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General Technical Report PNW-124
April 1981

EDITOR'S
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Influence of Forest and Rangeland Management on Anadromous Fish Habitat in Western North America

EFFECTS OF LIVESTOCK GRAZING

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USDA FOREST SERVICE
ANADROMOUS FISH HABITAT
PROGRAM

U.S. Department of Agriculture Forest Service
Pacific Northwest Forest and Range Experiment Station

ABSTRACT

This paper documents current knowledge on interactions of livestock and fish habitat. Included are discussions of incompatibility and compatibility between livestock grazing and fisheries, present management guidelines, information needed for problem solving, information available for problem solving, and future research needs.

KEYWORDS: Livestock grazing, range management, fish habitat, riparian ecosystems.

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INFLUENCE OF FOREST AND RANGELAND MANAGEMENT ON ANADROMOUS FISH HABITAT IN WESTERN NORTH AMERICA

William R. Meehan, Technical Editor

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1981

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PREFACE

This is one of a series of publications on the influences of forest and rangeland management on anadromous fish habitat in western North America. This paper addresses the effects on fish habitat of livestock grazing. Our intent is to provide managers and users of forests and rangelands with the most complete information available for estimating the consequences of various management alternatives.

In this series of papers, we will summarize published and unpublished reports and data as well as the observations of scientists and resource managers developed over years of experience in the West. These compilations will be valuable to resource managers in planning uses of forest and rangeland resources, and to scientists in planning future research.

Previous publications in this series include:

1. "Habitat requirements of anadromous salmonids," by D. W. Reiser and T. C. Bjornn.

2. "Impacts of natural events," by D. N. Swanston.

4. "Planning forest roads to protect salmonid habitat," by Carlton S. Yee and Terry D. Roelofs.

8. "Effects of mining," by S. B. Martin and W. S. Platts.

11. "Processing mills and camps," by Donald C. Schmiege.

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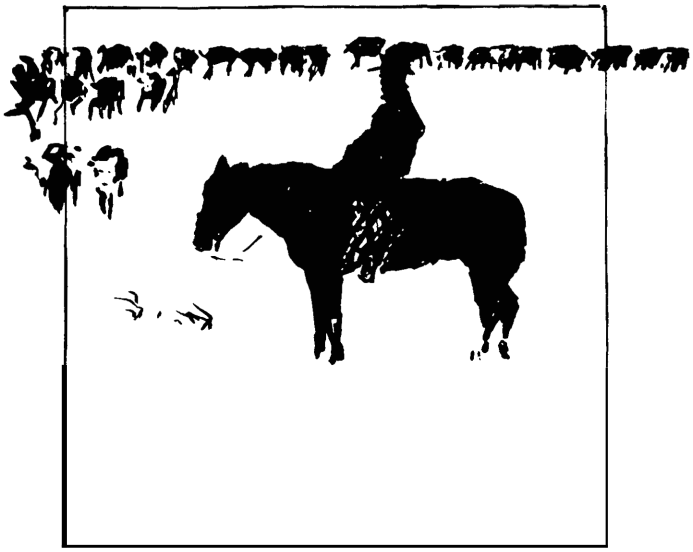
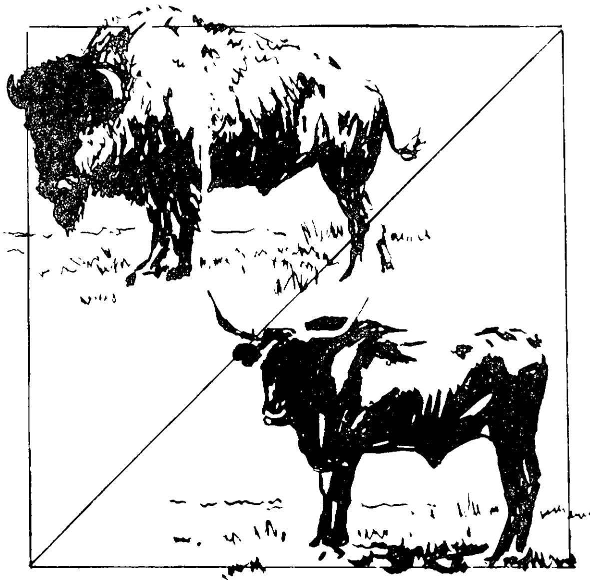


INTRODUCTION

Range was originally thought of as land for livestock use, but today, rangelands are managed for many other uses as well. The USDA Forest Service (1972) defines range as an ecosystem complex that contains the native and natural grasslands and pastures of the 50 States and Puerto Rico. This definition includes streams and their riparian environments, as well as forest communities suitable for grazing by livestock. Streams and adjacent habitats are the most productive ecosystems in rangelands. Livestock concentrate along these streamside zones (Holscher and Woolford 1953), and this excessive use has caused many environmental problems.

The USDA Forest Service definition of range increases the importance of range managers' understanding all range uses and how they relate to maintaining high-producing aquatic environments. Blaisdell et al. (1970) suggested that this definition of range insures that certain lands will not be ignored or mismanaged. They also pointed out that livestock production is but one of many range functions. Problems associated with management of riparian and aquatic environments must be solved, however, before these lands can be used for grazing without sacrificing associated resource values.

The forest range environment includes 1.2 billion acres in the United States. Sixty-nine percent of this rangeland was grazed by livestock in 1970, furnishing 213 million animal unit months of forage. Much of this rangeland has become depleted of natural and desirable vegetation, affecting runoff and adversely altering sediment recruitment and transport. Even though livestock use on western ranges has passed the 100-year mark, the effects of grazing on aquatic resources are just beginning to be understood. Research has not fully identified these problems, described their magnitude, or provided methods for their solution. As a result, resource managers have few data to assist them in correcting problems when they become apparent.



GRAZING HISTORY

Several publications provide a good historical background on the use of public ranges for livestock production (U.S. Senate 1936; Anderson and Harris 1973; Parsell 1973; Adams 1975; Meehan and Platts 1978.1/ 2/ Following is a brief summary.

Before the influx of Europeans into the Western United States, natural ecosystems existed in which wild ungulates usually grazed within the range's carrying capacity. Tf forage produced by a given range suddenly became scarce or nonexistent, wild grazing animals either migrated to more favorable ranges or sustained a mortality that brought the herds into balance with range capacity.

1/Unpublished report, "Effects of livestock grazing on wildlife, watershed, recreation and other resource values in Nevada," U.S. Dep. Int., Bur. Land Manage. Eval. Rep., 96 p. Washington, D.C. 1975.

2/Unpublished report, "Effects of livestock grazing and the livestock industry on wildlife," by F. H. Wagner. Paper presented at symposium on livestock interactions with wildlife, fish, and their environments, Sparks, Nev., May 1977. On file at Univ. Calif., Davis.

Soon after this country was settled, the possiblity of using the vast rangelands for livestock production was recognized, and since 1895 the number of cattle on western ranges and pastures has increased continually (see footnote 2).

Where the ranges were heavily stocked and livestock confined within barriers, changes in vegetation took place. Livestock trampled and compacted the soil, and the high-quality, fibrous-rooted plants gradually gave way to shallow-rooted annual species or taprooted forbs or shrubs that could exist on areas with lowered water tables. As soil compacted and favorable ground cover diminished, infiltration of water into deep soils lessened and surface runoff increased (Johnston 1962, Tromble et al. 1974, Heady 1975, Stoddart et al. 1975, Hibbert 1976). The accelerated rate of erosion had major effects on terrestrial and aquatic productivity. Rich topsoil was lost by the erosive action of wind and water, and the quality of streams receiving the eroded material was reduced. In addition, fine sediment smothered the spawning and rearing habitats of fish.

As the livestock industry grew through the 19th century and into the mid-1930's, the number of animals occupying the available range increased far beyond its carrying capacity. Serious concern about overgrazing of National Forest lands developed in the late 1920's. The situation became so critical by the mid-1930's that Congress enacted the Taylor Grazing Act in 1934 to reverse the trend on the remaining rangeland in the public domain and to help stabilize the livestock industry. Little attempt was made to regulate grazing, however, and detrimental effects continued to occur.

By the mid-1960's, management by allotment had become an accepted practice, and this essentially is the practice today. Public awareness of environmental quality--including that of rangelands--brought into clearer focus the original goals of the Taylor Act. New approaches to range management were being considered during this period, such as those described by Johnson (1965) and Hormay (1970), which demonstrated that rest-rotation grazing can benefit range conditions. Livestock grazing studies were still focused on impacts on forage and physical characteristics of watersheds; influences of grazing on the aquatic ecosystem were still not given adequate attention. Also during this period, what was formerly sheep range was rapidly being converted to cattle range, placing more stress on riparian habitats.

In the 1970's, the importance of riparian vegetation to wildlife was becoming apparent in the literature (Patton 1977). Fishery biologists, however, were not well informed on grazing problems and their contribution to the understanding of land managers during this period was inconsequential. Today, decision-makers and fishery biologists see the need for better management of streamside zones, and scientists are undertaking studies of the interactions between livestock and fisheries. These trends are encouraging and will lead to better management of livestock and the aquatic habitat.

ENVIRONMENTAL CONCERNS

Recent, well-publicized events: demonstrate the frustations land managers and scientists have experienced in dealing with complex range-management problems and the necessity of making decisions based on limited data (Miller 1972). The Natural Resources Defense Council in a 1973 suit questioned the adequacy of a USDI Bureau of Land Management (BLM) Environmental Impact Statement, "Livestock Grazing Management of National Resource Lands," to protect the environment. In the 1974 settlement of that suit, the BLM agreed to complete more than 200 separate environmental impact statements for livestock grazing on public lands in the West.

Leopold (1974), at the West Yellowstone Wild Trout Symposium, said that livestock grazing may have cumulative ecological ill effects on productivity of both lands and waters. Leopold admitted this hypothesis was intuitive, with few facts to back up his statement, and pleaded for studies to clear up the issue. During this same period the BLM reported that riparian and aquatic habitats are being damaged on BLM lands by improper livestock grazing.[3/]

The Council for Agricultural Science and Technology in 1976 assigned a national interdisciplinary team of 18 scientists to evaluate a court-requested environmental impact statement on range management on selected BLM lands. The team concluded that for the BLM to predict future responses of other resources (fish, wildlife, recreation, water, and timber) to changes in grazing management would be futile without a strong base of reference to trends in range condition (Council for Agricultural Science and Technology 1976). In addition, the report said many of the scientific declarations in the impact statement about adverse effects of grazing were made without substantiating data. The report implies that many disciplines make far-reaching, conclusive statements without background research to substantiate them.

?/Unpublished report, "The effects of livestock grazing on wildlife, watershed, recreation and other resource values in Nevada,'' U.S. Dep. Int., Bur. Land Manage. Eval. Rep., 58 p. Washington, D.C. 1974.

Behnke and Zarn (1976) identified livestock grazing as the greatest threat to the integrity of trout-stream habitat in the Western United States. Behnke believes that the rehabilitation of streams suffering from the impact of livestock grazing offers the best possibility of increasing wild, self-sustaining trout populations in the Western United States.[4/] Saltzman (1976) stated that overgrazing and irrigation are the most serious and least understood ecological problems in the Western States. Gallizioli (1977) reported that in Arizona the single most important range-management problem limiting the attainment of potential fish and wildlife benefits was overgrazing by livestock. Bakke (1977) observed that loss of trout and salmon habitat from overgrazing has long been a frustrating problem in Oregon.

[4/]Unpublished report, "Livestock grazing impact on stream fisheries: Problems and suggested solutions," by R. J. Behnke. Paper presented at symposium on livestock interactions with wildlife, fish, and their environments, Sparks, Nev., May 1977. On file at Univ. Calif., Davis.

Proceedings of a seminar (Townsend and Smith 1977), a symposium,[5] and a forum (Cope 1979) addressed the interactions of livestock with wildlife and fish and their environments. These documents reflected the conclusion that livestock grazing degrades aquatic and riparian communities. Seminar members concluded that livestock grazing is the single most important factor limiting wildlife (including fisheries) production in the West. The symposium concluded that livestock grazing has severely reduced riparian vegetation and altered stream geomorphology, adversely affecting fish populations.

Because we do not understand cause and effect in the relation of livestock to fisheries, controversy exists about what effects livestock grazing has on streams and streamside environments. Scientists take both sides of the issue, and some scientists maintain that no detrimental effects occur from some strategies of livestock grazing. The Council for Agricultural Science and Technology (1974) stated that livestock grazing is being managed and integrated with other uses of Federal lands and that no evidence has been found that well-managed grazing of domestic livestock is not compatible with a high-quality environment. Hayes (1978) concluded that a rest-rotation grazing system in the meadows studied did not significantly accelerate channel movement. Kimball and Savage (1977) concluded that unrestricted livestock grazing can be detrimental to grazed riparian zones through streambank trampling and overuse of streamside vegetation.

[5] Unpublished proceedings of a symposium on livestock interactions with wildlife, fish, and their environments, Sparks, Nev., May 1977. On file at Univ. Calif., Davis.

They found that, under intensive livestock management, aquatic ecosystems can be restored or maintained at a lower cost than through the installation of artificial stream-improvement structures. Gifford (1975) discussed some beneficial effects of range-improvement practices on runoff and erosion.

The literature demonstrates that improper livestock grazing degrades streams and their riparian environments. The solution is to determine how best to manage streamsides so forage can be used and the fishery protected.

PRESENT MANAGEMENT

Protection and management of streams and streamside zones has been an integral part of administration of National Forests by the USDA Forest Service for some 70 years. Other agencies presently are assuming roles in the management of stream and streamside ecosystems.

Most of the rangelands were overgrazed during the past 85 years, so emphasis in present management is mainly on protection and improvement of plant cover. Today's range-management guidelines are just beginning to call for different management strategies for different habitat types; the guidelines of the past covered only broad combinations of lands that mixed the riparian zones with the upland zones. Land managers have often failed to recognize that streamside environments are different from other terrestrial systems and so need specialized management. The stream, the riparian environment, and adjacent upland environments each require different management strategies. For example, a broad riparian zone in a wet meadow has a different influence on a stream than a narrow riparian zone in a sagebrush ecosystem.

The fact that scientists still differ in their interpretation of the effects of grazing strategies on streams and riparian habitats complicates resource management. These disagreements must be resolved, because more and more pressure is being brought on land managers to increase the production of all resources. Grazing land is continually being reduced; this conflicts with the projected needs for an additional 70 million acres of range within the next 25 years to meet the demands for red meat (Council for Agricultural Science and Technology 1974). The increasing demand for energy development, recreation, and high-quality water will conflict with the demand for red meat--unless management can be more effective.

The solution to the environmental issue is certainly not to argue whether or not livestock grazing degrades riparian and aquatic systems, but to identify and develop grazing systems that are compatible with fishery and riparian habitats. In an extensive literature review, Meehan and Platts (1978) were unable to identify any widely used grazing strategy compatible with the environmental needs of aquatic ecosystems. The task of modifying existing grazing strategies or developing new ones that are environmentally compatible will be difficult. The problem becomes more complex when related range-management practices other than grazing alter streams and streamside environments. These include fertilization, irrigation, wetland drainage, brush control, debris disposal, control of undesirable forbs, mechanical soil treatments, seeding, prescribed burning, rodent control, insect and disease control, water development, fences, and timber thinning.

Scientists and land managers realize that solutions to grazing problems are not easily found. No single discipline possesses the skills and knowledge to solve all of the problems. Past studies have identified many problems and offer some guidance, but more studies are needed to develop a better understanding of the relation of grazing to fisheries. Agencies responsible for management of streamside environments have not adequately considered the influence of livestock grazing. Not all of the answers can be found right away. Persuading land managers to recognize and implement management practices that protect streams and their riparian environments will be difficult.

Most grazing systems currently in use 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 on the type and condition of the rangeland. Five grazing systems have come into common usage, which improve distribution of livestock and enhance plant growth and vigor.

In the season-long grazing system, selected pastures are used throughout the grazing season or any part of the year that grazing is feasible. Handling and movement of livestock are minimized, and the least investment of money is required. Past problems with this system have included the concentration of animals at favored locations (especially in riparian ecosystems); not all the herbage was adequately used, and more desirable forage plants were often overused, creating undesirable changes in range forage. This type of management can disperse livestock over more of the stream bottomlands than some of the crowding techniques such as rest-rotation.

The system of rotation grazing breaks the range into selected pastures or units that are used for shorter periods with heavier stocking of animals, followed by a period of rest to allow the vegetation to recover. This system favors maintenance of existing plant species and reduces uneven grazing.

Deferred grazing calls for the delay of grazing on a selected pasture to allow plant reproduction and establishment.

Deferred-rotation grazing is a systematic rotation system that includes deferment of selected pastures from grazing for certain periods. The success of this system is based on the premise that the complete allotment will benefit from these short rests. Grazing is usually allowed on all portions of the allotment for at least part of each growing season.

Rest-rotation grazing allows complete rest on part of the pastures during certain years or entire growing seasons. In this system, the vegetation is closely cropped and a high trampling effect exists for a short period, which helps regeneration by planting seeds. A more uniform use of forage resources is provided through better livestock distribution. Recent studies, however, suggest that rest-rotation grazing may concentrate animals on streambanks, resulting in overuse of riparian vegetation such as willow (*Salix* spp.)[6]

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[6] Speech, "Rest-rotation grazing - a bummer," by W. R. Meiners. Presented to Soc. Range Manage., 27th Annual Meeting, Tucson, Arizona, 1974.

LIVESTOCK ANQ AQUATIC HABITATS

Streams have been subjected to damaging events since the time they were formed--damage from such natural events as glaciation, floods, temperature changes, fire, droughts, and--more recently--by human occupation of streambanks and use of streatns and their surroundings for mining, timber harvest, livestock grazing, road construction, recreation, and sewage and waste disposal.

Livestock grazing can affect all four components of the aquatic system: streamside vegetation; stream channel morphology; shape, quality, and quantity of the water column; and structure of the soil portion of the streambank. Livestock grazing can cause annual micro-changes in the environment that can accumulate over many decades. These subtle changes are difficult to detect, whereas environmental changes from such sudden catastrophies as flood damage are usually readily observable and measurable. Whether a stream has suffered a catastrophic event or a long series of small annual events, the results for fish can be the same. The stream and its fisheries have been damaged and, even when stress is relieved, recovery may take years.

Effects of livestock grazing on fish and the aquatic environment have been listed by Armour (1977), Meehan and Platts (1978), and Platts (1978a, 1978b, 1978c). These papers are summarized in the next section, and additional effects of grazing are discussed.

STREAMBANKS

Streambanks bordering small streams (of stream order less than 6) provide the habitat edge needed to maintain high densities of fish. Fish often adapt to this habitat edge because stable and well-vegetated streambanks provide cover, control water velocities and temperatures, and supply terrestrial foods. The condition of the streambank often governs water depths and velocities the fish must live in. Stable streambanks are necessary to the fish in small streams.

The sloughing and collapse of streambanks caused by improper livestock grazing is probably the greatest effect of livestock on fish populations. Streambanks erode because livestock congregate along streams for shade, succulent vegetation, and drinking water. Elimination of vegetation and caving of overhanging streambanks by livestock are among the principal factors contributing to the decline of native trout in western streams (Behnke and Zarn 1976, Behnke 1977). Winget and Reichert found that livestock grazing adjacent to selected Utah streams reduced bank stability 59 percent.[7] In other Utah studies, where livestock exclosures were used, streambank stability increased 100 to 740 percent (Berry and Goebel 1978).[8]

Marcuson (1977) found that an ungrazed portion of Rock Creek, Montana, had 2.5 times less channel erosion than an adjacent stream section that was grazed. Duff states that when livestock were introduced into an area that had been ungrazed for *4* years, a 14-percent decline occurred in streambank stability within 6 weeks after introduction of grazing (see footnote 8). Hayes (1978) concluded, however, that streambank degradation--during spring runoff--occurs more often and to a greater extent along an ungrazed streambank than along a grazed streambank.

[7] Unpublished report, "Aquatic survey of selected streams with critical habitats on NRL affected by livestock and recreation," by R. Winget and M. Reichert. U.S. Dep. Inter., Bur. Land Manage., Utah State Office, Salt Lake City, 109 p.

[8] Unpublished report, "Livestock grazing impacts on aquatic habitat in Big Creek, Utah," by D. A. Duff. Paper presented at symposium on livestock interactions with wildlife, fish, and their environments, Sparks, Nev., May 1977. On file at Univ. Calif., Davis.

STREAMSIDE VEGETATION

In combination with undercut banks and streamside debris, streamside vegetation provides fish cover. Binns found cover highly significant in determining fish biomass in Wyoming streams.[9] Boussu (1954) increased trout biomass more than 200 percent by simulating natural cover in a South Dakota stream. When cover was eliminated, trout biomass decreased.

Habitat for terrestrial insects, which are an important part of fish diet, is provided by the streamside vegetation which also provides organic material for about 50 percent of the stream's nutrient energy (Cumins 1974). Detritus formed from terrestrial plants is a principal source of food for aquatic invertebrates and eventually for fish (Minshall 1967, Meehan et al. 1977). A change in the quantity and quality of detritus reaching the stream can result in a decline in numbers of the organisms that fish eat and in a disruption of the stream's ability to process organic matter (Cummins 1974; Vannote, in press).

Streamside vegetation shades streams and keeps water temperatures cool (Brown 1976). Stream temperature for trout should not exceed 65°F (18.3°C) and should be even lower during the critical spawning and incubation periods. In the West, streams from which riparian vegetation has been removed are often too warm in summer and too cold in winter.

Streamside vegetation protects streambanks by reducing erosive energy, by helping deposits build the streambank, and by protecting the streambank from damage by ice, logging debris, or animal trampling. Removal of vegetation exposes soil to erosion by rain or surface runoff.

[9] Unpublished report, "Evaluation of habitat quality in Wyoming trout streams," by N. A. Binns. On file at Wyoming Fish and Game Department, 260 Buena Vista, Lander, Wyoming, 1974.

Improper livestock grazing can affect riparian environments by changing, reducing, or eliminating vegetation and by the actual elimination of riparian areas by increasing channel width, channel aggradation, or lowering of the water table. The most apparent effects on fish habitat are the reduction of shade and cover and resultant increases in stream temperature, changes in stream morphology, and the addition of sediment through bank degradation and off-site soil erosion.

Duff (see footnote 8) found that when cattle were introduced into an area that had not been grazed for 4 years, the riparian vegetation declined 35 percent to pre-rest conditions in 6 weeks. Lorz (1974) found no difference in fish populations in ungrazed as compared with grazed sections of the Deschutes River, Oregon, when dense willow cover was on one or both banks.

Claire and Storch found that the willow canopy in an exclosed area provided 75 percent more shade to the stream than was found in the areas outside the exclosure that received year-round grazing.[10] Gunderson (1968) found streamside cover was 77 percent more abundant along an ungrazed section of Rock Creek, Montana, than along a grazed section. Stream temperatures increase in small headwater streams when riparian vegetation is removed and changes occur in the composition of fish communities in downstream waters (Vannote, in press).

[10] Unpublished report, "Streamside management and livestock grazing: An objective look at the situation," by E. Claire and R. Storch. Paper presented at symposium on livestock interactions with wildlife, fish, and their environments, Sparks, Nev., May 1977. On file at Univ. Calif., Davis.

WATER QUALITY

Salmonids need water of high quality: it cannot be too warm or cold, too fertile or infertile, too fast or slow, or too high or low in dissolved gases. Water of acceptable quality, quantity, and regimen must first be present before the stream channel and streambank can form and contain it so that it fits the habitat needs of the fish. The quality of subsurface flows that enter streams is usually excellent; this new water needs only to be charged with certain gases and nutrients to sustain fish life. Most streams have high-quality water at their origin that deteriorates in downstream areas because of land uses.

As water quality decreases and the water becomes more turbid, fish must survive in a medium in which they have difficulty seeing or moving. Often a less turbid area is not available to them. Migrating fish may avoid turbid streams, but fish forced to remain in turbid waters may have trouble feeding, using oxygen, and reproducing.

Changes in water quality from range-management practices have long been recognized (Sartz and Tolstead 1974, Busby and Gifford 1978). Research to date has centered on water temperature, sediment accrual, and increased bacterial concentrations through addition of animal wastes to the streams; the true effects on living systems, however, have not been adequately determined.

TEMPERATURE

Claire and Storch noted that the average stream temperature of Oregon's Deschutes River through an exclosure that was ungrazed for 10 years was 12°F (6.7°C) lower than stream temperatures in grazed sections (see footnote 10). Removal of streamside vegetation can increase water temperatures in small headwater streams (Brown and Krygier 1967). The literature is uniform in predicting higher summer water temperatures with less streamside vegetation cover (Gibbons and Salo 1973).

SEDIMENT

Stream-channel sedimentation caused by soil erosion on millions of acres of rangeland has long been recognized as a major problem. Lusby (1970), studying the effects of grazing on watershed hydrology in Colorado, found that ungrazed watersheds produced only 71 to 76 percent as much sediment as did grazed watersheds. Moore estimated that rangelands accounted for 28 percent of the annual sediment production within the Environmental Protection Agency's Region 10 (excluding Alaska) and was second only to croplands in total production of sediment.[11] He indicated that depleted plant cover and trampled soils are the most important factors contributing to erosion on graz'ed (particularly overstocked) lands. Duff (see footnote 8) found stream channel widths were 173 percent greater in grazed stream reaches of Big Creek, Utah, than in ungrazed stream reaches.

The general impact of sediment from rangelands on water quality has been documented (Engle 1972, Grant 1975). Although the effects of sediment on fish directly attributable to poor range-management practices have not been well documented, the general effects of sediment on fish and fish habitat are better known.

Several studies have demonstrated that rangeland abuse resulted in adverse hydrologic consequences including accelerated sediment transfer from the land to streams (Branson and Owen 1970, Branson et al. 1972, Gifford 1975). Studies that evaluate the effects of various grazing systems (e.g., rest-rotation and deferred-rotation) on in-stream sediment accrual are lacking.

Large quantities of fine sediment change the structure of aquatic communities, diminish total productivity, and decrease water permeability of channel materials used by fish for spawning (McNeil and Ahnell 1964, Cooper 1965). Saunders and Smith (1962) reported that increases in fine sediment decreased productivity of aquatic life by 37 percent; Cordone and Kelley (1961) found a decrease of 59 percent.

Fish need in-stream cover (rocks, rubble, gravel), especially during juvenile stages and winter conditions, and depend on aquatic and terrestrial invertebrates for food. Fine sediments filling the gravel-rubble interstices reduce the amount of protective cover and force young salmonids to live in surface waters where they are more exposed to severe winter conditions and predation. Large amounts of fine sediment kill fish embryos incubating in the streambed (Phillips et al. 1975) by impeding intergravel waterflow, thereby reducing oxygen supply to embryos and allowing toxic metabolic wastes to accumulate. Sedimentation in stream channels also depresses the food supply for fish by filling channel interstices and reducing the substrate's potential to produce food.

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[11] Unpublished report, "Livestock grazing and protection of water quality," by E. Moore. Environ. Prot. Agency, 1976, Seattle, Washington.

ANIMAL WASTES

A considerable effort has been devoted to studying the effects of livestock wastes from feedlots, pastures, and wildlands on water quality (Morrison and Fair 1966, Robbins et al. 1972, Barker 1973). The primary consideration in these studies has been bacterial contamination. A program designed to evaluate the effectiveness of potential treatment and control measures for feedlot wastes has been underway for several years (Shuyler 1973). Summaries of studies and recommendations for treatment of feedlot wastes have been made by Porter et al. (1975) and Manges et al. (1975). A detailed bibliography on management of livestock waste has been prepared by Miner et al. (1972).

Kunkle and Meiman (1967 and 1968), Kunkle (1970), Darling and Coltharp (1973), and Skinner et al. (1974) attribute high concentrations of coliform bacteria in study streams to livestock grazing. Although livestock-caused bacterial concentrations do not directly affect suitability of habitat for fish, they are nonetheless important indicators of water quality and hence relate indirectly to fish habitat.

WATER QUANTITY

Livestock managers were generally unaware, in the early years of the industry, of the limits to which vegetation and soil could be stressed (Council for Agricultural Science and Technology 1974). l'hese resources have only recently been afforded their full credit as controllers of water on the land (Croft 1953). Range practices can significantly affect water yield, peak stream discharge, stormflow runoff, and associated water quantity factors. Water management and rangeland management are thus closely interrelated.

Many studies show the effects of livestock grazing on runoff (Haynes and Neal 1943, Packer 1953, Leithead 1959, Liacos 1962, Rauzi and Hanson 1966, Lusby 1970, Sartz and Tolstead 1974, Smiens 1975). As grazing intensity increases, water yield as runoff increases. Soil compaction and consequent decrease in infiltration rate, as well as cover depletion, are the primary reasons.

Other studies have specifically demonstrated that infiltration rates decrease as grazing intensities increase (Coupland et al. 1960, Branson et al. 1962, Johnston 1962, Meeuwig 1965, Rauzi and Smith 1973, Smiens 1975).

FISH POPULATIONS

The literature shows that streams modified by improper livestock grazing are wider and shallower than these streams would have been naturally. Generally, they have channels that contain more fine sediment, streambanks that are more unstable, banks that are less undercut, and higher water temperatures in summer than undisturbed streams. A recent detailed review of the literature (Meehan and Platts 1978), however, pointed out the lack of quantitative data in this field; nevertheless, most of the reported studies show decreases in fish productivity with increasing livestock use.

Three years after being fenced to exclude livestock, Otto Creek, Nebraska, improved from a nonproducer to a major producer of trout (Armour 1977). The stream width decreased, streambanks quickly stabilized, and water temperatures in summer were 2° to 5°F lower than before livestock exclusion. Claire and Storch (see footnote 10) found that over a 10-year period of nongrazing within an exclosure on the Deschutes River, Oregon, the fish population shifted from predominantly dace (Rhinichthys sp.) to rainbow trout (Salmo gairdneri Richardson).

Marcuson (1977) found that biomass of brown trout (S. trutta Linnaeus) per unit area within a nongrazed section of Rock Creek, Montana, was 340 percent higher than in an adjacent stream section that was heavily grazed. In the same stream, Gunderson (1968) found that trout were 27 to 400 percent more abundant in ungrazed than in grazed sections. Kennedy (1977) reported that trout numbers were 240 percent higher in ungrazed sections of an Oregon stream than in grazed sections. Duff found trout populations 360 percent higher in ungrazed stream reaches of Big Creek, Utah, than in grazed stream reaches (see footnote 8). Lorz (1974) reported that trout populations were about 350 percent higher in ungrazed sections of the Little Deschutes River, Oregon, than in grazed sections. These studies strongly suggest that improper livestock grazing decreases both quality and quantity of fish populations.

Kimball and Savage (1977) reported a 425-percent increase in fish populations in a section of Diamond Fork Creek, Utah, after livestock had been kept away for 4 years, and forage utilization was reduced 60 percent from past use, once grazing was resumed. The installation of structures for stream improvement and the planting of willows and grasses within the study area may also have contributed to the increase in number of fish collected. Fisheries apparently can benefit from improvements in present patterns of livestock management. Lorz (1974), Marcuson (1977), and Duff (see footnote 8), however, all reported reduced vegetation and more unstable streambanks in areas being grazed by the commonly used methods.

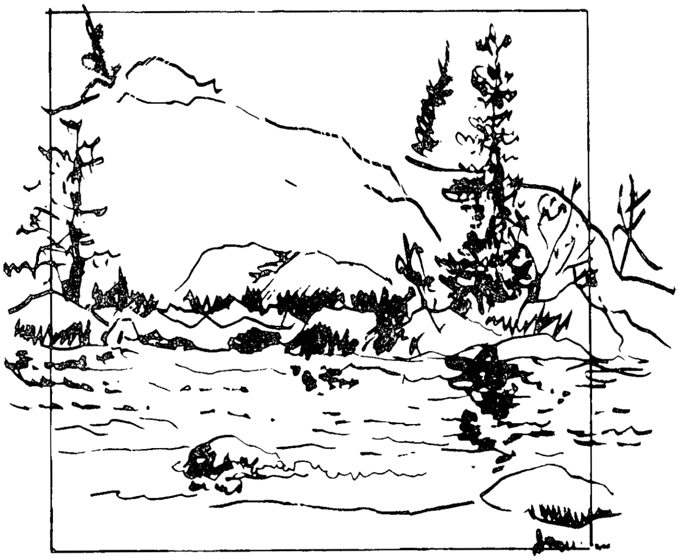


Table 1--Condition of riparian-aquatic habitat resulting from various grazing strategies (see text footnote 5)

System	Condition of resulting riparian-aquatic habitat
Year-long grazing	Poor
Season-long grazing	Poor
Deferred grazing	Poor to fair
Rotation grazing	Poor to fair
Deferred-rotation grazing	Poor to fair
Rest-rotation grazing	Poor to variable[1/]
Short duration, high-intensity grazing	Variable[1/]
No grazing	Good to excellent

[1/] Resource damage, especially streambank cutting, within heavy-use units may not be repaired within the grazing cycle.

AVAILABLE GUIDELINES

Present management direction related to streams and streamside ecosystems varies among agencies and among divisions within agencies. Management direction is supplied to land-management agencies through laws, regulations, manuals, land-use plans, and allotment guides. This management direction generally requires protection of soil, water, and air. Agencies have recently been given additional guidance through Public Laws 92-500 and 95-217, which provide definite guidance for control of nonpoint-source pollution.

A livestock-fishery interaction symposium (see footnote 5) rated some of the most commonly used grazing strategies (table 1). Based on this analysis, present range-management guidelines are not commensurate with maintenance of high-quality fish habitat. The symposium proceedings lists goals for managers:

- Sufficient streamside vegetative canopy should be maintained to prevent unacceptable water temperatures.
- Streambanks should be well vegetated to hold soil in place and to keep trampling damage by livestock to a minimum.
- Overhanging streamside vegetation (within 2 feet of stream surface) should be maintained to provide needed fish cover.

Range-management practices presently recommended for protecting, restoring, or enhancing fish and riparian habitats were listed as:

- Allow complete rest from livestock grazing to degraded riparian areas for as long as required to meet the above goals.
- Defer grazing on streamside areas to late fall when possible.

- Recognize specific needs of the different ecological units in ranges or pastures. For example, hillsides differ greatly from riparian areas in grazing suitability and potential for grazing damage, and managing these two habitats as a single unit is unrealistic.

- Improve off-stream distribution of livestock in areas bordering, riparian zones.

- Allocate vegetative cover in the streamside zone for fish at the same time forage is allocated for livestock grazing.

A problem facing biologists attempting to evaluate the influences of different systems of livestock grazing is that methods must be developed to detect, within narrow limits, natural variation in streamside vegetation, in streambank and stream channel conditions, and in standing crops and community structure of fish. Combined effects of geology, climate, soil, vegetation, and water runoff often result in unstable stream conditions, even without grazing livestock. Natural variation is difficult to isolate because most aquatic sites have been modified by land uses for a long time, and recognizing what is and what is not "natural" is difficult.

Studies in Wyoming have associated environmental conditions with trout biomass (Wesche 1973, 1974). Biologists need, however, to develop better methodology to isolate and evaluate natural and artificial changes in aquatic components (Platts 1976). Workable guidelines will be difficult to develop until these problems are solved.

The USDA Forest Service has two research programs designed to further the knowledge of livestock effects on aquatic systems and assist in the preparation of better guidelines. One of these studies is being conducted in eastern Oregon by the Pacific Northwest Forest and Range Experiment Station[12/] and the second, by the Intermountain Forest and Range Experiment Station in central Idaho.[13/] These studies will quantitatively evaluate the effects of different types of livestock-grazing practices on aquatic and riparian systems. Other agencies are probably also conducting research on this problem.

[12/] Study plan, "The influence of grazing on riparian and aquatic habitats in the central Blue Mountains," by J. M. Skovlin and W. R. Meehan, USDA For. Serv., Pac. Northwest For. and Range Exp. Stn., Portland, Oreg., 1975.

[13/] Study plan, "The effects of livestock grazing in high mountain meadows on aquatic environments, streamside environments, and fisheries," USDA For. Serv., Intermt. For. and Range.Exp. Stn., Boise, Idaho, 1975.

INFORMATION NEEDED

Studies that will provide resource managers with quantitative information upon which to base land-use planning decisions are needed on both the physical-chemical and biological aspects of the interrelation of livestock grazing and the aquatic habitat. Physical and chemical considerations include effects of livestock use of valley bottoms on water quality, stream channel morphology, streambed condition, and the riparian zone. Biological information is needed on impacts of livestock on standing crop and species diversity in populations of fish and benthic invertebrates, bacteriological aspects of water quality, and recreational and esthetic values in the use of the fishery and the aquatic and riparian ecosystems.

Advanced grazing systems have been used with the goal of enhancing the welfare of the range and production of livestock. Resource managers need to know how these grazing systems influence other resources including populations of anadromous and resident coldwater fish.

The broad research needs encompass a wide area: inventory, assessment, and classification; ecosystem dynamics; autecology and physiology of deciduous tree species; impacts of land-management practices; social and economic problems; and alternatives in riparian management.

Fishery biologists are confronted with the problem of determining how different types of grazing systems affect the various aquatic components and how changes in these components affect fish health and survival. Fishery research needs thus narrow down to seeking answers to these questions:

- Which of the existing grazing systems are most compatible with the fishery resource?
- What innovations are needed to make livestock grazing more compatible with fishery needs?
- Is one grazing strategy best suited for riparian areas?
- What is required and how long does it take for a stream altered by livestock grazing to return to natural conditions?
- What techniques are available or should be developed to reduce the recovery time for degraded streams?
- How much is fish production increased from improvement or protection from livestock grazing of streamside areas?
- If streams need to be protected by fences, what type of stream and how much of each stream should be fenced?
- How much vegetative canopy is needed on streambanks to prevent unacceptable stream temperatures?

- How do different classes of livestock affect the riparian environment?

- What are the first indicators that a stream is beginning to deteriorate or to improve from management of livestock?

- How much forage use can the different vegetative types and streambanks support without unacceptable changes?

- Is livestock grazing less damaging at some times of the year than at others?

Once these questions are answered, strategies for range management can be improved. The future demands that streams be as productive as possible in grazed areas and the first step is an effective research program to provide the needed answers.

SUMMARY AND DISCUSSION

Livestock grazing can affect all components of the aquatic system. Grazing can affect the streamside environment by changing, reducing, or eliminating vegetation bordering the stream. Channel morphology can be changed,by accrual of sediment, alteration of channel substrate, disruption of the relation of pools to riffles, and widening of the channel. The water column can be altered by increasing water temperature, nutrients, suspended sediment, bacterial populations, and in the timing and volume of streamflow. Livestock can trample streambanks causing banks to slough off, creating false setback banks, and exposing banks to accelerated soil erosion.

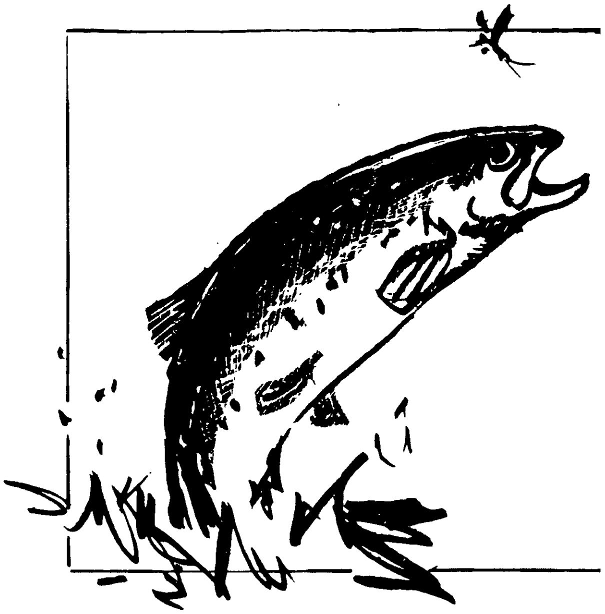
Documenting and evaluating effects of these alterations are difficult, because nature causes similar alterations and effects. Fishery biologists are confronted with the problem of determining how different types of grazing systems affect the various aquatic components and how changes in these components affect fish health and survival. Whether a stream suffers a catastrophic degrading event or a long period of annual lesser events--such as grazing by livestock--the result for fish can be the same and recovery may take years.

Streams and streamside zones are most critical for multiple-use planning and offer the greatest challenge for proper management; stream habitats, therefore, should be identified as separate management units to receive intensified management. Land-management agencies responsible for managing livestock grazing must give adequate consideration to the influence of grazing on streams and streambanks. Land managers often fail to recognize stream ecosystems as separate systems in their management programs. This oversight occurs even though studies have demonstrated that practices that protect streambanks from damage also enhance the potential of riparian vegetation to support other resources (Gunderson 1968; Marcuson 1977; Duff (see footnote 8)).

Past management has allowed streamside environments to deteriorate, and land managers do not have the information they need to correct the problems. Fishery and range researchers must concentrate on providing such information to land managers, so that each riparian resource can he managed without infringing on other uses.

McGowan (1976) and Platts (1978c) doubt that present grazing strategies will solve the problems in the aquatic environment that grazing causes. If this assessment is valid, research is needed that does more than just evaluate present management systems. Scientists must conduct interdisciplinary research that will result in recommendations for new grazing strategies. When such strategies are available to the resource manager, rangeland decisions can be made with maximum consideration and understanding of the aquatic resource.

Improved livestock management will result in more stable streambanks and stream channels, reduction of soil erosion and consequently reduced stream sedimentation, improvement of streamside vegetative cover, improved water quality, and increased riparian forage and fish production. Improvement of streamside vegetation will also increase the abundance and diversity of terrestrial wildlife. Proper management of livestock will increase resource values and, in turn, economic benefits to all users. A short-term loss of forage for livestock may occur, when overused and degraded riparian communities are put under proper management, but increased forage production should ultimately be a result of improved resource management.



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