The poor condition of the Bad River watershed also adversely affects fishing in the Missouri River which is important to the Pierre-Fort Pierre area economy. Bad River sediment deposits reduce fish production by smothering eggs. In addition, for six to eight weeks following major runoffs, suspended sediments from Bad River muddy water and greatly reduce fishing success in twenty to thirty miles of the Missouri River.

Improved grazing strategies can significantly reduce erosion in the Bad River drainage. Moderate and flexible stocking rates are essential due to the wide fluctuations in timing and amounts of annual precipitation. Cross fencing and stock water developments can improve livestock distribution, provide better control of grazing intensity, and take pressure off riparian areas by changing grazing patterns and reducing trailing.

Various rest-rotation grazing strategies can keep livestock off streambanks and other fragile areas during the times they are most vulnerable to damage.



Typical degraded riparian area in the Bad River drainage. The channel is downcut and banks are near vertical walls 8-12 feet high. There is little riparian vegetation to protect streambanks against further erosion or to slow runoff and reduce transport of sediment and bedload downstream.

This riparian area in the Bad River drainage shows the vegetative potential of the degraded area in the photograph above. This area is maintained in a healthy condition by being included in a separate pasture that is not grazed during the growing season. Dormant season grazing has allowed both woody and herbaceous plants to maintain vigor and regenerative capabilities. The vigorous growth slows and provides a protective blanket against high spring and summer runoff. Inset: close-up view of the same area dominated by cottonwoods, willows, and western snowberry.

Alternating seasons of use in pastures can allow warm or cool season grasses to be rested during critical reproductive phases.

- Cross fencing and off-stream water developments are important tools to reduce overgrazing and trailing impacts on vulnerable riparian and drainage areas.
- Multiple pastures and rest-rotation grazing strategies allow riparian areas to be protected when they are most vulnerable to livestock damage.
- Restoring and protecting riparian areas requires decreasing the rate of runoff from uplands, restoring riparian vegetation, and protecting streambanks from livestock during vulnerable periods.
- The adverse effects of accelerated erosion and runoff due to improper grazing in the Bad River watershed are felt far beyond the drainage.

SAND Creek — Idaho

Sand Creek is located in southwestern Idaho at about 2,200 feet elevation. Annual precipitation is approximately nine inches

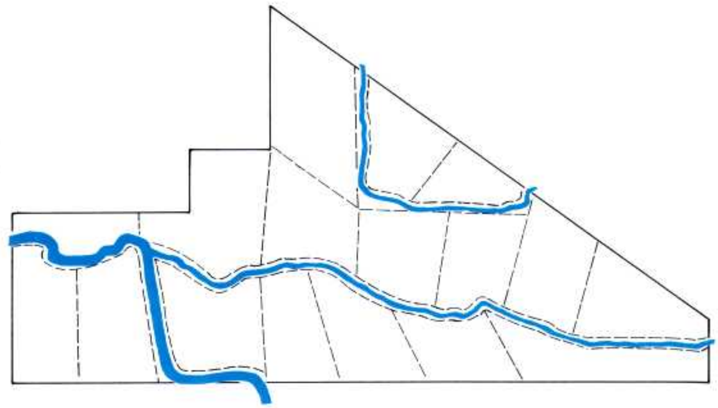
and comes mainly as snow and spring and fall rain.

In the early 1930s this privately-owned site was cleared and leveled to flood irrigate 170 acres of pasture. In recent years approximately 125 cows, 3 to 4 bulls and their off-spring were grazed year-round. Portions of the area were grazed for short periods and devoted to producing hay for winter feed.

Earthen irrigation and drain ditches and stream-banks were trampled and eroding. Ditch maintenance was a major operating cost. Significant amounts of sediment were entering Sand Creek.

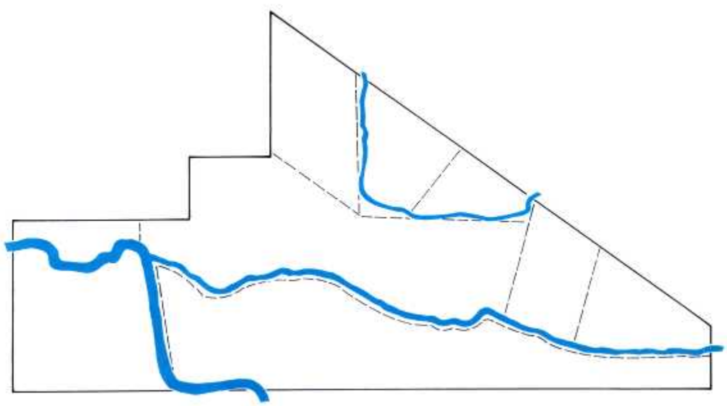
In late 1987 the property was sold. The new owner set a goal of maximizing profit. Protection of riparian areas or reducing nonpoint source pollution were not planning considerations.

Additional pastures and high animal density allowed forage to be grazed to the proper stubble height and properly rested to encourage optimum regrowth.



After Planning

With the traditional pasture configuration and season-long, continuous grazing, livestock could not be economically managed to optimize forage production (or protect riparian areas, reduce erosion of irrigation and drain ditches and streambanks, and minimize sediment contribution to Sand Creek).



Before Planning

Steam corridor fencing allows vegetation to stabilize and protect the steep bank on the left, and to create wildlife habitat. With careful management, livestock grazing can be controlled to prevent damage to the streambank on the right. Without careful management, the very high intensity grazing system on this property could be disastrous for riparian values.

The 170 acres were divided into fifteen pastures and grazed April-October by a single herd of 600 yearling steers. Fences blocked livestock from Sand Creek and all earthen drain and irrigation ditches. Stock water was piped to troughs.

The grazing system was designed to meet the physiological needs of the dense stand of fescue, and thereby maximize forage production. Plants were allowed to reach Soil Conservation Service-recommended height before animals were turned in. High animal density encouraged uniform forage utilization. When the recommended minimum stubble height was achieved, animals were moved to the next pasture.

Grazed pastures received the SCS-recommended amount of rest for regrowth before livestock were reintroduced. The recommended minimum stubble height was maintained late in the growing season to encourage storage of energy for forage production the following spring.

This grazing system more than doubled the pounds of beef traditionally produced on this property. The cost of grazing improvements was recovered during the first year of operation.

Fencing livestock out of earthen irrigation and drain ditches reduced operating costs and production of sediment. Denying livestock access to streambank loafing areas reduced erosion. Streambank vegetation fenced off from livestock provides excellent habitat for waterfowl, upland game birds and other wildlife, and filters irrigation water running off pastures.

- Achieving the long-term benefits of restored riparian areas and reduced nonpoint source water pollution was compatible with short-term profits.

- Meeting the physiological needs of the forage plants was the key to maximum profit.

- This grazing strategy obtained dramatic, profitable results by applying centuries-old grazing concepts and commonly available forage management guidelines and technical assistance.

HUFF Creek — Wyoming

Huff Creek is located at 6,600 feet elevation in the mountain foothills of southwestern Wyoming. Precipitation averages

approximately sixteen inches per year and comes mainly as snow. Peak runoff normally occurs in April or May.

Huff Creek is one of several streams within a 91,000 acre multiple-permittee allotment in the Rock Springs District of the Bureau of Land Management.

Prior to livestock grazing, the riparian area probably was dominated by sedges, rushes and willows. The area was predominately grazed by sheep from the late 1800s until the late 1960s when most permittees converted to cow/calf operations. This conversion prompted aerial spraying of herbicides to kill upland and riparian shrubs and increase grass for continuous, May-September grazing.

Herbicides and intensive grazing eliminated riparian willows and, consequently, beavers. The water table dropped and streambanks eroded. The riparian area shrank and was invaded by sagebrush and rabbitbrush. Stream water temperatures and silt load increased.

Once a popular cutthroat trout fishery, the Wyoming Game and Fish Department estimated Huff Creek's trout population declined from 222 fish per mile in 1958 to 36 per mile by 1978.

In the mid-1970s the trout in Huff Creek were identified as a pure strain of Bonneville cutthroat, then under consideration for listing as a threatened species under the Endangered Species Act. To provide the fish emergency protection, in 1976 and 1979 livestock were excluded from two stream reaches totaling about one mile in length. Instream structures and rock riprap were installed to elevate the water table, improve trout habitat and reduce streambank erosion.

The area inside the fences responded dramatically. Streambanks healed. The stream channel narrowed

Huff Creek, September 1976

Huff Creek, November 1980

and deepened. Within five years the riparian area had roughly doubled in width due to the elevated water table. Vegetation shifted from sagebrush and rabbitbrush back to grass. Grass inside the fences was dense and over two feet high. One stockman remarked he had never seen anything like it in that area. Grass outside the fence was sparse, less than two inches tall, and dominated by sagebrush.

The demonstrated potential for increasing livestock forage while simultaneously protecting other riparian values prompted the livestock association to change its grazing strategy for the six mile long Huff Creek drainage.

A rider was hired to herd stock in the north half of the allotment. Grazing in the Huff Creek valley bottom was delayed until late August through September. The lower half of the valley received light grazing because the herder accelerated the animals' natural drift pattern.

Herding and strategically placed salt blocks improved livestock distribution and provided ungrazed forage for stock being trailed to winter pastures.

The number of calves and weight gains improved. In three years riparian vegetation outside the fence looked the same as vegetation inside the fence. Huff Creek had narrowed by about one-third, doubled in depth, and water temperatures had declined. The percentage of eroding streambanks decreased from about 80% to 20%. The number of Bonneville cutthroat increased to 444 per mile, an 1,100% increase over 1978 levels.

The success on Huff Creek and similar efforts elsewhere removed the immediate threat to survival of the Bonneville cutthroat. In 1987 the U.S. Fish and Wildlife Service decided to wait until 1992 to review the results of habitat recovery projects before deciding whether to proceed with listing the fish as a threatened species.

Inside (left) and outside (right) a Huff Creek riparian protection fence in 1984 after improved grazing management through herding.

■ Herding livestock to fresh forage, and providing grazed forage proper rest for regrowth, are ancient arts that still work. Animal weight gains improved concurrently with improved riparian conditions.

■ Steep terrain and natural barriers facilitated herding by restricting livestock movement between drainages.

■ Herding was successful at keeping cattle out of a drainage; it was not successful at keeping cattle out of the riparian area once they were in the drainage.

■ Herding was as effective as fences in controlling livestock grazing of riparian areas.

■ The effective rider clearly understood the objective of the riparian improvement grazing strategy, was dedicated to the project and worked the cattle daily.

■ The area had been in a deteriorated condition for so long local stockmen were surprised by the vegetative potential revealed by improved grazing management.

HENRY'S Fork River — Idaho

The Henry's Fork River rises on the continental divide on the west side of Yellowstone Park and drains a 4,000 square mile

area in eastern Idaho. The elevation of this case study site is about 6,200 feet. Annual precipitation averages approximately forty-five inches which comes mainly as snow and to a lesser extent from summer thunderstorms.

The river is fed by numerous large springs; Big Springs alone discharges approximately 0.5 million gallons per day. The spring water provides excellent growing conditions for rainbow trout which attract anglers from all over the world. The spring water keeps much of the river from freezing, thereby providing good winter conditions for fish and wildlife, including the threatened trumpeter swan.

Bison, antelope, moose, elk and deer grazed the watershed for thousands of years. Cattle and sheep have grazed the area since the late 1800s, numbering more than 3 million animals in their heyday.

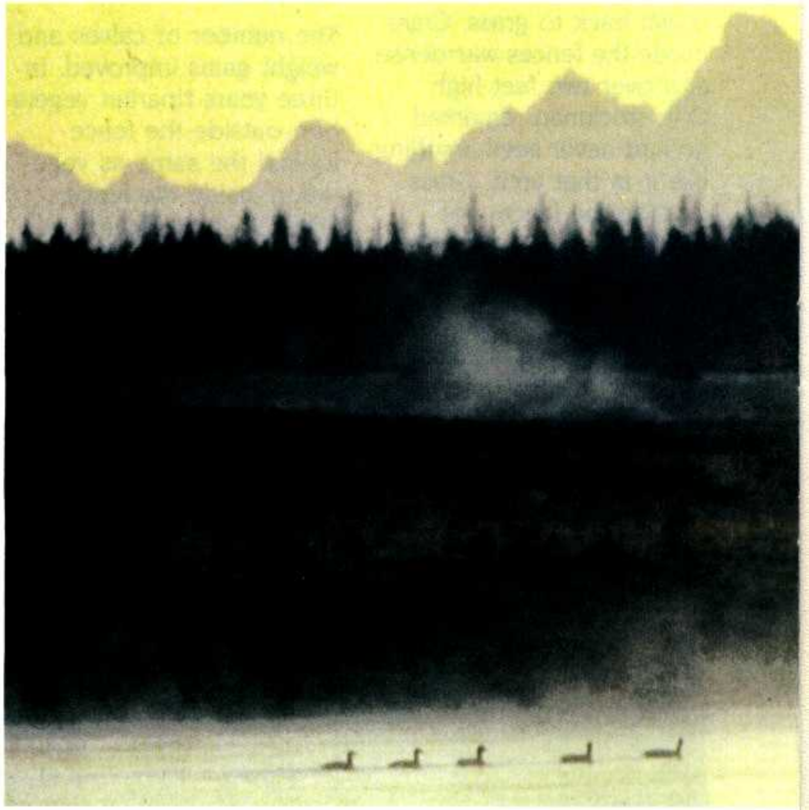
In the 1960s and mid 1970s the 12,700 acre Railroad Ranch — famed world-wide in trout fishing circles — was donated to the State of Idaho. Forty-seven hundred acres became Harriman State Park. An adjacent 1,000 acres, called Harriman East, are managed by the Idaho Foundation for Parks and Lands. Together they encompass six miles of some of the best rainbow trout habitat in the U.S.

Deeds transferring the property contained strong convenants to protect the environment. Livestock numbers were drastically reduced on Harriman East. Nonetheless, mid June to mid October continuous grazing still resulted in poor utilization of upland forage, damage to riparian vegetation and streambanks, and increasing conflict with growing numbers of fishermen.

In 1984 the single pasture was divided into four pastures, one of which was a narrow "set-back" pasture parallel to both sides of the river. This pasture included more land area than a typical stream corridor exclosure, but less area than normally would be included in a riparian pasture.

Livestock were grazed under a rest rotation system. The set-back pasture won't be grazed until riparian and streambank recovery objectives are met. Then it will be grazed under special prescription.

Implementing this grazing system allowed the live-



stock permittee to continue grazing the same number of animals to start, and increase animal numbers by 25% in the fourth year of operation, despite two consecutive years of drought. The non-profit Park Foundation continued to get badly needed grazing revenue. The set-back pasture eliminated fishermen-livestock conflict, and allowed future livestock use of streambanks to be carefully controlled to protect fish habitat.

The adjacent area now within the 4,700 acre Harriman State Park traditionally was grazed June-October by large numbers of livestock. After the park was formed, grazing was restricted to approximately 2,500 acres. The grazing period was limited to a few weeks in late fall to eliminate conflicts with spring waterfowl nesting and brood rearing in the riparian area and adjacent uplands, and to eliminate summer livestock conflicts with growing numbers of fishermen.

This grazing system accomplished its objectives by forgoing the majority of the area's livestock forage potential. However, it had the unintended consequence of concentrating livestock on Henry's Fork streambanks.

By late fall upland grasses are mature and dormant. Livestock naturally are attracted to the green vegetation in the riparian area. Streambank vegetation was overgrazed and banks were trampled which degraded important shoreline trout habitat. This eventually led to increasing complaints from the public that livestock grazing was not compatible with the park's mandate to protect the high quality Henry's Fork trout fishery.

In 1988 the Henry's Fork

Henry's Fork River, 1985. Trampling by livestock and loss of vegetation caused streambanks to slough and lay back. This resulted in loss of important shoreline habitat for juvenile and trophy trout.

Foundation, a private organization of fishermen, local businessmen and property owners, proposed to cost-share with the State of Idaho a solution to livestock/fishery conflicts in the park. Within a few months a plan was developed, approved, funded and implemented.

Both sides of the Henry's Fork River were fenced to exclude livestock from streambanks; alternative stock water was available.

The fence was strategically located far enough back from the river to provide generous area for waterfowl nesting and brood rearing, and abundant cover from predators. Additional design considerations included providing adequate loafing area for fishermen, birders and picnickers, and minimizing visual obtrusiveness of the fence from the river.

The fence eliminated all sources of conflict that had severely limited and threatened to end livestock grazing on the park. It provided park managers the option of capitalizing on the significant revenue potential for increasing grazing on virtually all of the 2,500 acres available to livestock.

- **Drastically reducing both the number of livestock and the grazing season were not sufficient to achieve riparian management objectives on Harriman State Park.**

- **Innovative, practical solutions were possible even when extremely high riparian and stream resource values appeared to be irreconcilable with livestock grazing.**

- **Private and public cost-sharing and win-win solutions, facilitated quick, efficient riparian protection. On the Harriman East site, the solution was devised and implemented almost immediately due to cooperation of the livestock grazing permittee.**

- **Livestock grazing on these park lands almost certainly would have been eliminated if riparian conflicts had not been speedily resolved. The solutions not only maintained livestock grazing, but allowed it to increase. Nonetheless, some livestock interests strenuously opposed fencing to protect Henry's Fork streambanks from the effects of livestock grazing.**

Slightly different spot, 1988. A good grazing strategy encourages shoreline vegetation and more vertical streambanks. Some sites take much longer to show major change than others. Here the growing season is short and the winters are severe. Because Henry's Fork flow and sediment load are controlled by an upstream reservoir, streambank building is a slow process.

HORSE Heaven Creek — Oregon

Horse Heaven Creek is located in central Oregon. Elevations in the case study area range from about 3,600 feet to 4,500

feet. Annual precipitation ranges from nine inches in the lower areas to fifteen inches in the higher elevations.

This area has been grazed by domestic livestock for more than a century. In this case study the rancher runs a cow/calf operation on 43,000 acres of private and public land. The rancher cleared over 6,000 acres of juniper on his private land to improve upland range conditions by encouraging native grasses. Before and after studies showed treated areas improved from 19 acres per animal unit month (AUM) to 2.7 acres per AUM.

In spite of improved upland conditions, the rancher was still concerned about his livestock "... lying on the creeks and starving to death." His cattle tended to concentrate on and overgraze riparian areas and underutilize abundant upland forage.

To solve this problem, he fenced over six miles of Horse Heaven Creek into separate pastures. They were rested from grazing for a three-year recovery period, then grazed under a high intensity short-duration spring grazing system. At the rancher's request, the U.S. Forest Service also fenced the riparian area on his allotment upstream, which is grazed in the same manner.

The rancher's cattle now graze the uplands more, and more uniformly. The riparian areas and creek have improved dramatically.

The combination of improved upland and riparian vegetation has reduced erosion and improved streamflows. Streams that used to go dry in some years now flow in years with half as much precipitation.

Summer of 1988 after the riparian pasture had been rested from grazing for three growing seasons (1983-85), followed by high intensity short duration spring grazing 1986-88. Willows grew profusely and stabilized the stream channel above the reservoir. As the result of reduced sediment loads and generally improved habitat conditions, trout now spawn in the stream feeding the lake.

Summer of 1984 after riparian areas were fenced into separate pasture and rested for two growing seasons. Note sediment deposited in upper end of reservoir from poor condition uplands after summer thunderstorms.

Improvements in upland and riparian vegetation allowed the rancher to increase his cow/calf numbers by 50% and improve the average weaning weights of calves by 150 lbs. Improved riparian conditions attracted more elk and beaver. According to this successful rancher, "The best environment for raising cattle is also the best environment for wildlife." He considers beaver a positive influence on watershed recovery. "I wish I had more of the irrigating [expletive deleted]."

He credits good diversity in upland and riparian vegetation with providing more stability to his livestock operation, especially during dramatic variations in weather patterns. His ranching philosophy is, "The closer that you can have it to like nature would have it the better off you are in the long run. Its more economically sound."

Restoring vigorous riparian vegetation led to increased beaver activity. Beaver dams stored water and trapped sediments. Elevated water levels subirrigated adjacent land, which expanded riparian areas and provided more livestock forage and more wildlife habitat.

"THE closer that you can have it to like nature would have it the better off you are in the long run. It's more economically sound."

- Despite availability of abundant upland forage, cattle tended to concentrate in and overuse riparian areas.

- Improved management of upland and riparian vegetation combined to reduce erosion and sedimentation of streams and irrigation and fishing reservoirs, and to enhance summer streamflows.

- Fencing riparian areas into separate pastures allowed the rancher to obtain optimum utilization of upland and riparian forage and improve watershed conditions.

- Improved riparian vegetation encouraged beaver activity which raised stream water levels and expanded the riparian area. This increased livestock forage and wildlife habitat and decreased erosion and sedimentation.

- Good riparian management was an integral part of increasing the ranch's long-term productivity and profitability.

Riparian Grazing Strategies

THE preceding case studies are representative of a wide range of riparian area conditions, problems, and opportunities.

For the most part, they demonstrate that the productivity of degraded riparian areas can be restored, usually with a net gain in livestock forage.

This runs counter to the common perception that improved management of riparian areas is a zero-sum game where improvements in fish and wildlife habitat, water quality and other watershed values can only be achieved at the expense of livestock forage.

These case studies also demonstrate there is no cookbook of simple, universal recipes for successful riparian grazing strategies.

There are virtually infinite variations in hydrologic and climatic conditions, in geology, soils, and stream character, and in plant species and plant communities. Local site condition, trend and potential also vary widely. This natural variation and complexity is compounded by variations in local grazing traditions, and in the economic status, attitudes and objectives of livestock operators.

As illustrated in this infrared photograph, riparian areas over much of the western United States are thin lines of green across vast areas of arid and semiarid land. Traditional grazing strategies for the most part have been designed for the far more extensive upland vegetation. In consequence, riparian vegetation has been overgrazed and riparian areas and streams degraded over large areas of land.

FOR the most part... the productivity of degraded riparian areas can be restored, usually with a net gain in livestock forage.

A successful riparian grazing strategy must be custom designed to fit the specific circumstances. However, many years of experience and research have tested and proven some common denominators and practical rules of thumb.

RIPARIAN Management Objective

A clearly defined objective or desired future condition for the riparian area is the foundation of a successful grazing strategy.

This seemingly obvious step actually represents a fundamental departure from traditional livestock grazing management on most western lands.

Grazing typically has been targeted on the far more extensive upland forage, predominately grasses. This, of course, was unlikely to result in proper grazing of riparian grasses, forbs or woody plants. In fact, until very recent years, some livestock grazing manuals referred to streamside areas as "sacrifice areas."

SITE Potential, Condition and Trend

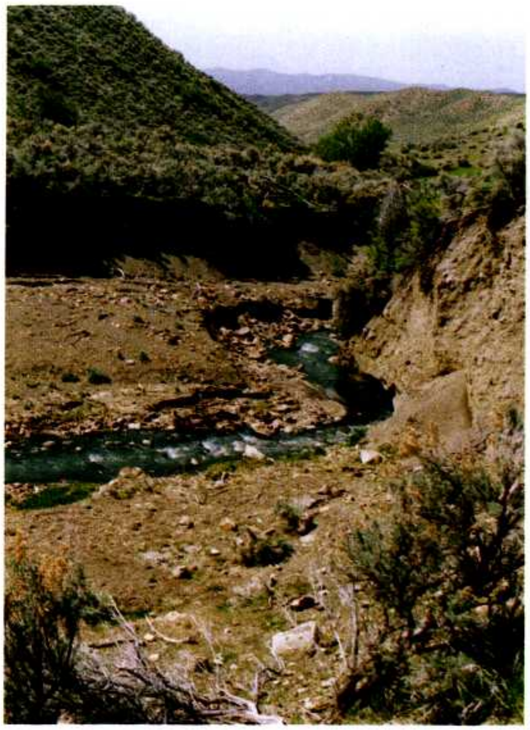
IN order to establish realistic objectives for riparian areas, it is important to know the vegetation potential of the site under proper grazing management.

Unless the riparian area is in extremely degraded condition, or the stream is rapidly depositing soil from upstream sources, the potential of the site for various species of plants may be obvious. If it isn't, this insight may be available from similar sites in the local area.

Some riparian areas are so badly degraded there is little evidence to support predictions of vegetation potential. Some areas have been degraded for so long, or the deterioration has been so gradual, that no one can recall what vegetation used to be there. In these cases, relic areas — areas inaccessible to livestock because of terrain, or early man-made livestock exclosures may provide useful insight. Rapidly evolving ecological classification technology can be used to help predict or confirm vegetation potential.

The present condition and trend of the desired riparian vegetation also may strongly influence the choice of grazing strategy. For example, different strategies might be used to restore severely deteriorated vegetation, to encourage an improving trend, or to maintain a desired condition once it is achieved.

Laterally unstable stream channel. Loss of upland vegetation and topsoil concentrates and increases the speed of runoff. Doubling the velocity of streamflow quadruples its erosive power and gives it 64 times more bedload and sediment carrying power.



Vertically unstable stream channel.

The condition and trend of streambanks also will influence the design of grazing strategies to protect or restore riparian areas. Fragile or actively eroding streambanks likely will require a different grazing strategy than might be appropriate under more stable conditions.

Streams work off energy by constantly cutting and filling their channels in response to changes in flow, sediment load, and streambank condition. Riparian plant communities in good condition resist the cutting and stabilize the fill.

In areas with deep alluvial soils, accelerated downcutting of the stream channel can be triggered by increased rate of runoff resulting from loss of upland vegetation and topsoil. Downcutting lowers the streambed and the groundwater table, reduces the riparian area and destabilizes streambanks. If downcutting isn't blocked by resistant geologic formations or man's intervention, it could migrate upstream and potentially disrupt the hydrologic function of the entire watershed.

Where streams with gravel or rock bottoms resist downcutting, laterally unstable stream channels can result from activities that degrade riparian vegetation and otherwise destabilize streambanks. Weakened streambanks are more vulnerable to erosion. The stream channel becomes progressively wider and shallower at the expense of the riparian area and water quality.

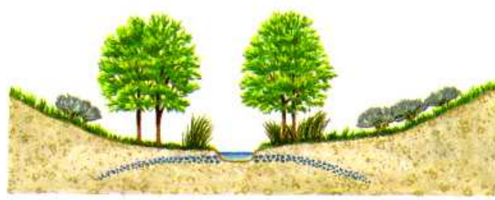
STRUCTURES *treat symptoms of the problem. If used as a substitute for changes in grazing necessary to improve riparian and upland conditions, investments in structures may be wasted.*

PROPER *management of riparian and upland grazing usually is the best, most cost-effective treatment for stream channel instability and watershed deterioration caused by improper grazing. In some cases, instream structures such as weirs, rip rap and gabions can help reduce streambank erosion, stabilize the stream channel, reduce downcutting of the streambed and lowering of the water table, and trap sediment to rebuild streambanks.*

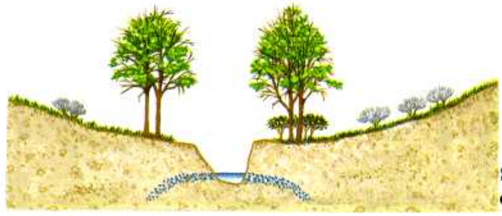
Structures treat symptoms of the problem. If used as a substitute for changes in grazing necessary to improve riparian and upland conditions, investments in structures may be wasted. If improperly designed or deployed, instream structures may accelerate stream channel and riparian damage.

In streams prone to downcutting, △ *instream structures have the greatest payoff when used during Stage 1 conditions to prevent downcutting and keep it from migrating upstream. Instream structures used to combat Stage 2, 3 and 4 conditions can be very expensive to build and maintain and have high risk and rate of failure.*

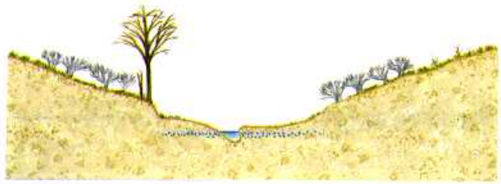
In streams prone to lateral or sideways channel movement, ▷ *instream structures generally can be justified as a first resort only when there is not enough soil left to support adequate riparian vegetation. Or when the stream channel is so unstable it prevents recovery of the riparian zone within an acceptable period of time.*



Stage 1: Unincised

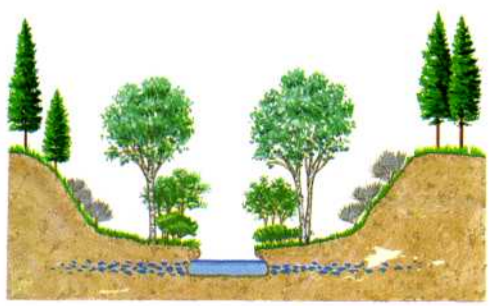


Stage 2: Rapid downcutting

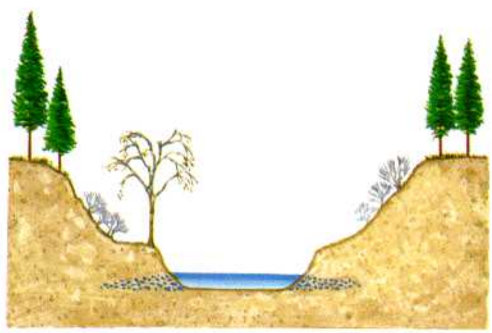


Stage 3: Channel widening and forming new floodplain

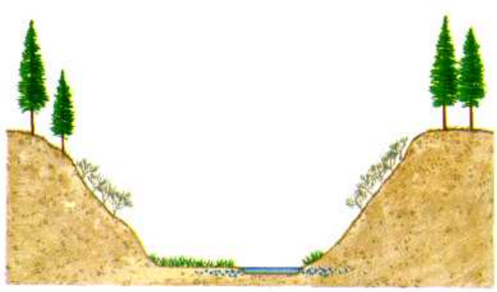
Stage 4: Channel widened enough to form a new stable channel and floodplain



Streambanks and channel in good condition

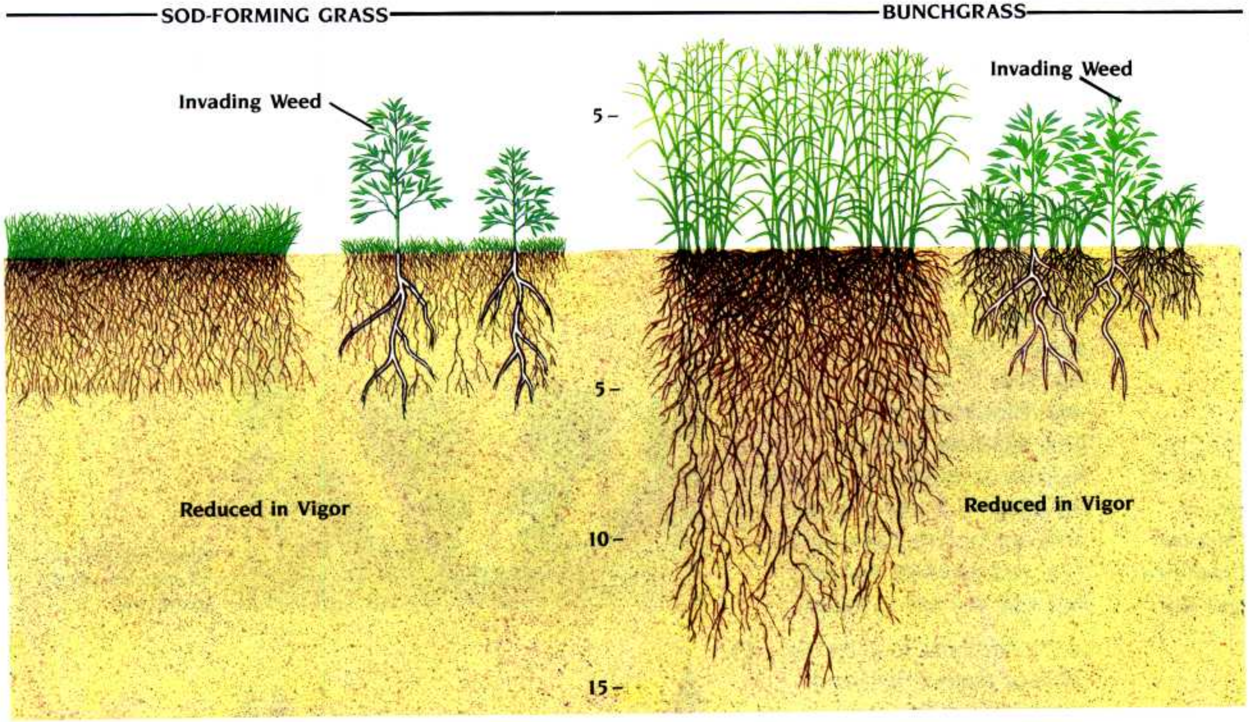


Stream channel widens and shallows in response to deteriorating upland and/or riparian conditions



Stream channel very wide and shallow; stream moves back and forth in channel until stabilized by vegetation

EFFECTS of overgrazing on root production, plant vigor and species composition. From: Understanding Grass Growth: The Key to Profitable Livestock Production



When plants are severely grazed, root growth stops. Regrowth of foliage takes precedence over providing energy for root growth. Continuous severe grazing causes roots to die back, reducing plant vigor. Plants then produce less livestock forage, are more susceptible to low soil moisture, and may be replaced by plants less palatable to livestock and less beneficial to protection of upland watershed conditions, riparian areas and stream channels.

Grazing strategies which provide for foliage to be properly pruned, and which allow sufficient rest from grazing for plant regrowth and energy storage in roots, will produce more livestock forage over the long term than strategies that allow continuous grazing during the growing season.

PLANT Physiology

A successful riparian grazing strategy will fit the plant(s) one wants to encourage. Desirable plants that are grazed too severely, too often, or at the wrong time, will be reduced in vigor, suppressed by less palatable plants, or killed.

A grazing strategy designed to protect or encourage only riparian plants may adversely affect upland grasses and/or result in substantial under-utilization of upland forage.

Grazing strategies either must be designed to: (a) concurrently meet the needs of both upland and riparian vegetation over time; (b) include riparian areas in separate pastures to allow special management; or (c) exclude livestock from riparian areas through herding or fencing.

Under continuous, season-long grazing, riparian vegetation likely will be severely grazed late in the growing season. At this critical time foliage is needed to manufacture and store energy for root growth and for initial foliage production the following spring.

In this area, willows put on new growth in mid-summer. This new growth becomes particularly attractive to livestock when upland forage dries out and riparian grasses have been depleted.

This riparian area had been subject to continuous, season-long grazing for many years. When this photograph was taken, livestock had been excluded from the area right of the fence for one year.

Riparian vegetation characteristically is quite different than the plants on adjacent uplands. A grazing strategy targeted on upland grasses, for example, may result in severe overgrazing of riparian grasses, forbs, shrubs and tree seedlings.

GRAZING Strategies

Decreasing the number of livestock is commonly offered as the simple solution to degraded riparian conditions. But even under light stocking rates livestock tend to concentrate on riparian vegetation during various seasons of the year. Unless the reduction were extreme, it might not achieve the desired improvement in riparian conditions. This is especially likely if the riparian area is in a deteriorated condition with slow recovery potential.

In short, restoring degraded riparian areas generally requires managers to change the way livestock are grazed.

A successful riparian grazing strategy will fit the unique circumstances of each site, including watershed and stream conditions, riparian and upland vegetation, terrain, class or kind of livestock, and the management capability and objectives of the livestock operator.

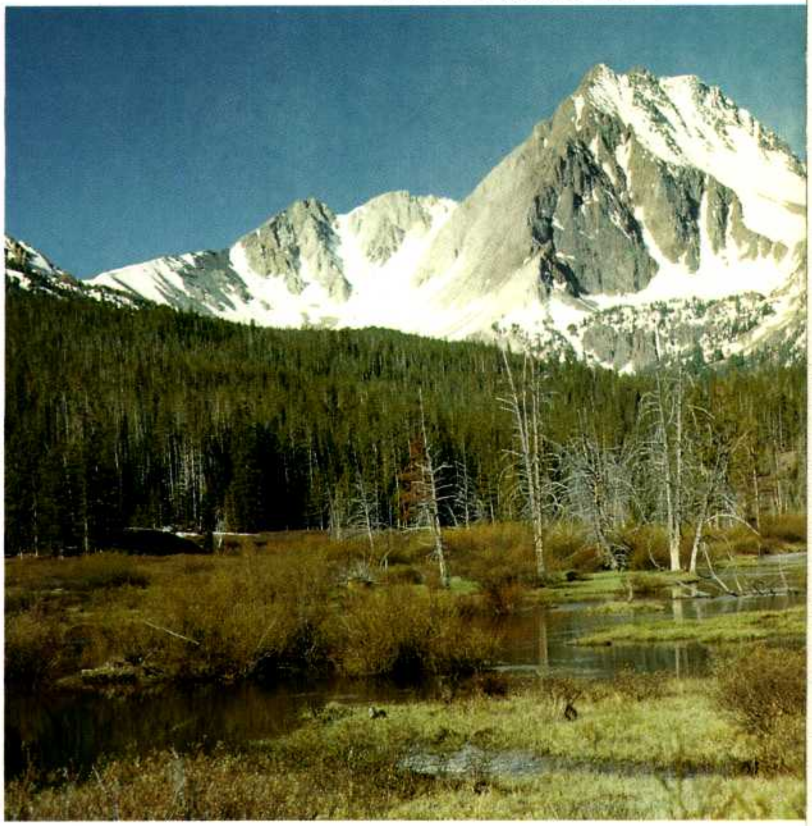
These circumstances occur in virtually infinite variation across the West. No one grazing strategy will fit all situations. The most promising strategies for protecting or restoring riparian areas incorporate one or more of the following features:

- **Including the riparian area within a separate pasture with separate management objectives and strategies.**
- **Fencing or herding livestock out of riparian areas for as long as necessary to allow vegetation and streambanks to recover.**
- **Controlling the timing of grazing to: (a) keep livestock off streambanks when they are most vulnerable to damage; and (b) coincide with the physiological needs of target plant species.**
- **Adding more rest to the grazing cycle to increase plant vigor, allow streambanks to heal, or encourage more desirable plant species composition.**
- **Limiting grazing intensity to a level which will maintain desired species composition and vigor.**
- **Changing from cattle to sheep to obtain better animal distribution through herding.**
- **Permanently excluding livestock from riparian areas at high risk and with poor recovery potential when there is no practical way to protect them while grazing adjacent uplands.**

RESTORING *and protecting riparian areas is a long-term job requiring a long-term commitment.*

TIME

The deterioration of western riparian areas and associated uplands didn't happen overnight. In many areas the process began more than a century ago. In many areas it is continuing, despite reported improving trends in upland conditions.



Loss of topsoil and the gullies and arroyos resulting from improper land management for all practical purposes have permanently altered and diminished the productivity of large areas.

On high gradient streams where the channel is unstable, or where seed sources for native riparian plants are absent or in short supply, or where sediment loads are low, recovery may take decades.

In areas with shallow soils and where streams carry limited sediment to rebuild streambanks, it might take centuries to restore productive riparian areas.

In high elevation glaciated stream basins with little soil building potential, and in some areas where stream channels are severely downcut, restoration of degraded riparian areas probably won't occur until the passing of another ice or volcanic age.

However, as the preceding case studies demonstrate, many riparian sites have potential for dramatic recovery.

Even severely degraded riparian areas can be restored when site conditions and management are right. For example, on low gradient streams flowing through alluvial valley bottoms, particularly where the stream carries a large sediment load at high flows, the right grazing strategy can produce dramatic recovery of riparian vegetation and streambanks.

This initial recovery of vegetation should not be confused with achieving the desired long-term condition for the riparian area. Nor is it a substitute for changes in upland grazing management that may be required to restore and maintain the long-term productivity of the watershed.

The longer it takes to implement improved grazing strategies on deteriorated riparian areas and adjacent uplands, the higher the cost in forgone watershed values, including livestock forage, water quality, and fish and wildlife. And the higher the risk of essentially irreversible damage.

Harsh climatic conditions, thin soils and low stream sediment levels put many riparian areas at high risk of irreversible damage from improper grazing.

Flexibility

Rigid application of a paper grazing system can be a prescription for failure on the ground.

It may be difficult to accurately predict how the riparian area will respond to variables in weather, human and animal behavior, stream runoff and other conditions. In addition, if the riparian area is in a degraded condition, it probably will require a different grazing strategy to start than might be used to maintain the desired condition once it has been achieved.

Commitment

Commitment to steady progress is important to achieve and maintain the desired riparian condition.

Restoring and protecting riparian areas is a long-term job requiring a long-term commitment. A riparian improvement grazing strategy that is contingent upon favorable short-term circumstances, for example, good weather, low hay prices, a strong market for livestock, etc., probably is doomed to eventually fail.

The initial dramatic increase in vegetation possible on many riparian areas is just the first step toward recovery. If this first new growth proves irresistably attractive to a grazier fallen on temporary hard times, years of progress and investment could be quickly wiped out.

Any grazing strategy probably will fail to meet riparian improvement objectives if the livestock operator, or in the case of public lands, the permittee and the land manager, are not committed to making it work.

Everyone involved in the grazing/land management operation should have a clear understanding of the problem, including the on- and off-site costs of degraded riparian areas and uplands. They need to understand where they are starting from. Where they are trying to go. Specifically how they are going to get there. The eventual payoff in increased long-term productivity. And how progress toward the goal will be evaluated.

Monitoring & Evaluation

Many progressive livestock operators routinely monitor their riparian and upland pastures because it is good business.

Monitoring and evaluation are essential to determine progress or lack of progress toward riparian and upland objectives. To signal if, when, and how grazing strategies should be changed in response to changing conditions.

However, monitoring obviously deteriorated conditions, without first changing the management responsible for those conditions, does not seem to be a wise investment. These resources could be better spent monitoring and evaluating the results of implementing new grazing strategies to increase productivity of riparian areas and adjacent uplands.

The nonpoint source provisions of the Clean Water Act bring a new dimension to monitoring of grazed watersheds. States will systematically monitor and evaluate chemical, physical and biological water quality indicators such as sediment load, temperature, dissolved oxygen and fish populations. The results will be used to ensure compliance with state programs adopted to achieve the act's mandate to attain and maintain designated beneficial uses such as drinking water, agricultural water supplies and fish and wildlife production.

Obstacles & Opportunities

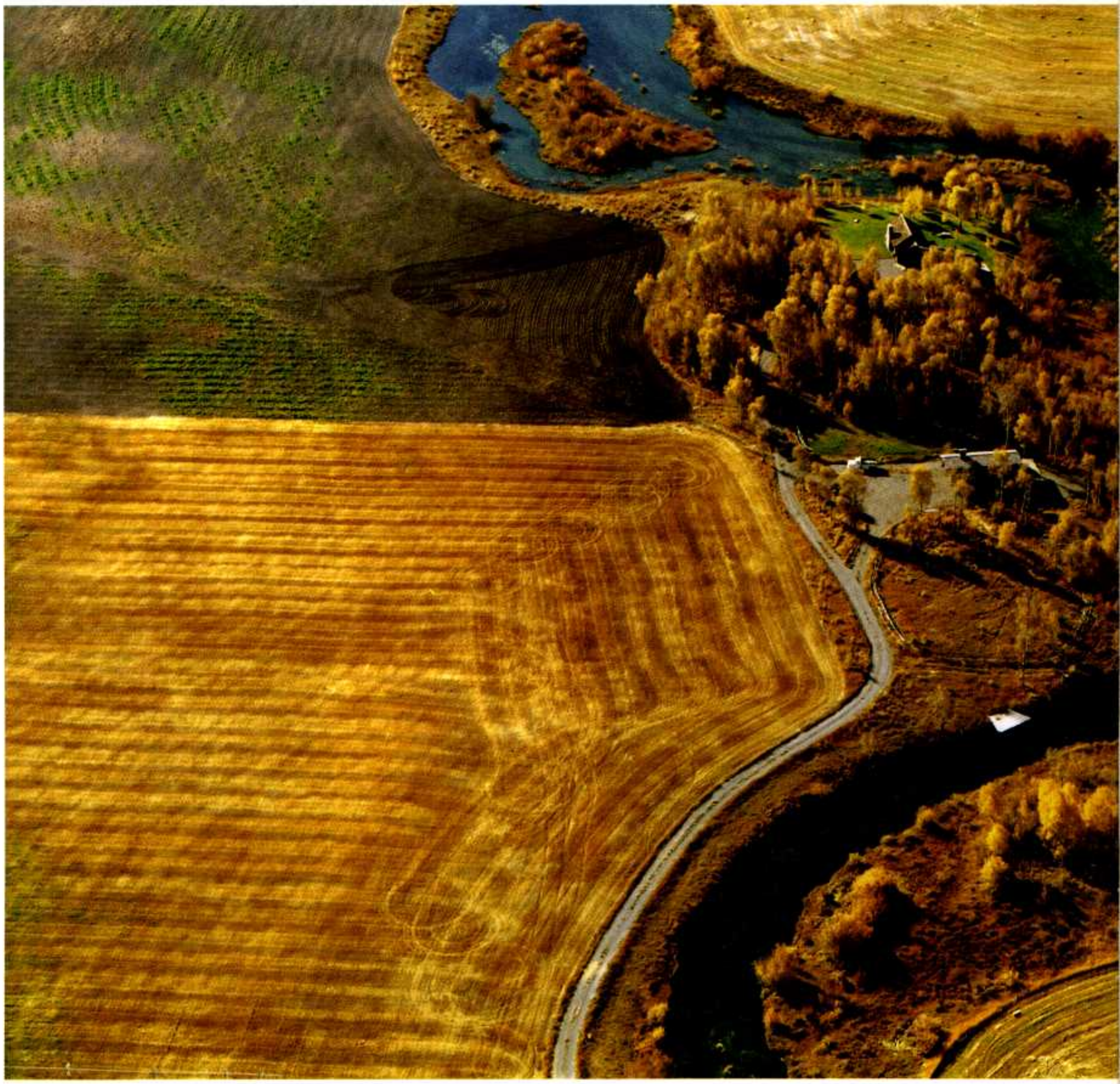
Progressive stockmen and land managers have long demonstrated there are no insurmountable technological barriers to restoring and protecting the long-term productivity of western riparian areas and adjacent uplands.

Nonetheless, many millions of acres of private and public land and associated riparian areas are in need of improvement; vast areas are in desperate need. This clearly indicates there are formidable educational, economic and social barriers to widespread transfer of proven technology to the ground.

The preceding case histories are representative of broad areas of land in the West. They reflect a large reservoir of riparian improvement knowledge and practical experience. This experience strongly suggests that initiatives in the following areas would help break down barriers to improved grazing management on western riparian areas.

Education

Traditional grazing practices are resistant to change. It is frequently and widely acknowledged that education about the techniques and benefits of improved riparian grazing managment should have highest priority. In most cases, however, education has no priority in budgets. Therefore, it is not surprising there is widespread lack of understanding and acceptance of proven riparian management technology. And of the enormous direct and indirect costs of deteriorated western riparian areas and adjacent uplands.



It is difficult, but not impossible, to capture these costs in economic terms. For example, Harold Dregne, Professor of Soil Science at Texas Tech University, roughly estimates the value of potential forage lost due to past and present overgrazing of western rangelands to be approximately $200 million per year. Even greater economic losses may be attributed to reduced quality and quantity of usable water, diminished fish and wildlife populations, shortened economic life of water supply and hydroelectric reservoirs, and other costs of deteriorated watersheds.

It is important to know more about the nature, magnitude and distribution of these costs in order to marshall private, public and political support for remedial actions. But the cost of present deteriorated riparian conditions is the dark side of the problem. It is equally important to quantify the social and economic benefits of improving the long-term productivity of western riparian areas and associated uplands.

POCKETBOOK Economics

The preceding case studies and similar projects throughout the West demonstrate that protecting and restoring riparian areas need not be a zero-sum game where gains to fish, wildlife and

water quality come at the expense of livestock grazing. In many cases there can be a net gain in livestock forage.

In some cases this can occur concurrently with riparian restoration through improved management of riparian areas and associated uplands. In some cases reductions in grazing may be unavoidable to restore severely damaged riparian areas or protect extemely vulnerable ones. But even in most of these latter instances, the eventual payoff is likely to include disproportionately large increases in future livestock forage production.

The gap between paying now and benefitting later is the biggest challenge confronting improved management of private and public riparian areas.

Given understanding of the problem and the technology for solving it, livestock operators who can afford to make investments in long-term productivity are likely to do so out of enlightened self-interest like any other business person. Unless they are in the livestock business for philanthropic purposes, however, cash flow and assurance of future dividends will be important considerations in their investment strategies.

THE gap between paying now and benefitting later is the biggest challenge confronting improved management of private and public riparian areas.

Many livestock operators, no matter how well intended, simply cannot afford to change their present grazing strategies if that change requires lost revenue or additional time or money.

A successful program for achieving the private and public benefits of improved riparian management will be responsive to both situations. It will include innovative approaches to attract long-term private and public investments in enhanced productivity, and to offset or mitigate politically untenable short-term social and economic costs.

TECHNOLOGY Transfer by Demonstration

Small scale, "postage stamp," demonstration projects have proven value for demonstrating the techniques and benefits of improved riparian management. They have helped overcome the inertia of tradition and other resistance to change in many areas, and should be strategically targeted on new market areas. However, the emphasis must now shift from micro demonstration projects to full-scale application focused on economic units and complete watersheds. This is the intent of Congressionally authorized appropriations under Section 319 of the Clean Water Act.

INCENTIVES & Disincentives

The complex system of governmental economic incentives and disincentives applicable to western grazing lands offers untapped opportunities for encouraging protection and restoration of riparian areas.

In recent years Congress enacted anti sod- and swamp-buster laws to discourage activities that reduce long-term productivity. There is precedent, opportunity, and need for similar riparian amendments to laws applicable to grazing land.

WINDOWS of Opportunity

Windows of opportunity are created when grazing allotments on public land become vacant or permits are transferred. Opportunity to allow riparian areas and adjacent uplands to heal before resuming grazing. To change permitted grazing strategies. To hold restored allotments in reserve for use in times of drought, or to take the pressure off degraded riparian areas elsewhere. Elimination of any statutory or administrative barriers to these opportunities should have high priority.

"... IT is profitable, under the present system of agricultural technologies, markets, and policies, to mine the inherent productivity of the fragile cropland and rangeland sites as if they were nonrenewable resources. In doing so, long-term productivity is sacrificed for shorter-term profits."

— Congressional Office of Technology Assessment, 1981.

The dramatic contrast in riparian conditions upstream (private land) and downstream (public land) of this fence line is representative of a fundamental, pervasive problem.

Private/Public Cost-Sharing

Both public and private land graziers own extensive riparian areas and associated uplands. The costs of deteriorated riparian areas and adjacent uplands don't stop at property lines. Neither do the many benefits of improving riparian and upland conditions. This provides the basis for expanding on a long tradition of private-public cost sharing.

Existing statutes, policies and programs such as the federal small watershed program, should be reviewed for opportunities to encourage creative riparian improvement cost-sharing.

There is growing public awareness of the value of western riparian areas, and of the costs resulting from their deteriorated condition. Hunters, fishermen, other outdoor recreationists and the businesses they support increasingly recognize they have a stake in the productivity of public lands that comprise the majority of some western states. They represent millions of potential allies for the approximately 30,000 livestock permittees who graze public lands and for livestock operators who only graze private land.

Fish and wildlife enthusiasts particularly are increasingly willing to help fund cooperative riparian/upland fish, wildlife and livestock habitat improvement projects. This opportunity could be enhanced by expanding state and federal challenge cost-share programs and dedicating a percentage of grazing fees to that purpose.

The ultimate solution to restoring and maintaining the productivity of western riparian areas is to restore and maintain the productivity of watersheds. This requires special consideration for and emphasis on restoring and protecting riparian areas.

The preceding case studies and similar projects throughout the West demonstrate it can be done.

Rapidly growing public awareness of the value of riparian areas presents a unique opportunity for a new private/public partnership to enhance livestock forage, fish and wildlife populations, water quality and other values produced on western watersheds.

A growing number of individuals and organizations contribute labor and money to watershed improvement projects on both private and public lands.

"To protect your rivers, protect your mountains."

— Emperor Yu of China, 1,600 B.C.

For More Information:

Understanding Grass Growth: The Key to Profitable Livestock Production; Waller, Moser & Reece. Trabon Printing Co., Inc., Kansas City, Missouri.

Range Site Descriptions; U.S. Soil Conservation Service field offices.

Field Office Technical Guide; U.S. Soil Conservation Service field offices.

Impacts of Technology on U.S. Cropland and Rangeland Productivity; Congressional Office of Technology Assessment. Library of Congress Catalogue Card # 82-600596.

Desertification of the United States; Sheridan, 1981, Council on Environmental Quality, Washington, D.C.

Rangeland Management: Some Riparian Areas Restored but Widespread Improvement will be Slow; Government Accounting Office, June 1988. Report # RCED-88-105.

Protecting America's Wetlands: An Action Agenda — The Final Report of the National Wetlands Policy Forum; The Conservation Foundation, Washington, D.C.

Preserving Communities & Corridors; Defenders of Wildlife, Washington, D.C.

Videos

Riparian Management and Channel Evolution; U.S. Bureau of Land Management, Phoenix Training Center.

Cooperative Rangeland Management—The Riparian Approach; U.S. Bureau of Land Management, Phoenix Training Center.

Riparian Areas & Grazing Management; U.S. Environmental Protection Agency.

Riparian Management — A Challenge for Our Future; Bureau of Land Management, Prineville, Oregon.

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