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Livestock grazing and the aquatic environment

A thorough understanding of relationships between livestock grazing and fisheries is needed to manage range adjacent to coldwater streams

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LIVESTOCK regularly uses valley bottoms adjacent to streams in the West as grazing and loafing areas. Until recently, the effects of this use on aquatic resources in coldwater streams had not been identified or quantified. As a result, livestock grazing and fisheries generally were and still are managed without a thorough understanding of their interrelationships.

The combined effects of geology, climate, geomorphology, soil, vegetation, and water runoff often result in unstable stream conditions in the natural state. When land uses place additional stress on aquatic habitats, damage usually occurs.

Extent of Range Resources

Rangeland is usually defined as land on which grasses, forbs, or shrubs predominate as the native vegetation. Even commercial forest can be used for livestock grazing. Forest range includes all natural ecosystems that either produce or are

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capable of producing forage (16). This encompasses 1.2 billion acres in the 48 conterminous states, 622 million acres in the 11 western states.

In 1970 livestock grazed on 834 million (70 percent) of these forest range acres. This use amounted to 213 million animal unit months (AUM).

Research Interest in Forest Range

Conservation and management of range generally began and focused on the national forests (59). National forests resulted directly from the action of leaders who recognized the widespread exploitation and depletion of forest and watershed resources. A system of forest reserves established in 1891 was transferred in 1905 to what has since become the U.S. Forest Service. The areas later were renamed national forests.

Serious concern about national forest land management developed in the late 1920s. The concern focused primarily on grazing lands. Research showed that the degree of soil erosion caused by livestock grazing varied with slope gradient, aspect, soil condition, plant type, vegetation density, and accessibility to livestock (48) but demonstrated that soil disturbance was greater in areas overused by livestock (13). The susceptibility of soils to erosion increased as vegetation deteriorated. Livestock trampling reduced ground cover density and increased bare soil openings (39), which usually resulted in increased watershed runoff and erosion.

Proper grazing use, however, causes minimal, if any, resource damage, and by the mid-1960s new approaches were being considered. Rest-rotation grazing, for example, was found to benefit range conditions (22). Livestock grazing research continued to focus on impacts on forage and physical watershed characteristics, however. What these influences meant to aquatic ecosystems did not receive adequate attention.

This changed in the early 1970s, when concern began to grow about the effects of livestock grazing on biotic resources. Severe changes were found in streamside environments from livestock use that could affect the quality of the fishery (41). Management officials (8) concluded that livestock grazing severely damaged streams in Nevada. The supporting evidence was subjective, however. Nevertheless, researchers began to look at influences on resources other than the land.

History of Range Use

Several documents trace the history of livestock production on public and private

ranges (8, 37, 40, 59). Before white settlers moved into the western states, wild ungulates grazed compatibly with the carrying capacity of natural ecosystems. If, for some reason, the forage species on a given range became scarce during a particular season or year, wild grazing animals either migrated to more favorable range or increased mortality brought the herds into balance with range capacity.

The grazing potential of the vast rangelands became apparent early in the nation's westward expansion. As man saturated the ranges with livestock and confined them within manmade barriers, drastic changes in vegetation occurred. Livestock trampled and compacted the soil. High quality, deep-rooted plants gradually gave way to shallow-rooted species that were less nutritious and often only of seasonal benefit.

As soil compaction increased, infiltration of water into deep soils decreased and surface runoff increased (20, 30, 46, 54, 56). This accelerated erosion (5, 31) had two major effects on terrestrial and aquatic productivity. The erosive action of wind and water began to strip the natural ecosystems of their rich top soils, and water quality began to decline (15, 37) as the soil was dumped into streams and rivers. Fine sediment smothered spawning beds and altered the habitat of invertebrate and fish populations.

As the livestock industry grew during the 1800s and into the mid-1930s, livestock numbers increased far beyond the carrying capacity of the available range. Many ranges deteriorated badly. In response to the situation, Congress in 1934 passed the Taylor Grazing Act to stop the damage to the remaining public domain, to provide for its orderly use and improvement, and to attempt to stabilize the livestock industry using these lands. While the intent of the act was good, the objectives were not achieved. Grazing privileges were allocated largely on the basis of use prior to the act. Little attempt was made to regulate grazing according to the carrying capacity of rangelands. Also, there was little public interest in rangeland conditions during this period.

By the mid-1960s management by allotment had become an accepted practice. The situation remains essentially the same today. Public awareness of environmental quality, including the condition and use of rangelands, has brought the original goals of the Taylor Act more clearly into focus.

A number of recent publications summarize the literature on various aspects of grazing resources. One lists available material on grazing in the Pacific North-

west (3). Another summarizes many of the effects of grazing management and research in Europe and Asia as well as some work in the United States (1). Still another lists numerous documents pertaining to the effects of livestock grazing on water quality and associated factors (37). In addition, the Environmental Protection Agency prepared an annotated bibliography concerned with animal wastes (44, 45).

Effects on Water Quantity

Early livestock growers generally were unaware of the grazing limits of vegetation and soil (11). Only recently have these resources been given full credit for their abilities to control water on the land (14). Range practices significantly affect water yield, peak stream discharge, stormflow runoff, and associated water quantity factors. Water management and management of rangelands are closely interrelated.

Many studies show that as grazing intensity increases water runoff increases (2, 21, 27, 28, 30, 31, 39, 46, 51, 54, 56). The primary causes are soil compaction and resulting reduction in infiltration rate, as well as cover depletion.

Other studies specifically demonstrated that infiltration rates decrease as grazing intensities increase (7, 12, 23, 35, 47, 49, 58). In one study (49), for example, infiltration rates obtained with a sprinkling infiltrometer over a 2-hour period were five times greater on an ungrazed control area than on a heavily grazed area (12 acres per animal unit), three times greater than on a moderately grazed area (17 acres per animal unit), and two-and-one-half times greater than on a lightly grazed area (22 acres per animal unit).

Effects on Water Quality

Range management practices can alter water quality. Although a half century of research has been devoted to this problem, the true effects on living systems remain unknown. Most studies to date have centered on sediment accrual and increased bacterial concentrations through the addition of animal wastes to streams.

Sediment

Large quantities of fine sediment change the structure of aquatic communities, diminish productivity, and reduce the water permeability of channel materials used by fish for spawning (9, 34). In one case increases in fine sediment reduced the biotic productivity of an aquatic environment by 37 percent (52). In another case the reduction was 59 percent (10).

Stream channel sedimentation caused by soil erosion on rangelands was recognized

long ago as a major problem (37). The general impacts of sediment from rangelands on water quality have been documented (11, 15, 18). The effects on fish of sediment directly attributable to bad range management practices are not well documented, however.

While several studies demonstrate that rangeland abuses result in adverse hydrologic consequences, including accelerated sediment transfer from the land to streams (5, 6, 17), evaluations of the effects of grazing systems, such as rest-rotation and deferred-rotation, on instream sediment accrual are lacking. In a study of the grazing effects on watershed hydrology in western Colorado, ungrazed watersheds produced only 71 to 76 percent as much sediment as grazed watersheds (30). Soils in this area are poorly developed and generally consist of a shallow, weathered mantle overlying the widely distributed Mancos Shale. Sediments came from both gullies and hillsides, with site-derived sediments more predominant on steeper slopes.

Rangelands account for an estimated 28 percent of the annual sediment production within Region 10 (excluding Alaska) of the Environmental Protection Agency and are second only to croplands in total sediment production (37). Depleted plant cover and trampled soils are the factors contributing most to erosion on grazed, particularly overstocked, lands.

Animal Wastes

Considerable research has been done on the effects of livestock wastes from feedlots, pasture, and wildlands on water quality (32, 36, 43, 55). Bacterial contamination has been the primary consideration in these studies.

In one of many specific studies on stream pollution from animal wastes, dissolved oxygen stress and high ammonia concentrations killed essentially all the game fish—largemouth bass, white crappie, and channel catfish—in a 45-acre, flood control reservoir (53). Inadequately treated feedlot runoff was pumped into the reservoir. At the time of the fish kills, biochemical oxygen demand (BOD) concentration was 86.5 milligrams per liter. This compared with 5 milligrams per liter in a control reservoir. Ammonium nitrogen concentrations were 6 milligrams per liter in the affected reservoir and 0.85 milligrams per liter in the control reservoir.

While land spreading of animal wastes is an effective means of minimizing water pollution because of the soil's natural waste treatment capabilities, direct dumping of fresh animal wastes into streams causes excessive pollution (50). Concentrations of

animals, as in feedlots or heavily stocked areas, should be located away from streams and other drainageways.

Maintenance of water quality also requires care in the use of cattle manure slurries for irrigation (4). Lagoons or collection pools for irrigation runoff must be isolated from natural drainages or flood-prone areas so the wastes do not contaminate runoff or groundwater.

Three groups of bacteria are indicators of pollution by livestock and wild ungulates: the coliform group, fecal coliform bacteria, and the fecal streptococci. In a Colorado study (26), concentrations for all three groups in a small, high-elevation stream were highest in the evening and lowest in the afternoon. This cycle apparently related to rising stream levels in early evening that flushed streambanks. Highest concentrations of the coliform groups in cattle-contaminated sites occurred during peak runoff periods in the spring. Fecal streptococci concentrations were highest during mid-summer low flows. Summer storm flows increased the concentrations of all three bacterial groups.

An earlier study involving several Colorado watersheds produced similar results (25). Still another study (38) identified overland flow from summer rainstorms as the single, most important factor regulating bacterial counts.

While bacterial concentrations do not relate directly to the suitability of fish habitat, they are important to water quality and, therefore, relate indirectly to fish habitat.

Grazing Effects on Fish Habitat

There is a lack of quantitative data in the literature pertaining directly to interrelations between livestock grazing and coldwater fish habitat. Some information has been gathered but remains unpublished (personal communication with Errol Claire, Oregon Department of Fish and Wildlife).

The most detailed, published research was conducted on Rock Creek in south-central Montana (19). The quantity of brown trout in pounds per acre was 32.5 percent greater in the stream sections adjacent to an ungrazed area than in the section adjacent to a grazed area. Streamside cover, such as overhanging banks, brush, and debris, was 76.4 percent greater in the ungrazed area than in the grazed area. Other stream parameters in the Rock Creek study were average eroded channel width and average water width (considerably greater in the grazed area than in the ungrazed), percent of total stream as riffles

(greater in grazed areas), and percent of total stream as pools and runs (greater in ungrazed area).

In a follow-up study to the initial work on Rock Creek, the pounds per acre of brown trout were 42.3 percent greater in the stream along an ungrazed section than along a grazed section (33).

The density of brown trout in central Oregon's Little Deschutes River appeared in a recent study (29) to be determined primarily by the physical environment, particularly cover. While the researcher lacked quantitative data relating cover to livestock grazing along the stream, this treatment was an implied source of streamside cover reduction.

On a 40-mile segment of Bear Valley Creek in central Idaho, fish habitat was damaged more along grazed sections, primarily from bank trampling, than along ungrazed sections (42).

Grazing Systems and Range Improvements

A grazing system designates a specialized management strategy. Most current systems are based on grazing selected pastures, with certain types and timing of grazing or nongrazing recurring at yearly intervals. The systems vary depending on the livestock operation and the type and condition of rangeland.

Five grazing systems are commonly used to distribute livestock better on the range available and provide better plant growth and vigor. These systems are season-long or continuous grazing, rotation grazing, deferred grazing, deferred-rotation grazing, and rest-rotation grazing (24, 57).

Season-long grazing, one of the earliest practices, requires the least range investment. Handling and movement of livestock are minimized. Problems with the system include the concentration of animals at favored locations, especially in riparian habitats; inadequate use of the herbage available; and overuse of more desirable forage plants. This system often disperses livestock use over more stream bottomlands than some of the crowding techniques, such as rest-rotation.

Rest-rotation grazing has some disadvantages because it often requires more livestock movement. This increases the trailing potential in riparian habitat. While trampling may help plant ripened seeds, it also causes streambank erosion and instability. Nevertheless, the system is a popular one. Recent research indicates that rest-rotation grazing may have harmful effects on other land uses.¹ Its effects on

¹Meiners, William R. 1974. "Rest-Rotation Grazing—A Bummer." Paper given at the 27th Annual Meeting, Society for Range Management, Tucson, Arizona.

aquatic and riparian environments have not been thoroughly documented, however.

Grazing systems are varied to meet the requirements of a livestock operation, promote the growth of forage plants, and match soil qualities. While modern systems promote the growth of desirable plants, research has not determined how these systems relate to the environment.

Many range management practices improve forage resources and their use by livestock (60). Fertilization, seeding, undesirable plant and animal control, mechanical soil treatments, water spreading and drainage, prescribed burning, and timber thinning are among the methods used to improve range forage resources. Water developments, fences, trails, and similar improvements permit more effective grazing management. Long-term closure or temporary (3- to 5-year) exclusions of livestock by fencing may be the only effective restoration measure in some cases.

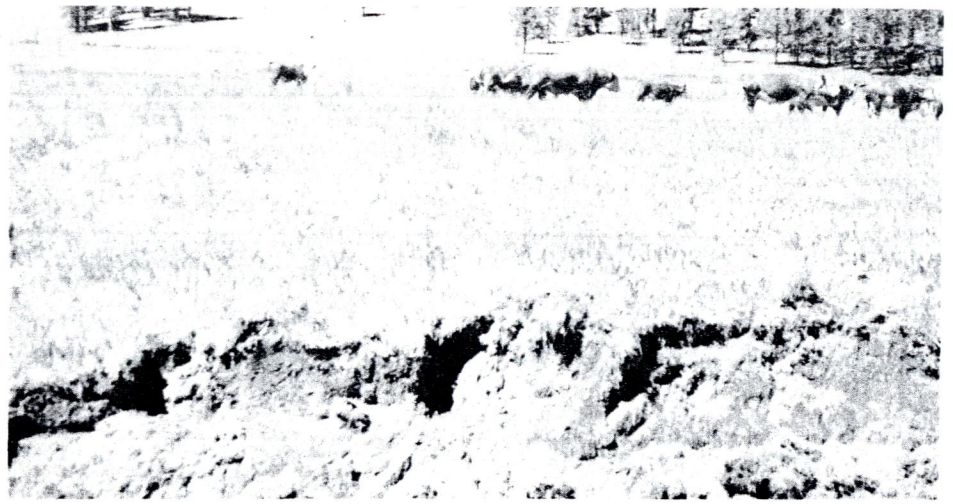
These factors and other management elements, such as kind of livestock, seasons of use, and grazing intensity or stocking rate, must be thoroughly understood before resource managers can manipulate grazing systems to also protect the high quality habitats of resident as well as anadromous coldwater fishes.

Recommendations for Future Study

Further research is needed on both the physical/chemical and biological aspects of livestock grazing and aquatic habitat interrelationships. The resource manager needs this type of quantitative information to make sound land use planning decisions. Physical and chemical considerations include the effects of livestock grazing in valley bottoms on water quality, stream channel morphology, streambed condition, and the riparian zone. Biological information must concern livestock impacts on standing crop and species diversity of fish and benthic invertebrate populations, bacteriological aspects of water quality, and recreational and esthetic values involved in use of the fishery and aquatic and riparian habitats.

Modern grazing systems seek to improve livestock production while protecting range. Resource managers need to know how these grazing systems influence other resources, including anadromous and resident coldwater fish populations.

Before the impacts of such land uses as livestock grazing on fish habitats can be evaluated, researchers need to know what the natural or pristine conditions of streams are or were prior to these uses.



A bull throwing pieces of sod into the air with his head caused this severe streambank damage.

Pristine habitats are increasingly difficult to find. Serious consideration should be given to locating and preserving such stream habitats to serve as study areas and to furnish baseline data on the condition and productivity potential of streams in the western United States.

Once natural conditions are established and the effects of grazing various stream and riparian habitats are known, then researchers will be able to provide resource managers with guidelines for predicting the effects of alternate grazing strategies on the condition and productivity of stream and riparian systems. This information then, will enable resource managers to make decisions more effectively on the use of rangelands with maximum consideration of aquatic resources.

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