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Extension FactSheet

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Livestock and Streams

Negative Effects of Livestock Grazing Riparian Areas

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The current environmental focus on controlling nonpoint pollution to protect our surface water has led to the discussion of management of riparian areas. The Environmental Protection Agency states that agriculture has a greater impact on stream and river contamination than any other nonpoint source. Grazing, particularly improper grazing of riparian areas can contribute to nonpoint source pollution. Negative impacts downstream include the contamination of drinking water supplies (55% of Ohio's drinking water comes from surface water (Brown, 1994)), eutrophication of Lake Erie (Richards et al., 2002), and hypoxia in the Gulf of Mexico (Rabalais et al., 2001).

Photo courtesy of USDA Natural Resources Conservation Service. Overgrazed sheep pasture causing gully erosion.

This series of fact sheets looks at the issues of livestock and streams and what livestock producers can do to protect this precious resource. Before we discuss managing grazing livestock to decrease nonpoint pollution, it would be helpful to review the damage livestock can do to riparian areas and surface water.

One cannot discuss the effects on streams by grazing livestock without recognizing the interwoven and connected nature of watersheds, riparian zones, streams, and watershed activities. Activities affecting watersheds or riparian zones also affect stream ecosystems directly, indirectly, and cumulatively. Although this series of fact sheets primarily focuses on the riparian areas, it is understated that mismanagement of the land resources in the watershed can have as big an impact on surface water.

What Impact does Vegetation Removal Have on Riparian Areas?

Riparian areas are the green vegetated areas adjacent to a creek, stream, or river. Riparian areas include streams, streambanks, and wetlands adjacent to streams.

Impacts of vegetation removal can be placed into two categories: shifts in the plant community structure and removal of plant growth or biomass. Livestock can do both of these. Major changes in the plant community

Photo courtesy of Jim Hoorman. Hogs in a dry creek with little vegetation and streambank stability.

structure and usually a reduction in the number of species have been reported in the western United States. Similar or possibly even more drastic results are possible for the more humid and wet eastern United States riparian areas (Belsky, et al., 1999).

Riparian vegetation has a major influence on channel shape. Vegetation increases stream bank strength by binding the soil with roots and shields banks from erosion during high flows and flooding. Kauffman and Krueger (1984) report that bank sloughing increases when vegetation removal exceeds 60%. Streams with heavily vegetated riparian areas are narrower and deeper than those that flow through poorly vegetated areas (Kauffman and Krueger, 1984).

Small streams in New Zealand intensively grazed by cattle had greatly reduced shading by riparian vegetation, resulting in substantial increases in daily maximum temperatures during summer (Quinn, et al., 1992). Higher daily thermal fluctuations have also been associated with increased solar activity on the stream surface (Kauffman and Krueger, 1984). In general, differences in physical habitat and invertebrate communities were minor between paired grazed and riparian-protected reaches of the larger riparian zone, where grazing by cattle and/or sheep had little or no effect on stream shading (Quinn et al., 1992).

In uplands, vegetation removal exposes soil to the energy of raindrops, facilitates sheet flow erosion with an increase in the amount of runoff and the ability to move sediment. Runoff from a heavily grazed watershed was 1.4 times higher than a moderately grazed watershed and 9 times higher than a lightly grazed watershed (Rauzi and Hanson, 1966).

Summary of Effects of Vegetation Removal

- Vegetation removal exposes soil to the energy of raindrops, facilitates sheet flow erosion, runoff, and the ability to move sediment.
- In contrast, vegetation increases stream bank strength to resist erosion.
- Stream channels along heavily vegetated areas are deeper and narrower than along poorly vegetated areas.
- Sediment runoff is higher for heavily grazed watersheds compared to lightly grazed watersheds.

What Impact Does Vegetation Removal Have on Water Temperature?

Vegetation removal leads to higher stream water temperatures (Li et al., 1994). Riparian forest clearing in the northeastern United States resulted in increases in temperature of from 3.6 to 9.0 degrees F (Sweeney, 1993). The ungrazed stream was warmest in winter, coolest in summer, and had the narrowest range of mean daily temperature. Temperatures during summer and winter were significantly different among three streams in Pennsylvania, at least in part, related to the absence of shading due to a nearly complete lack of woody vegetation along two streams which were grazed (Wohl and Carline, 1996).

Dissolved oxygen levels decline due to higher water temperatures. Algal blooms deplete oxygen by respiration at night or high oxygen demand for decomposition of algae and fecal material. This lowered oxygen environment means insufficient oxygen in spawning gravels, reduced rate of food consumption, growth, and survival of salmonids and other aquatic species, especially at their early life stages (Belsky et al, 1999). For example, it has been reported that watersheds in eastern Oregon with greater riparian canopy had higher numbers of rainbow trout (Li et al., 1994).

Summary of Temperature Effects

- Removal of streamside vegetation can increase mean temperature and temperature extremes.
- Streams along wooded riparian zones may be cooler in summer and warmer in winter.
- Relatively small changes in stream temperature can shift aquatic communities—a 3.6 degree F increase is sufficient to shift from a coldwater to a warmwater habitat.
- An increase in stream temperature from 3.6 to 9 degrees F is common when streamside vegetation is removed.

Photo courtesy of USDA Natural Resources Conservation Service. Sedimentation from soil erosion.

Photo courtesy of USDA Natural Resources Conservation Service. Fish migrating to spawning area.

What Effects Does Sediment Have on Riparian Areas?

Sedimentation is recognized as the most prevalent and damaging pollution in streams in North America (Waters, 1995). Livestock grazing riparian areas can increase sediment load from the watershed, increase instream trampling, increase disturbance and erosion from overgrazed streambanks, reduced sediment trapping by riparian and instream vegetation, decreased bank stability and increased peak flows from compaction. In streams assessed in 2000, the most common agricultural pollutant was silt, which was a contributing factor for 31% of streams considered impaired (USEPA, 2000).

What Impact Does Sediment Have on the Habitat for Aquatic Organisms?

Sediment associated with livestock grazing occurs during snowmelt or heavy rainfall, when removal of vegetation and compaction combine to facilitate overland flow (Gardner, 1950; Bryant et al., 1972; Owens et al., 1983; Orodho et al., 1990).

Photo courtesy of USDA Natural Resources Conservation Service. Stream with cobble and gravel bottom.

Fine sediments increase in pools and quiet water areas from the increased erosion. Many invertebrates (insects) in streams require relatively silt-free habitats. These organisms live in the spaces between rocks in the bottom of streams (Minshall, 1984).

Sediments cover and fill rocky substrates, entomb eggs and larval fish, and hinder emergence of hatched fish. Water flow in gravel is impaired, developing embryos do not receive sufficient oxygen, and metabolic wastes are not flushed.

Siltation of cobble and gravel also covers hard substrates required for algal growth. This means that invertebrates that scrape algae from gravel and cobble for food will decline. It also means that invertebrates that filter food from the water column will increase. Generally, invertebrates that dwell in rock spaces are the most important food for fish that feed on invertebrates; when these species decline, so do desirable fish populations (Waters, 1995).

Siltation can reduce the foraging success of aquatic organisms, fish migration can be disrupted, and respiratory systems and gills of invertebrates and fish can be impaired. Species composition and numbers of invertebrates are changed by increased sedimentation and resultant habitat changes. Pools can be filled, dam and reservoir capacity reduced, and filtration costs for domestic water supplies increased (Belsky et al., 1999).

What Effects Do Livestock Grazing Have on Sediment?

Sediment yield in a grazed watershed was 20-fold higher when compared to an ungrazed watershed (White et al., 1983). Sediment associated with livestock grazing occurs during snowmelt or heavy rainfall, when removal of vegetation and compaction combine to facilitate water flow into the stream (Gardner, 1950; Bryant et al., 1972; Owens et al., 1983; Orodho et al., 1990).

Sedimentation from livestock grazing can be heavy enough to blanket stream beds with silt, but more commonly, leads to a gradual decrease in the depth of pools (Quinn et al., 1992; Sidle and Sharma, 1996).

One comparison for sediment delivery from rotational grazing, continuous grazing, and croplands watersheds was done in Oklahoma (Olness et al., 1975). Precipitation was similar across the watersheds. Runoff ranged from 4 to 13 inches, with the highest values for the continuously grazed watersheds. Sediment delivery was highest for the continuously grazed watersheds, 8 and 10 tons of sediment per acre, and had the highest erosion index. None of the other watersheds yielded more than 4.4 tons per acre. One rotationally grazed watershed yielded the lowest sediment, 0.5 ton per acre, and the other was similar to wheat and alfalfa fields, about 1.0 ton per acre.

After excluding the grazing of the banks of most perennial streams, erosion-prone hills, and pockets of native forest; sediment loads dropped by 85% in a New Zealand study (Williamson et al., 1996). A riparian zone with a diversity of vegetation is able to trap 80% to 90% of sediments transported from fields (Naiman and Decamps, 1997).

For the same percent vegetative cover, more soil loss occurred from plots on steep rather than gentle slopes, and the gentle slopes could withstand more grazing pressure without seriously affecting the plant re-growth compared to steeper slopes. Slopes exceeding 5.8% are likely to suffer soil erosion even under moderate grazing

Photo courtesy of USDA Natural Resources Conservation Service. Winter feeding on pasture causes the highest soil erosion and highest nutrient losses.

pressure (Mwendera and Saleem, 1997a; Mwendera, et al., 1997).

The greatest risk of summer runoff, and thus sediment yield, appears to occur in August (Owens, et al., 1989; Naeth and Chanasyk, 1996). In Ohio, annual sediment concentration decreased by more than 50% and the amount of soil lost decreased by 40% during a five-year period when cattle were fenced out of the stream relative to a seven-year period where a beef cowherd had access to a 64-acre watershed in Coshocton, Ohio (Owens et al., 1996). Average annual soil losses were reduced from 1.1 to 0.62 ton per acre while annual precipitation averages were similar during each management period.

What Effect on Sedimentation Does Winter Feeding Near Riparian Areas Have?

Winter-feeding caused a high degree of soil and plant cover disturbance and an increase in surface runoff and erosion as compared with the pastures grazed only in the summer (Chichester, et al., 1979). Feeding cattle in a winter-feeding area increased runoff and caused more chemical movement, for example, total nitrogen, total phosphorous, and organic carbon, as compared with the pastures only grazed in the summer.

Evidence also suggests that cattle wintering areas may cause other related water quality problems. Winter feeding areas have shown increases in nutrients and soluble salts that can lead to development of problems with color, taste, odor, and biochemical oxygen demand (BOD). These areas can also directly produce odors from decaying products and high bacteria and pathogen loadings from animal waste.

In one small, pastured watershed in eastern Ohio, runoff and sediment losses were studied for 20 years (Owens et al., 1997). In Period 1, a beef cow herd was rotationally grazed during the growing season for 12 years and was fed hay in this watershed during the dormant season. During the next three years of this study, Period 2, there was only summer rotational grazing. There was no animal occupancy on this watershed during the last five years, Period 3.

Annual runoff was more than 10% of precipitation during Period 1 (4.7 inches) and less than 2% during Periods 2 and 3 (0.55 and 0.24 inches, respectively). The decrease in annual sediment loss was even greater with the change in management, yielding 2015, 130, and 8 lb per acre for the three respective periods.

Over 60% of the soil loss during Period 1 occurred during the dormant (winter) season. Low amounts of

Photo courtesy of Jim Hoorman. Horses in a permanent pasture with continuous grazing causing streambank erosion and sedimentation and changes to stream morphology.

runoff and erosion from three adjacent watersheds with summer-only grazing supported the conclusion that the increased runoff and erosion during Period 1 resulted from the non-rotational, continuous winter-feeding on pastures. When the management was changed, the impacts of the previous treatment were not long lasting, changing within a year.

In a related study in Ohio, the largest monthly average sediment concentrations were 0.8 grams per liter for 2 years without the presence of livestock. It was one and a half times higher for 3 years with 17 cows and their calves grazing during the summer months only. Sediment concentrations were four times higher for an additional six-year period with all-year grazing and hay being brought in for winter feed. Annual sediment losses were 0.09, 0.53, and 0.94 ton per acre, respectively, across the three grazing levels (Owens, et al., 1989).

Summary of Sediment Effects

- Sediment yield increases with increasing grazing pressure with lower levels related to ungrazed or "retired" riparian areas.
- Sediment yield increases with heavy or continuous grazing, especially during the dormant season.
- Soil loss increases with steeper slopes.
- Sediment in streams reduces habitat for sensitive macro-invertebrates and other aquatic life.

Can Grazing Livestock Affect Stream Morphology?

Livestock grazing, as well as other land uses, can affect stream morphology. Stream morphology is the study of a stream's form, structure, and channelization. There are a large number of complex, interrelated factors that determine riparian form and function that can be affected by livestock grazing which include stream discharge, sediment load, resistance of the banks and bed to movement of flowing water, vegetation, and temperature. Changes in these variables will cause an adjustment of the dynamic equilibrium of streams.

What Are the Changes in Stream Morphology Due to Livestock Grazing?

Streambank degradation is related both to the number of livestock grazed and the duration of grazing (Bohn and Buckhouse, 1986). Unstable stream channels and the loss of fish and invertebrate habitat are often attributed to cattle grazing practices in riparian areas in the western United States. Cattle grazing often cause large changes in channel morphology, causing wider, shallower stream channels (Knapp et al., 1998) with significant native vegetation overhang and extensive fish habitat changing to wide braided channels with little cover for fish or amphibians (Williamson et al., 1992).

A number of studies have examined effects of livestock by fencing riparian areas to exclude grazing and then noting the effects on riparian vegetation and stream morphology. Magilligan and McDowell (1997) selected four gravel-bedded, steep streams in eastern Oregon and excluded cattle for 14 years to study stream changes. Reductions in bankfull widths by 10 to 20 percent and increases of 8 to 15 percent in pool area were the most common and identifiable changes in excluding the cattle. Not all channel properties demonstrated adjustment, leading Magilligan and McDowell (1997) to suggest that perhaps 14 years is an insufficient duration for these variables to adjust.

In an examination of two grazed and one ungrazed reaches where grazing had been excluded for 11 years, the ungrazed section demonstrated improved riparian vegetation and a deeper, narrower channel. However, exclusion of grazing for two years along a 0.6 mile section of a stream channel that had experienced historical grazing did not lead to substantial stream recovery, indicating that it may take many years of excluding livestock from streams for the full benefits to be realized by the stream (Platts and Nelson, 1985).

Shifting the location of cattle grazing can cause significant downstream impacts. Cattle moved into wet riparian areas upstream caused decreases in thalweg depth (i.e., the location of the deepest portion of the channel), increases in fine sediment deposition in the channel, and loss of pool volume in these upstream areas. It was also reported that the deposition of fine sediment in reaches

Photo courtesy of USDA Natural Resources Conservation Service. Pools and riffles create fish habitat.

Photo courtesy of USDA Natural Resources Conservation Service. Meandering streams create fish habitat.

with high volumes of large woody debris increased (Sidle and Sharma, 1996).

Pool/riffle ratio (a measure of fish habitat), as well as soil and vegetation stability, varied significantly with cattle density (Meyers and Swanson, 1991). As pool/riffle ratios changed, other channel properties are seen to change as well. Continuous, heavy grazing resulted in a stream reach (low part of the stream bank adjacent to a stream) that became four times wider and one-fifth as deep as an adjacent area that was only lightly grazed (Platts and Wagstaff, 1984).

What Are the Stream Stability Changes Due to Grazing?

The removal of riparian vegetation has severe effects on stream channel characteristics. Streambank stability is reduced due to fewer plant roots to anchor soil, less plant cover to protect the soil surface from erosional disturbance and the shear force of trampling hooves. Impacts include increased streambank sloughing, increased erosion, increased channel width, and reduced depth. Streambank undercuts are reduced due to streambank breakdown by sloughing and trampling.

The stream channel contains fewer meanders and gravel bars due to increased water velocity. Pools decrease in number and quality from increased sediment and loss of woody debris (Belsky et al., 1999).

Comparisons of grazed and ungrazed streams found that grazed stream channels tend to be wider with shallower banks (Marcuson, 1977; Duff, 1979). When animals graze directly on streambanks, mass erosion from trampling, hoof slide, and streambank collapse causes soil to move directly into the stream (Platts, 1991).

The loss of stream channel integrity and diversity results in impacts to fish populations. For example, Marcuson (1977) studied the difference in habitat and fish populations in grazed and ungrazed stream sections. The study documented 80% more stream alteration in the grazed area than in an adjacent ungrazed area with the grazed area losing 11 acres of a 120-acre pasture. The ungrazed section produced 256 more pounds of fish per acre than the grazed section.

Summary of Effects Due to Channel Morphology

- Unstable stream channels and the loss of fish and invertebrate habitat are often attributed to cattle grazing practices in riparian areas.
- Stream channels along heavily vegetated areas are deeper and narrower than along poorly vegetated areas.
- Livestock management often causes local changes in habitat, thereby impacting fish and invertebrates.
- Changes are much more pronounced in small streams than large ones; impacts on lakes are under-studied but appear to be minimal.
- The natural variance among stream channels, lakes, and wetlands makes generic conclusions very difficult. Most impacts and most Best Management Practices will be site-specific. Site-specific BMPs depend on stream morphology.

Photo courtesy of Jim Hoorman. Horses in the stream deposit urine and feces causing excess nutrients and eutrophication. Manure deposited along or directly into streams elevates concentrations of phosphorus and nitrogen (Lemly, 1982).

What Impact Does Eutrophication Have on Riparian Areas?

The presence of some aquatic vegetation is normal in streams and indicates a healthy stream. Algae and aquatic plants provide habitat and food for all stream animals. High levels of nutrients (especially phosphorus and nitrogen) promote an overabundance of algae and floating and rooted aquatic plants. An excessive amount of aquatic vegetation is not beneficial to most stream life. Plant respiration and decomposition of dead plant life consume dissolved oxygen in the water.

Eutrophication is the process where aquatic vegetation grows quickly and decomposes, consuming oxygen from the stream. Lack of dissolved oxygen creates stress for all aquatic organisms and can cause fish kills.

Elevated levels of nutrient input often results in dense growths of filamentous green algae, i.e., *Cladophora* spp. These dense growths promote the production of some insect species, and replace diverse populations of attached plant microorganisms. Many herbivorous insects decline greatly in response to dense algae blooms (Li et al., 1994). The dense filamentous algae reduce feeding efficiency of insect eating fish due to a switch in the insect prey base (Tait et al., 1994).

What Are the Nutrient Loads Associated with Grazing?

Concentrations of Ammonium Nitrogen (NH4-N), total Kjeldahl N, and total P, were directly related to the density of grazing livestock. Leachates from the standing plant material, surface litter layer, surface soil, and manure deposits indicated manure and standing plant material were likely sources of most chemical components in runoff water (Schepers et al., 1982).

Over-application of fertilizer and manure can overload the soil with phosphorous. Iron, aluminum, and calcium in the soil bind excess phosphorous. In flooded soils, iron binds less phosphorous than it does in drier, aerobic soils. This decreased binding ability increases the availability of phosphorous for plant uptake and for movement into surface water (Green and Kaufman, 1989).

Since riparian areas have limited ability to hold excess phosphorous, they are relatively ineffective in protecting streams against poor phosphorous management practices on upland areas. Thus, good upland management is necessary to protect against phosphorous pollution (Bellow, 2003).

Owens et al. (1994) found that the various forms of nitrogen (N) increased in ground water during a five-year period with 200 lb N per acre annual fertilizer application to a grass-pasture grazed by beef cattle and reached levels that were usually in excess of 10 PPM. Ohio EPA has set 10 PPM nitrate-nitrogen as the upper threshold for drinking water. Nitrate concentrations in groundwater dropped rapidly after alfalfa was inter-seeded into the grass pastures and N fertilizer was no longer applied. The amount of N lost via subsurface flow decreased, but subsurface flow remained the main pathway for N loss compared with surface runoff or sediment-attached N.

In a related study in Ohio, Owens et al. (1989) found nutrient concentrations remained low across three grazing

Photo courtesy of USDA Natural Resources Conservation Service. The uneven recycling of N through feces and urine may increase nitrate leaching. The extent to which nitrate can leach from beneath urine and fecal spots under soil and climatic has not been studied extensively.

Photo courtesy of USDA Natural Resources Conservation Service. Cattle in feedlot with stream causing soil erosion and eutrophication.

levels, with the exception of potassium (K) concentration, which increased with all-year grazing.

The nitrate losses in a N-fertilized orchardgrass field in central Pennsylvania averaged across three years were 10.4 lb per acre for the control, 15.0 lb per acre for manure applied, 196.2 lb per acre for urine applied in spring, 214.1 lb per acre for summer applied urine, and 281.0 lb per acre for fall-applied urine (Stout, et al., 1997). These losses represent about 2% of the N applied in the feces and about 18%, 28%, and 31% of the spring-, summer-, and fall-applied urine N.

Winter-feeding caused a high degree of soil and plant cover disturbance and an increase in surface runoff and erosion as compared with the pastures grazed only in the summer. Feeding cattle in a winter-feeding area increased runoff that caused more chemical movement of total N, total P, and organic carbon as compared with the pastures only grazed in the summer (Chichester et al., 1979).

The level of nitrogen leaching as the result of urination by cows depended upon soil type, moisture conditions, and grazing intensity in the Netherlands. Nitrate levels rarely exceeded 11.3 PPM in a wet moderately grazed field, but were often exceeded in a drier more heavily grazed pasture (Hack-ten Broeke et al., 1996).

Total nitrogen in runoff from a cattle-grazed watershed in the Pacific northwest ranged between < 0.9 to 3.6 lb per acre per year, whereas only 0.44 lb per acre per year was measured in a non-grazed watershed over a three-year period (Jawson et al., 1982). Total nitrogen received in precipitation was equal to or greater than nitrogen lost in runoff from the grazed watershed. Nitrate-N levels in the runoff were normally less than 1 mg/l. Total P (TP) losses in runoff from the grazed watershed ranged from 0.09-1.2 lb per acre per year and from < 0.09 to 0.15 lb per acre per year from the ungrazed area (Jawson et al., 1982).

Concentrations of ammonia nitrogen (NH4-N), nitrate nitrogen (NO3-N), total phosphorous (TP), soluble P, and chloride (Cl-) in runoff from a 6.2-acre cow-calf grazed pasture in Nebraska were 6%, 45%, 37%, 48%, and 78% greater, respectively, over a three-year period when livestock were grazing in comparison to periods when cattle were removed (Schepers and Francis, 1982).

Mean concentrations of Kjeldahl N, total P, Calcium (Ca), and potassium (K) were 190, 150, 24, and 240 times higher, respectively, in surface runoff from a grazed and fertilized hill pasture than those in rainfall over one year. Concentrations tended to be high in summer and were strongly related to grazing. The peak of nitrate concentration after grazing lagged approximately two weeks after the Kjeldahl N peak and probably depended on nitrification of ammonium from dung and urine (McColl and Gibson, 1979).

Do Riparian Zones Impact Nutrient Flow?

Dissolved nutrients are transported into streams primarily in the groundwater (Gregory et al., 1991). Because of the riparian zone position within the watershed, it intercepts the soil solution as it passes through the rooting zone prior to entering the stream. Riparian zones also contribute seasonal pulses of dissolved components derived from plant litter into streams. Thus, the riparian zone functions to remove nutrients and modify inputs to the stream.

Riparian forests were responsible for removal of more than three-quarters of the dissolved nitrate transported from

Photo courtesy of USDA Natural Resources Conservation Service. Riparian forest buffers and protects stream water quality.

croplands into a Maryland river (Peterjohn and Correll, 1984). Natural riparian forests can denitrify and release 25 to 35 pounds of nitrogen per acre per year (Cole, 1981). Because of their unique position at the interface between terrestrial (land) and aquatic ecosystems, riparian zones play a critical role in controlling the flow of nutrients from watersheds.

What Effect Does Livestock Exclusion Have on Riparian Areas?

Sediment, phosphorus, particulate- and nitrate-nitrogen concentrations, during 71 run-off events over 22 months, were lower and varied significantly less at retired riparian pasture than at grazed riparian pasture sites (Smith, 1989). Riparian pasture retirement is an effective means of reducing surface runoff pollutant loads to waterways.

After exclusion of grazing ("retirement") from the banks of most perennial streams, erosion-prone hills, and remnant pockets of forest in a New Zealand watershed; loads decreased by 27% for particulate P, 26% for soluble P, 40% for particulate N, and increased by 26% for dissolved N (Williamson et al., 1996). Williamson et al. (1996) predicted that retirement reduced total phosphorous loads by 20% in the lake that receives runoff from the watershed.

During 12 years after retirement from grazing, dominant vegetation in the set-aside areas changed from pasture grasses to native species in pasture along the edge of a small stream in New Zealand (Cooper et al., 1995). The riparian set-aside soils had higher water conductivity indicating that surface runoff water transported into the zone would infiltrate, fill soil pores, and emerge as subsurface flow at the stream edge. This research implied that riparian set-aside has led to the development of a zone likely to supply runoff to the adjacent stream that is depleted in sediment-bound nutrients and dissolved Nitrogen (N) but enriched in dissolved Phosphorous (P).

Summary of Nutrient Effects

- Excess nutrients in streams cause eutrophication to increase. Eutrophication is the process where aquatic vegetation grows quickly and decomposes, consuming oxygen from the stream.
- Nutrient concentrations (various forms of N and P) in runoff increase with increasing grazing duration.
- Retiring areas from grazing but maintaining grass vegetation reduces nutrient delivery, but dissolved N may be reduced differentially in relation to dissolved P.

For more information on the effects of livestock grazing riparian areas, see the following fact sheets:

- Understanding the Benefits of Healthy Riparian Areas, LS-1-05
- The Effects of Grazing Management on Riparian Areas, LS-3-05
- Best Management Practices to Control the Effects of Livestock Grazing Riparian Areas, LS-4-05
- Pathogenic Effects from Livestock Grazing Riparian Areas, LS-5-05

This fact sheet was adapted from Generic Environmental Impact Statement on Animal Agriculture: A Summary of Literature Related to the Effects of Animal Agriculture on Water Resources (G), 1999, Univ. of Minnesota.

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