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LIVESTOCK MANAGEMENT AND WATER QUALITY

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By

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Livestock Management and Water Quality

Introduction

Livestock producers are legally responsible to prevent the pollution of surface waters that grazing livestock can cause due to the waste products they generate. Some of the major non-regulatory reasons for adopting good livestock management practices are improved and/or increased animal health, pasture productivity, wildlife habitat, land value, and ecosystem health.

Individuals and organizations concerned about the effects of livestock grazing on the environment tend to view grazing as a static process with fixed negative effects on an ecosystem, regardless of differences in management. Dr. Nathan Sayre, professor of human geography at the University of California, Berkeley, uses ranching to make a point about sustainable natural resource use in the western United States:

> [Ranching] has outlasted beaver trapping and bison hunting. Beaver and bison look like cases where an activity was ecologically unsustainable. But in truth *it wasn't the activities per se that were unsustainable but the way they were practiced in the 19th century*, which can be traced to economic forces and property relations rather than ecology… The way [ranching] is practiced today is radically different from the way it was practiced then, even if we call it by the same name. (2005: 2; emphasis added)

Applying this dynamic perspective of historical land use to water quality, the presence or absence of cows in a riparian area is not as important as the way they are managed. Also critical are the effects of plant community changes from influences such as climate, weather events, and fire on potential pollutants such as sediment, pathogens, nutrients, and stream temperature.

This bulletin addresses the effects of livestock grazing on water quality in streams and demonstrates the relationship that commonly associated pollutants have on ecosystem health. Sediment, pathogens, and water temperature are emphasized to illustrate how livestock management practices that promote healthy pastures[1], rangelands[2], and forestlands are steps toward ecosystem health.

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[1] Pasture refers to lands where "periodic cultivation is used to maintain introduced (nonnative) forage species, and agronomic inputs such as irrigation and fertilization [may be applied] annually" (Holechek et al. 1995: 1).

[2] Rangeland is "uncultivated land that will provide the necessities of life for grazing and browsing animals" (Holechek et al. 1995: 1).

According to the National Research Council (1994: 35), rangeland health deals with the "degree of integrity of the soil and ecological processes that are most important in sustaining the capacity of rangelands to satisfy values and produce commodities." For purposes of this discussion, ecosystem health carries the same definition as rangeland health. Because clean water is commonly valued as one of the most important "commodities" natural ecosystems provide, federal and state laws dictate that a standard level of water quality be maintained. A decline in water quality (regardless of cause) is therefore often considered a result of "malfunctioning" ecological processes necessary for capturing, storing, and safely releasing clean water. When referring to rangeland health within a specific geographic area (that which drains to a common water body), the term "watershed health" is often used.

Water Quality

From an ecological perspective, clean water should have low pathogen levels, sediment loading within a natural range of variability (all streams have different potential for sediment production according to specific geology, vegetation, slope, source water, etc.), no harmful amounts of chemicals, and a temperature range that supports aquatic life. Water quality is influenced by many human activities, whether agricultural, industrial, or recreational, as well as factors beyond our control such as climate events and most wildlife activities. Livestock grazing is one factor over which we have some control. However, purposeful water quality change requires adaptation of many other local land management practices as well, all of which ultimately influence the surrounding ecosystem.

Effects of Grazing

When livestock do not have access to regularly supplied hay and grain, they are completely dependent on plants for food. Differences in the timing, intensity, and frequency of grazing events result in effects on the landscape that are highly variable. In the absence of human constraint on their behavior, large ungulate herbivores tend to "follow the green," moving from low elevation or warm areas where grass grows first in the spring toward higher elevation, colder areas where green-up and peak vegetation production does not occur until summer. This pattern optimizes the consumption of quality forage and deposition of plant- available nutrients and soil-building organic material. It also tends to reduce the duration of impact by a herd or flock on a water body with regard to manure deposition and streambed disturbance, which often resuspends bacteria-laden sediment. Land managers need to utilize this symbiotic relationship rather than disrupt it.

Well-managed grazing that encourages even utilization of plants and allows time for plants to fully recover from defoliation offers a number of signifi benefits to the manager and ecosystem, many of which have a positive chain effect:

- Maximizes forage production
    - Minimized bare ground protects soil
    - Increased grass and forb stem density slows the overland sheet flow of water
    - Increased root growth and sloughing cycles build soil organic matter, which in turn increases:
        - Soil porosity
        - Water infiltration
        - Water-holding capacity
        - Nutrient (such as nitrogen and phosphorus) capture
- Removes the growing points of many weeds
- Reduces the likelihood of animals picking up internal parasites (when adequate residual plant height is maintained)

Grazing directly affects plant communities in several ways, including the processes of biomass growth, internal allocation of resources, litter dynamics, recruitment of new plants, and plant stature/longevity. Grazing indirectly affects competitive relationships among species, community composition, percent ground cover, soil development, and successional development of plant communities. Understanding how a grazing event will affect a plant community requires knowledge of the plants and animals involved, and is necessary for developing ecologically beneficial (i.e., successful) grazing management. Practical application of research findings and implementation of best practices combined with good on-the-ground observation skills are an excellent start. University Extension offices and USDA Service Centers are good sources of information and training.

When plants are grazed, there is a die-off of root material proportional to the amount of foliage removed. Since roots are the most important stabilizing influence on soil, overgrazing eventually results in soil loss primarily because plants are not healthy enough to maintain adequate root volume and depth. These same conditions contribute to sedimentation, poor infiltration rates, and nutrient export. However, when plants have time to adequately regrow from clipping, they replace their root volume so that each defoliation event results in increased organic matter to the soil. Soils with high organic matter content have the capacity to hold large volumes of water, thereby reducing the severity of high-water events by minimizing soil loss.

Plant type also affects sustainable grazing management decisions. A diversity of plant species is important to soil health and has implications for water quality. Perennial plants maintain a rough equivalence of above-ground biomass and below-ground root biomass (Fig. 1), although there is variation among species. These differences contribute partially to the relative adaptation or resistance of perennial plants to grazing pressure. Examples are bunchgrasses that have deep roots to access nutrients and enhance infiltration compared to shallower-rooted sod-forming species that protect the soil surface.

Sediment

Within the context of water quality, sediment is perhaps most significant as a carrier of pollutants (pathogens, nutrients, chemicals), but in excess can be a pollutant itself. Natural events, soil properties, topography, climate, and vegetation can all infl sediment production, transport, and storage.

Managing for sediment in sheet flow is a matter of simple physics. As water velocity increases, so does the amount of sediment water can carry. As water velocity slows, sediment falls out of suspension. Since plant stems slow water movement on the soil's surface, stem density is the most important factor in filtering sediment from overland sheet flow.

The infiltration and percolation properties of a soil affect its susceptibility to erosion. If precipitation is able to move into the soil at the point of contact and through

Figure 1. Bunchgrass root mass at various levels of defoliation (Reprinted by permission from the Agricultural Institute of Canada, Johnston 1961)

the soil once absorbed, less water will be prone to move across the surface and deposit sediment in streams. Significant sources of livestock-induced sedimentation in streams include streambank trampling, heavy grazing along streambanks, and livestock trail crossings.

Well-managed pastures build soil, capturing sediment that is carried by the wind, irrigation water, or run-on water from adjacent areas. Although rangeland pastures do not typically have the same ability to ameliorate overland flow as irrigated pastures, healthy rangelands are still characterized by the ability to capture and hold water.

Grass filters are one of the most effective solutions to a sediment problem upslope. A pasture can be viewed as a grass filter managed with livestock (Fig. 2). Grassed buffers are effective for reducing sediment, particularly adjacent to bare areas with manure (Dickey and Vanderholm 1981). The recommended buffer width varies depending on slope, soil type, precipitation pattern, and degree of manure loading.

Streambanks with vertical slopes, fine-textured soils, and high water-holding capacity are at risk for streambank-induced erosion. Such streambanks are most susceptible to hoof damage when they are wet, as in early spring. However, this is also the time when upland forage is greener and upland air temperatures are warmer than low-lying areas; therefore, the riparian zone is less of an attractant to livestock. When soil is dry, streambanks are much less susceptible to erosion, but livestock may tend to concentrate in riparian areas for the abundant forage and water. Later in the season when herbaceous vegetation has gone dormant (or is unavailable), livestock may shift their preference to woody species. Streams with rock and cobble substrate are less susceptible to the direct effects of hoof action, but still rely on vegetation to varying degrees for bank stability. If overgrazed[3], the survival and regeneration of woody species will be reduced; if this severe use occurs annually, the riparian system will lose woody species. The decline of either type of streambank vegetation results in a loss of plant root systems that help prevent erosion (Fig. 3).

Figure 2. Well-managed pasture with dense grass sward (Photo by Tipton Hudson)

Even where streambank trampling is not a problem, livestock trails may contribute to major sediment movement into nearby water. Regular trampling along trails keeps areas devoid of vegetation throughout the year, reduces infiltration rates, and exacerbates runoff. As the distance between forage sites and water sources increases, so does the amount of soil surface disturbed from trail use (George et al. 2004)

Pathogens

A pathogen is any agent that causes disease in animals or plants. Waterborne pathogens include certain species of bacteria, protozoans, viruses, and various invertebrates. Pathogenic microorganisms associated with mammals usually enter water from direct fecal deposits (containing water, urea, organic matter, nitrate, and bacteria) by animals or subsurface and overland flows of water (Larsen et al. 1994).

While a large number of viral, protozoal, and bacterial pathogens are potentially shed in human and animal feces, relatively few cause waterborne disease outbreaks. Pathogens suspended in feces and manure do not typically survive water quality treatments long enough to cause infection. And those pathogens that do survive to reach water bodies are often diluted to levels below that which will infect humans and other

[3]Overgrazing refers to grazing before a plant has recovered from the previous grazing event.

Figure 3. Denuded streambank in eastern Washington (Photo courtesy of the Washington Department of Ecology)

animals. Because of dilution and municipal water treatment, the vast majority of human infections caused by pathogens are instead spread by contaminated food or direct host-to-host contact. For disease outbreaks attributable to waterborne pathogens, the main contributor is water contaminated with human feces or sewage rather than agricultural operations or wildlife (Upton and Griffin 1999).

Although livestock are not a primary source for waterborne diseases, it is still important to reduce the risk of viable pathogens reaching source water by using management practices that prevent direct deposit of feces in source water. Bacteria attached to soil particles or aggregated into large clumps (i.e., associated with dried feces) are subject to settling and thus effectively removed from overland flowby vegetative filter strips or en route across a well-managed pasture (Muirhead et al. 2005).

Manure deposited immediately adjacent to a stream has a much greater influence on stream bacteria loading than that deposited farther away; the likelihood of more remote manure deposition reaching surface water is related to slope, vegetation, soil type, soil water levels, and the intensity and frequency of precipitation events. However, research results vary widely on what percentage of bacteria are transported as single cells and therefore how effective buffers are. It may be that in nutrient-rich environments, under conditions where soil is saturated with water or during intense rainfall events that break up manure pats and bacteria clumps, the majority of bacteria are carried by water as single cells.

Well-known pathogens such as Cryptosporidium and Giardia can cause illness at very low levels that are difficult to detect. Fecal coliform, which originates from the intestinal tract of warm-blooded animals, is the most commonly used indicator of pathogen pollution in watersheds because it is the easiest and least expensive to detect. However, fecal coliform bacteria do not necessarily transmit disease. Water regulatory agencies are interested in identifying and promoting a better detection method for pathogens because fecal coliform is often a weak indicator. For example, pathogens such as C. parvum, Shigella sp., and virulent strains of E. coli (a member of the fecal coliform subgroup)can be in water that meets all bacterial water quality standards (Fig. 4).

The following is a list of bacterial characteristics that are relevant to livestock management:

- Fecal coliform bacteria exposed to air die within 7–21 days once removed from the host.
- Fecal bacteria deposited directly into a stream settle out quickly, but can remain alive in a streambottom for 12–24 months.

Figure 4. Clear irrigation water moving through an irrigated pasture under intensive grazing (Photo by Tipton Hudson)

- Spikes in stream bacteria levels are primarily caused by direct fecal deposit or resuspension of streambottom sediments from high flow events or animal traffic.
- Use of watering tanks can decrease the time livestock spend in streams, thus reducing fecal bacteria pollution (by avoiding the direct deposition of fecal material and the resuspension of bacteria-containing bottom sediments by livestock movement).

Bacteria from wildlife is of concern as well. Water quality sampling results do not distinguish between wild or domestic sources of bacteria. Referring to wildlife, Robbins (1979: 1318) states that "Controlling pollutants from unconfined animal productionunits may be to no avail unless other pollutant sources that naturally occur in the same watershed are controlled as well… Additional information and research on the form and extent of natural pollutant sources are needed to formulate meaningful water quality management programs." Nearly 30 years later, biologists are just beginning to meaningfully analyze the sources of fecal coliform bacteria through DNA analysis.

Temperature

The major sources of heating in natural streams are 1) convective heat exchange with the underlying soil and overlying air and 2) absorption of direct solar radiation by water, both of which livestock grazing can affect. An increase in convective heat exchange results primarily from a change in the shape, or morphology, of a stream. Loss of riparian vegetation in a floodplain may cause a stream to channelizeand thus restrict floodwater access to the floodplain because less water is stored in the soil for later release and use by vegetation. The result is lower flows during the summer, less influx of cool water from surrounding soils, and warmer stream temperatures.

Canopy density and height are the dominant factors in the ability of streamside vegetation to intercept incoming solar radiation and reduce the rate of warming. Decline in the abundance and vigor of riparian plants in a floodplain may also cause streams to become shallow and wide, which increases the surface area that is exposed to warm air and solar radiation. In addition, the surrounding soils may be warmer since the replacement of riparian vegetation with upland vegetation reduces the shading capacity of the plant community, contributing to a warmer streambed and greater heat exchange between the water and underlying soil. Small streams are more susceptible to warming because they have a lower volume of water to absorb solar energy.

Well-managed grazing that allows adequate recovery time from defoliation promotes the vigorof herbaceous and woody vegetation that prevents streambanks from widening, reduces direct exposure to sunlight, and results in healthy soils with high organic matter and water-holding capacity.

Water Quality-Compatible Livestock Management Tools

Managing livestock to improve or maintain water quality must incorporate practices that 1) reduce the likelihood of direct deposition of manure, 2) discourage overland flow of bacteria-laden water, and 3) encourage precipitation and irrigation to enter the soil. Some of the tools livestock managers can use to help them achieve water quality levels that meet both legal and ecological health standards are described next.

Water Tanks

Water tanks can reduce the time that livestock spend drinking or loafing in streams by more than 90% (Fig. 5; Miner et al. 1992), which results in a corresponding decrease in the direct deposition of manure into streams (Sherer et al. 1988).

Figure 5. Water tank at intersection of fences (Photo courtesy of the Natural Resources Conservation Service)

Another way water tanks can benefit water quality is by lowering the risk of pathogens shed into surface water by young livestock with weakened immature immune systems from wet, cold spring conditions and manure-covered wintering areas.

Water tanks are also one of the most effective strategies for improving livestock distribution on upland forage and can significantly improve animal health by providing a source of consistently clean water. Tanks are therefore one of the cheapest solutions for confinement lots where access to surface water may be a concern, largely preventing direct deposition of manure and resuspension of streambed sediment. For more information on livestock distribution, go to *http://animalag.wsu.edu/forages/index.html*.

Water Gaps

An on-stream alternative to a water tank is a water gap, which is designed to make animals uncomfortable so that the time spent in direct contact with surface water is restricted to what is necessary for drinking. Creating relatively steep (~25% slope) water access roughened with large cobble effectively discourages streamside loafing (Fig. 6). Local Natural Resources Conservation Service (NRCS) or conservation district offices can provide guidelines for proper construction of water gaps.

Riparian Pastures & Fencing

Fencing is an invaluable aid in controlling livestock distribution to address water quality issues. Fences can be used to divide large paddocks into smaller ones if greater concentration of stock is needed to protect water quality. Drift fences (not enclosed) are used to direct animals away from sensitive areas.

Creating riparian pastures (i.e., fencing the riparian zone separately from adjacent uplands and utilizing the pasture as a separate unit) is an effective water quality management strategy because prolonged use of the riparian zone can lead to broken streambanks and manure loading. Fencing areas with similar vegetation encourages livestock to feed uniformly because there is generally less disparity in relative feed value within a given paddock than there would be if a paddock encompassed the benchtop, hillslope, floodplain and riparian area. Livestock managers need to consider soil types, topography, water tables, aspect changes, and slope breaks in designing pasture divisions.

Exclosures are a common tool to protect streams. They prevent livestock access to riparian areas and eliminate direct deposition of manure in streams, but may lead to the development of other problems such as weed infestation and

Figure 6. Hardened water access area (Photo by Tipton Hudson)

excessive vegetation accumulation in the riparian area, which can be a fire risk and source of bacterial growth. Research from California's grasslands indicates that *E. coli* transport decreases with increasing thatch (dead, fallen vegetation, particularly grass, often referred to as litter) up to 900 kg/ha; above this level, transport increases (Tate et al. 2006). Researchers theorize that extremely heavy thatch creates warm, nutrient-rich conditions between the thatch and soil that promote bacteria growth. By contrast, properly grazed enclosures serve as effective vegetative buffers by preventing excessive thatch buildup, maintaining higher grass stem density, and exposing fecal pats to sunlight. Increasing the age of manure pats and length of exposure to the sun are correlated to *E. coli* die-off. For these reasons, *E. coli* contamination of streams is greatest in the first seven days after livestock are removed from a riparian paddock (Meays et al. 2005).

When confinement is necessary (such as with animal feeding operations), berms and settling ponds can be strategically constructed to accept runoff water and prevent large quantities of concentrated manure from reaching surface water bodies. Vegetated filter strips between confinement lots and surface water can be managed either with controlled grazing or mowing to maximize stand density and prevent weed invasion.

Forested Riparian Buffers

Riparian forest buffers are frequently part of conservation cost-share programs because the deep, large root systems of woody vegetation are important for holding together the soil of streambanks, much like rebar is to the stability of concrete. Shallower grass roots are like a skin or sealer that protects the soil surface. The extensive root systems of woody vegetation promotes soil infiltration by creating macropores and increases water-holding capacity by increasing soil organic matter. While woody vegetation may not be as effective as grass in removing sediment from overland flow, a riparian forest allows water to pass through the soil en route to the water table or stream. The combination of grasses, sedges, rushes, shrubs, and trees in a riparian system is very effective at protecting water quality.

Riparian forest is also important for nutrient uptake and subsequent storage of carbon and nitrogen by woody stems (Lowrance et al. 1984).

Supplementation

Placement of supplemental feeds can result in improved water quality because it draws livestock away from streams. As most commercial supplements are highly palatable, animals will travel significant distances to consume them. Low-moisture blocks that provide additional protein to livestock when protein is lacking in natural forage have great potential to draw and hold livestock to a target area such as steep slopes or areas more than a mile from water (Bailey and Welling 1999). Supplementation also has potential to improve manure distribution (for even nutrient application) and increase the distance of manure deposition from surface water. Low-moisture blocks are more effective than salt for attracting livestock, and best used in combination with herding.

Herding

Herding is often misunderstood as "chasing," which has little long-term benefi to either livestock distribution or water quality since the animals generally come back after the stress is removed.

Herding refers to the low-stress movement of livestock from one location to another and giving animals a reason to stay in the new location. As such, it is an effective, ages-old method for managing livestock forage use. Transferring animals to an area away from water improves manure distribution and reduces their time in or immediately adjacent to streams, manure deposition, and disturbance of streambed sediments.

Herding in combination with supplementation is more effective than either alone. For more information on herding strategies, go to *http://managingwholes.com/–low-stress-livestock.html*.

Planned Grazing

Perhaps the most overlooked solution in the search for "fixes" to water quality problems linked to livestock is better grazing management. The timing, duration, and intensity of livestock grazing are factors in a watershed that can be controlled. The key to grazing that promotes rangeland health is allowing adequate time for plant recovery. Such grazing is not restricted to leaving enough residual vegetation or keeping livestock off a pasture long enough to allow replacement of the photosynthetic leaf tissue, but includes timing grazing so that it facilitates the long- term health and reproduction of the dominant (or desired) forage plants. Poor grazing management is akin to weeding a garden in reverse—removing the most desirable plants and leaving the least desirable to take advantage of nutrients, moisture, sunlight, and soil space. What is good for livestock is good for the ecosystem (i.e., the promotion of ecosystem health ensures a consistent, quality feed). Similarly, if rangeland health is poor, no amount of "band-aids" to water quality problems will work.

Planned grazing that promotes healthy plants also promotes healthy soil by ensuring root occupation throughout the soil profile facilitating aeration and creation of new organic matter, and maintaining optimumlitter levels on the soil surface. Soil with these qualities is able to maximize the infiltration of precipitation and its capacity to hold water, which in turn is optimal for keeping manure onsite, recycling nutrients, and preventing overland water movement that might carry bacteria.

During the growing season, livestock should not be allowed to graze any plants lower than 3–4"; 5–6" of vegetation is best maintained if the dominant foragespecies are large bunchgrasses. Because livestock do not prefer all plants equally, especially when there is low stocking density, animals need to be removed once they have grazed the most preferred species to a target height to prevent these plant stands from declining.

Feeding locations during the winter need to be changed periodically so that manure is distributed evenly across the landscape. Alternatively, winter grazing can significantly trim operating expenses and avoid concentrating manure. Damage to pasture grass is minimal after the first few killing frosts as long as the sod is not broken by heavy traffic. Guidelines are available through local Extension offices for stockpiling forage for winter grazing.

The recovery of preferred stream and ripariancharacteristics can be facilitated by changing the timing and duration of grazing. Oregon's Crooked River is an excellent example. In 1979, of the impacts from decades of continuous, season-long grazing were clearly evident in this river's riparian plant community and stream morphology (Fig. 7). Riparian-type vegetation was eliminated, causing the stream to become shallower and wider and thus warming the water and encouraging bacteria. The same location had changed dramatically by 1987 after a switch to spring-only grazing (Fig. 8). Eliminating mid- to late-season grazing led to the return of riparian vegetation with roots that captured and stabilized sediment and thus encouraged the channel to deepen and narrow. In addition keeping livestock out of the area for part of the year prevented livestock-induced resuspension of stream sediments and fecal bacteria.

Figure 7. Crooked River, Oregon, 1979 (Photo by permission of the National Riparian Service Team)

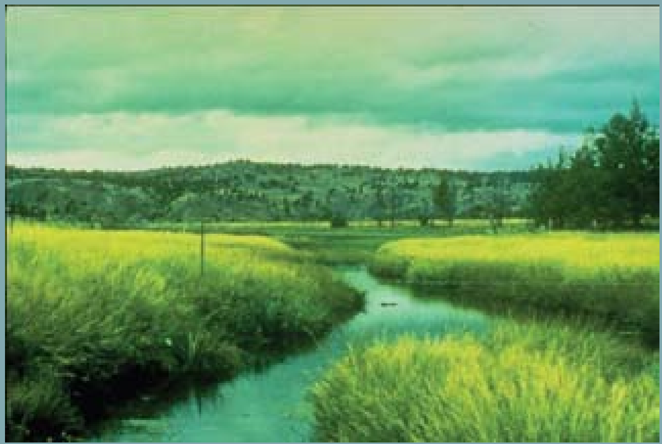

Figure 8. Crooked River, Oregon, 1987 (Photo by permission of the National Riparian Service Team)

Conclusion

The most important characteristic of a successful livestock manager is a commitment to ecologically sustainable management, which includes responding to changes on the land that illustrate a decline in vegetation viability. Otherwise known as adaptive management, the overall approach is simply close observation of the land allotted to a given number of livestock, and when things don't look right, changing the grazing management plan. Common sense will go a long way; Extension offices and conservation districts can help with less straightforward water quality and grazing management questions.

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Further Resources

EPA Compliance Center

Grass Growth and Regrowth for Improved Management

National Sustainable Agriculture Information Service:

Rangelands West

WSU Extension Central Washington Animal Agriculture Team

WSU publications

WSU Small Farms Team

WASHINGTON STATE UNIVERSITY EXTENSION