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CEAP Conservation Insight
Conservation Effects Assessment Project

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Rotational vs. Continuous Stocking Comparisons: Environmental and Wildlife Responses

Summary of Findings

- When riparian areas are grazed, continuous stocking at high grazing intensities has been shown to adversely impact water quality, hydrology, stream morphology, and wildlife habitat.
- Nutrients (e.g., nitrogen and phosphorus), sediment, and pathogens are the primary water quality constituents of concern for grazing management systems.
- Vegetative cover is key to reducing the kinetic energy of rainfall and thus transport of nutrients, sediment, and pathogens to surface waters.
- Regardless of stocking method, managing cattle access to riparian areas is important for protecting stream health.
- Proper grazing intensity is critical in developing and carrying out grazing management plans when livestock production and wildlife habitat conservation are concurrent objectives.

Introduction

Current grazing management practices are primarily designed to improve forage and animal performance with the overarching goal of increasing profit. Yet improved grazing management can reduce negative impacts on water quality and quantity, riparian health, and the functional processes within the management unit and watershed. Primary management unit and watershed functions include the abilities to capture, store, and release water slowly over time, and to capture and regulate the flow and cycling of nutrients and energy throughout the system. When riparian areas are grazed, continuous stocking at high grazing intensities has been shown to adversely affect water quality, hydrology, stream morphology, and wildlife habitat. Rotational stocking may provide environmental benefits. A large volume of literature is available that describes forage and animal responses to stocking method, but limited research has been conducted to evaluate the effects of rotational vs. continuous stocking on environmental responses. Understanding the potential environmental benefits of alternative stocking management practices is important in evaluating their overall use and effectiveness. This Conservation Insight examines the known environmental benefits and challenges associated with rotational and continuous grazing management systems.

Water Quality

Surface Waters. Nutrients (e.g., nitrogen and phosphorus), sediment, and pathogens are the primary water quality items of concern for grazing management systems. Pathogens and excess nutrients are introduced to pastures via manure and urine, while excess sediment often comes from bare soils in pastures as well as eroding streambanks (Figure 1). Though few studies have been conducted to examine the effects that rotational and continuous grazing management systems have on water quality, most studies indicate that, in part due to its effect on vegetation, continuous stocking has more of an adverse impact on water quality than rotational stocking (Table 1). Vegetative cover is needed to reduce the kinetic energy of rainfall and thus the transport of nutrients, sediment, and pathogens to surface waters. Generally, vegetative cover is greater on rotationally stocked pastures than on continuously stocked pastures, indicating that stocking method can have long-term implications for water quality. The available literature does not implicate continuous stocking, in general, as a water quality hazard; instead it indicates that this stocking method in combination with high grazing intensity reduces cover and therefore endangers surface waters (Table 2).

Groundwaters. Groundwater discharge from small watersheds affects the flow and water quality from larger watersheds.

Figure 1. Uncontrolled livestock grazing can negatively impact water quality and streambank stability.

Dissolved constituents such as nitrate-nitrogen (NO_3-N) and phosphorus (P) have the potential to adversely affect water quality. One study examining summer and winter rotational stocking practices estimated that 50% of the NO_3-N loads and 30% of the dissolved P loads in the streamflow originated from groundwater. Groundwater contamination, and subsequently surface water contamination, is of great concern in areas with karst geology. Karst geology is characterized by soluble rocks such as limestone and dolomite. These rocks slowly dissolve as rain, which is slightly acidic, flows through cracks and other openings. Over time, these openings can widen into larger conduits or even caves. In karst terrain, subsurface drainage and nutrient transport to groundwater can be rapid. Several years may be required before past land uses are no longer influential, particularly with respect to soil nutrient concentrations. Limited research suggests that a livestock producer can achieve lower NO_3-N losses and acceptable groundwater NO_3-N concentrations under haying or rotational stocking with low or no N inputs, even in areas with previous high N loading.

Hydrology

Hydrograph shape is influenced by variables such as soil compaction, upland and riparian vegetation, and stream morphology; all of which can be influenced by grazing activity. Few studies have examined the effects of different stocking methods on hydrology. In general, rotationally stocked pastures have greater infiltration rates and lower runoff volumes than continuously stocked ones. As with water quality, maintaining good vegetative cover is important in managing runoff volumes.

Stream Morphology

Eroding streambanks are a significant source of sediment to streams. Uncontrolled livestock grazing can negatively impact stream morphology and accelerate streambank erosion. Studies have shown that streams in continuously grazed pastures can experience greater levels of streambank erosion, fines (embeddedness), and turbidity than streams in rotationally grazed pastures.

Table 1. Water quality, hydrology, and stream morphology responses to stocking method.

Response[1]	Comparison[2]	Difference	Note[3]	Reference
Total phosphorus and sediment loss	C > R > N	TP: C was 1.3 times greater than R (5 cm); R (5 cm) was 2.8 times greater than N; C was 3.7 times greater than N. Sediment loss: C was 2 times greater than R.	Percent ground cover was directly correlated to TP and sediment loss.	Haan et al., 2006
TKN, NH_4, TKP, DRP, runoff	C = R	Not significant at P ≥ 0.10	Pastures were subjected to broiler litter applications.	Kuykendall et al., 1999
Total nitrogen, runoff volume	C > R	TN: C was 1.9-2.5 times greater than R. Runoff: C greater than R 75% of time.	TN: Ground cover was less than 50% for C and about 100% for R. Runoff: Amount of winter vegetative cover indirectly correlated to runoff volumes.	Owens and Shipitalo, 2009
Fecal coliforms	C > R	C was over 2 times greater than R for stream mean values.	FC levels still exceeded water quality standards.	Howell et al., 1995
Annual soil loss	C > R	C was 15.5 times greater than R.	Increased runoff with C, attributed to increased soil compaction and decreased vegetation.	Owens et al., 1997
Streambank erosion	C, R > N	C and R were 2-5 times greater than N.	Consideration should also be given to constituents such as P in streambanks.	Zaimes et al., 2008
Turbidity, fecal coliforms, fines, exposed streambanks	C > R	Turbidity: C was about 1.5 times greater than R. FC: C was about 2 times greater than R. Exposed streambanks: C was about 9 times greater than R.	Turbidity strongly correlated with TSS for studied streams.	Sovell et al., 2000
Fines (embeddedness), streambank erodibility	C > R	Fines (embeddedness): C was about 2 times greater than R. Streambank erodibility: C was about 1.5 times greater than R.	Streambank erosion significant source of sediment to streams.	Lyons et al., 2000; Weigel et al., 2000

[1] TP indicates total P; TKN, total Kjeldahl N; TKP, total Kjeldahl P; FC, fecal coliforms; T, total organic C; COD, chemical oxygen demand.
[2] C indicates continuous stocking; R, rotational stocking; N, non-grazed.
[3] TSS indicates Total Suspended Solids.

Pastures with exclusion fencing tend to have lower rates of streambank erosion than pastures without such riparian protection. Thus, regardless of stocking method, managing cattle access in riparian areas is important for protecting stream health.
It is important to note that realization of riparian benefits from changing from continuous to rotational stocking will require time. A number of years may be required for streambanks to recover and for establishment of riparian vegetation, particularly woody species, to occur.

Wildlife Habitat

A limited number of studies have evaluated the effects of stocking methods on wildlife. With the exception of certain macro-invertebrate assemblages (i.e., mayflies, caddisflies, and stoneflies), which respond to water quality changes associated with stocking methods, choice of stocking method did not have a significant effect on wildlife responses.

Given the limited data available, further studies are warranted. Based on the literature available at present, the choice of livestock grazing intensity on pastureland appears to be more critical for success of wildlife than the choice of stocking method.

Selecting the proper grazing intensity should be a primary focus in developing and carrying out management plans for agroecosystems in which livestock production and wildlife habitat conservation are concurrent objectives.

Responses to grazing intensity can vary widely among wildlife species. Thus, choice of grazing intensity must be evaluated within the context of which management practices benefit the broad array of wildlife present in the ecosystem rather than benefit just a single high-profile species.

Overall Summary

The majority of studies on the effects of stocking method on water quality, hydrology, stream morphology, and wildlife habitat indicate that rotational stocking has fewer negative environmental effects than continuous stocking. Accumulation of additional forage mass and ground cover during regrowth periods accounts for some of the benefits attributed to rotational stocking. In total, the literature supports stocking method as an important prescribed grazing practice, but one that is secondary in importance to grazing intensity.

Table 2. Water quality, hydrology, and stream morphology responses to grazing intensity.

Response[1]	Response to increased grazing intensity	Stocking rates compared[2]	Reference
NO_3-N, mineral-N, TP	No change	No livestock, 17 cows (64 ha)$^{-1}$ summer-only grazing, 17 cows (26 ha)$^{-1}$ year-round grazing	Owens et al., 1989
Organic-N, TOC, sediment	Increased	No livestock, 17 cows (26 ha)$^{-1}$ summer-only grazing, 17 cows (26 ha)$^{-1}$ year-round grazing	Owens et al., 1989
NO_3-N	Increased	60% available forage utilization, 80% available forage utilization, and 80% available forage utilization with grain supplement (33% dry matter intake)	Stout et al., 2000
NO_3-N, NH_4-N, total P, soluble P, COD, TOC, sediment	Increased	No livestock, 35-40 cow-calf pairs (40 ha)$^{-1}$	Schepers et al., 1982
Sediment loss	Increased	0.68, 0.51, and 0.32 ha AU^{-1}	Warren et al., 1986
Soil microbial biomass, N mineralization potential	Decreased	2.2 and 1.1 steers ha^{-1}	Banerjee et al., 2000
Infiltration rates	Decreased	0.65, 1.2, and 2.5 AUM ha^{-1}	Trimble and Mendel, 1995
Infiltration rates	Decreased	0.34, 0.68, and 0.51 ha AU^{-1}	Warren et al., 1986
Streambank erosion	Increased	0 to 1,600 kg ha^{-1}	Agouridis et al., 2005

[1] TP indicates total P; TOC, total organic C; COD, chemical oxygen demand.
[2] AU indicates animal unit; AUM, animal unit months.

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The Conservation Effects Assessment Project (CEAP) is a multi-agency effort to build the science base for conservation. Project findings help to guide USDA conservation policy and program development and help farmers and ranchers make informed conservation choices.

One of CEAP's objectives is to quantify the environmental benefits of conservation practices for reporting at the national and regional levels. Because the environment is affected by conservation actions taken on a variety of landscapes, the grazing lands national assessment draws on and complements the national assessments for cropland, wetlands, and wildlife. The grazing lands national assessment works through numerous partnerships to support relevant studies and focuses on regional scientific priorities.

This Conservation Insight was developed by Dr. Carmen Agouridis, Biosystems and Agricultural Engineering, University of Kentucky. It is summarized from: Sollenberger, L.E., C.T. Agouridis, E.S. Vanzant, A.J. Franzluebbers, and L.B. Owens. 2012. Prescribed grazing on pasturelands. Chapter 5, pp. 113-204. In: C.J. Nelson, editor, Conservation outcomes from pasture and hayland practices: Assessments, recommendations, and knowledge gaps. The Pastureland Conservation Effects Assessment Project (CEAP). Allen Press, Lawrence, KS.

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