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Influence of off-stream supplements on streambanks of riparian pastures

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Abstract

Accelerated erosion of streambanks in grazed riparian pastures is of concern to land managers. We tested the hypothesis that providing cattle free-choice off-stream water and trace mineralized salt would lessen negative impacts of grazing on cover and stability of streambanks compared to pastures lacking these amenities, and may therefore reduce the potential of accelerated erosion. The study was conducted on Milk Creek at the Hall Ranch Unit of the Eastern Oregon Agricultural Research Center near Union, Ore. Three replications each of 3 grazing treatments were examined: (1) non-grazed control; (2) grazed with supplemental water and trace mineralized salt provided ("supplemented"); and (3) grazed with no supplemental water or salt ("non-supplemented"). Each grazed pasture (approximately 12 ha) was stocked with cow-calf pairs for a mean stocking rate of 0.8 ha per AUM to achieve moderate grazing intensity of approximately 50% utilization of key forages. Pastures were grazed for 42 consecutive days during each of 2 years (1996–1997) beginning mid-July. Estimates of streambank cover ("covered" or "uncovered") and stability ("stable" or "unstable") were taken before (June) and after (September) grazing by examining 0.5 × 0.3 m plots placed on the greenline. Additionally, frequency of cattle hoof prints (number of plots with hoof prints/total number of plots) was measured as an indication of cattle presence in the greenline. Treatment effects were compared using one-way ANOVA. Streambank effects were consistent with observations of cattle distribution, with 26% of the streambank in supplemented pastures showing cattle presence (hoof prints), versus 31% for non-supplemented pastures. Off-stream water and salt attracted cattle into the uplands enough to significantly ($p \leq 0.05$) reduce development of uncovered and unstable streambanks from 9% in non-supplemented pastures to 3% in supplemented pastures. An "erosion index" indicated no significant ($p < 0.05$) difference in potential accelerated streambank erosion between supplemented and non-supplemented pastures.

Key Words: grazing, greenline, water quality, livestock, off-stream water

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Resumen

La erosión acelerada de los bancos de las corrientes de las praderas ribereñas apacentadas es una preocupación para los manejadores de tierras. Nosotros probamos la hipótesis de que proveyendo agua al ganado fuera del área de la corriente y sal de minerales traza se aminorarian los impactos negativos del apacentamiento sobre la cobertura y estabilidad de los bancos de las corrientes comparado con potreros carentes de estas prácticas de manejo y por lo tanto se puede reducir el potencial de una erosión acelerada. Este estudio se condujo en el arroyo "Milk" en el "Hall Ranch Unit" del Centro Agrícola de Investigación del Este de Oregon cercano a Union, Oregon. Se examinaron tres repeticiones de 3 tratamientos de apacentamiento: (1) control sin apacentamiento, (2) apacentamiento con suplemento de agua y sal de minerales traza ("suplementado") y (3) apacentamiento sin suplemento de agua ni sal ("no-suplementado"). En cada potrero apacentado (aproximadamente 12 ha) se colocaron pares de vaca-cría para obtener una carga animal promedio de 0.8 ha por UAM para alcanzar una intensidad de apacentamiento moderada de aproximadamente el 50% de utilización de las especies forrajeras clave. Los potreros se apacentaron 42 días consecutivos cada año durante dos años (1996–1997) iniciando el apacentamiento a mediados de Julio. Se tomaron estimaciones de la cobertura del banco de la corriente ("cubierto" y "descubierto") y de la estabilidad ("estable" e "inestable") antes (Junio) y después (Septiembre) del apacentamiento, las estimaciones se realizaron examinando parcelas de 0.5 x 0.3 m colocadas en la línea verde. Adicionalmente se midió la frecuencia de huellas de pezuña de ganado (número de parcelas con huellas/ número total de parcelas) como un indicador de la presencia del ganado en la línea verde. Los efectos de los tratamientos fueron comparados mediante ANOVA con un solo criterio de clasificación. Los efectos en los bancos de la corriente fueron consistentes con las observaciones de la distribución del ganado, el 26% de los bancos en potreros suplementados mostraron la presencia de ganado (huellas de pezuña) contra el 31% de los potreros no suplementados. El agua fuera de la corriente y la sal atrajeron al ganado alejándolo de la corriente los suficiente para reducir significativamente ($p \leq 0.05$) el desarrollo de bancos de corriente "descubiertos" e "inestables" de 9% en los potreros "no-suplementados" al 3% en los potreros "suplementados" Un "índice de erosión" indicó diferencia no significativa ($p < 0\ .05$) en la erosión acelerada potencial entre los bancos de corriente de potreros "suplementados" y "no suplementados".

Cattle management problems in the Intermountain Region are more often associated with improper distribution than abundance of livestock (Holechek et al. 1989). This is especially true in riparian areas where water and shade attract livestock during the hottest months (Stuth 1991). Roath and Krueger (1982) estimated 81% of forage used by livestock under a moderate stocking regime in an Intermountain riparian area came from a streamside meadow representing only 2% of the grazing area. In fact, several studies have shown wild ungulates and livestock use riparian areas disproportionately more than adjacent uplands (Gillen et al. 1984, Kauffman and Krueger 1984, Marlow and Pogacnik 1985). Disproportionate use is an important management issue because abundant evidence indicates *heavy* cattle grazing can cause deleterious effects on riparian habitats (Skovlin 1984, Larsen et al. 1998), including changes in streambank stability (Marlow et al 1987), increased sedimentation (Duff 1979), loss of riparian vegetation, stream widening and shallowing (Platts 1986). By comparison, there is far less information on ecological effects of *moderate* grazing, including the type of riparian use suggested by alternative grazing strategies such as deferred grazing, rest-rotation grazing, and off-stream water (Skovlin 1984, Larsen et al. 1998).

The work reported here was part of a larger study on the economics and environmental effects of a cattle dispersion management system in which off-stream water and trace mineralized salt was supplied in a controlled, replicated field experiment (Dickard 1998, Stillings 1998, Tanaka et al. 1999). Animals grazing riparian pastures with off-stream water spend significantly less time at the stream than those with no water trough (Miner et al. 1992, Godwin and Miner 1996, DelCurto et al. 1999). Can a shift in cattle distribution (toward uplands) result in reduced ecological impact on the riparian zone? Streambank cover and stability are 2 critical factors influencing water quality, water storage, stream channel morphology, erosion potential, and wildlife habitats in riparian areas (Kauffman and Krueger 1984, Platts 1986, Bohn 1986, Elmore and Kauffman 1994, Mosley et al. 1997). Our objective was to test the hypothesis that providing free-choice off-stream water and trace mineralized salt to cattle grazing riparian pastures would result in more stable streambanks with greater cover and may therefore be less prone to accelerated erosion than streambanks in riparian pastures lacking these amenities.

Materials and Methods

Study Site

The study was conducted on the Hall Ranch unit (45°7'41"N, 117°42'45"W) of the Eastern Oregon Agricultural Research Center, approximately 19 km southeast of Union, Ore. Mean annual precipitation is 66 cm, with approximately 60% occurring as snow. Elevation ranges from 1,050 to 1,250 m. The Hall Ranch includes 2 distinct riparian zones: the larger on Catherine Creek, a tributary of the Grande Ronde River, and the smaller on Milk Creek, a tributary of Catherine Creek. The 109 ha study area included the entire riparian zone and adjacent uplands of Milk Creek as it passes through the Hall Ranch, a 2.4 km section beginning at a private boundary on the north and ending at Highway 203 a few hundred meters from its confluence with Catherine Creek. The study area was grazed lightly from mid-July to mid-August in each of 5 years (1991–1995) prior to beginning this study (1996) at an average rate of 1.8 ha per AUM (range 1.5–2.0 ha per AUM).

Treatments

In May 1996, nine pastures (experimental units) of similar area (approximately 12 ha) in 3 blocks were delineated along the 2.4 km reach of Milk Creek (Fig. 1). The blocks were established because of differences in riparian habitat from the southern to northern section of Milk Creek. Block 1 was forested with Douglas hawthorn (*Crataegus douglasii* Lindl.) and ponderosa pine (*Pinus ponderosa* Dougl. Ex Loud.); Block 2 had components of both forest and meadow; and Block 3 was primarily meadow, dominated by Kentucky bluegrass (*Poa pratensis* L.), timothy (*Phleum pratense* L), sedges (*Carex* spp) and other dicots. Dominant riparian forages in all blocks were Kentucky bluegrass, sedges, timothy, meadow foxtail (*Alopecurus pratensis* L.), orchardgrass (*Dactylis glomerata* L.), and brome (*Bromus* spp.).The stream type (Rosgen and Silvey 1998) passing through Block 1 was predominately "C" with a few (less than 10%) inclusions of "B". The channel substrate in Block 1 varied from cobble to sand. In Blocks 2 and 3 stream type was a complex of "C" and "E" with mostly sand substrate. Within blocks, slope was similar among treatment pastures and varied between 0–3% in riparian meadows and 12-35% in uplands. Three treatments were randomly assigned to pastures within each block beginning in1996: (1) non-grazed control; (2) "supplemented" pastures, in which free-choice off-stream water and trace mineralized salt was provided; and (3) "non-supplemented" pastures, in which no off-stream water or salt was provided. The same treatments were assigned to pastures for both the 1996 and 1997 grazing

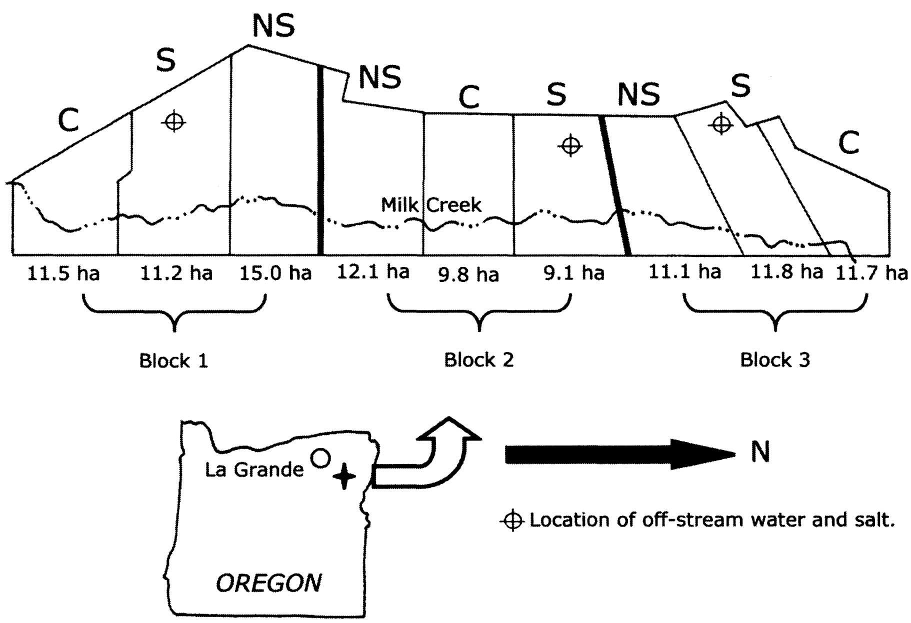

Fig. 1. Map of Milk Creek study area in northeastern Oregon showing block design, position and size (ha) of grazing treatments: C = control (not grazed); S = grazed, with supplements provided (free-choice off-stream water and trace mineralized salt); NS = grazed, with no supplements provided.

seasons. Free choice off-stream water was provided in troughs to supplemented pastures approximately 366 linear meters upslope from Milk Creek. Feeders containing trace mineralized salt were placed about 4.5 m from the off-stream water sources. Water and salt were placed at the same locales in 1996 and 1997. For the 2 grazing treatments, 10 cow-calf pairs were introduced into each of the 6 pastures for 42 consecutive days beginning mid-July 1996 and 1997 for a mean stocking rate of 0.8 ha per AUM (range 0.8–0.9 ha/AUM), or a little more than twice the grazing intensity of the previous 5 years. The length of grazing time and stocking rate were chosen with the objective of achieving a moderate intensity of approximately 50% utilization of key forage species within each pasture. Actual utilization was measured using the method of Cassady (1941) by clipping vegetation at ground level in 15 pairs of 0.25 m^2 circular plots placed at regular intervals from Milk Creek toward the uplands in each grazed pasture. Mean utilization averaged over the 2-year study was 31% (range 23–43%) in supplemented pastures and 47% (range 31–66%) in non-supplemented pastures (Dickard 1998).

Estimating Streambank Parameters

Estimates of streambank cover and stability were made during the second grazing year (1997) using the method of Platts et al. (1983) as modified by Bauer and Burton (1993). Such a streambank alteration rating can provide an early warning system for changes caused by certain land uses, including grazing (Platts et al. 1987). Because the same treatment design was used for both years, estimating streambank variables in the second year allowed assessment of the cumulative effect of 2 consecutive years of treatment.

Streambanks were examined before (June) and after (September) cattle grazing by pacing the entire length of Milk Creek on both sides and recording the appropriate streambank cover and stability class within plots defined lengthwise as a step (0.5 m) taken parallel to the stream. Plot width (approximately 0.3 m) was defined by the greenline, the first vegetation at the water's edge at or slightly below the bankful stage (Bauer and Burton 1993, Winward 2000). Each plot was first examined for the presence of hoof prints, defined as a clear impression of a hoof in soil or vegetation. Frequency (number of plots with hoof prints/total number of plots) was tallied for each treatment pasture.

The cover rating considered all organic and inorganic material that could provide protection from soil erosion. Plots were "covered" if they contained any of the following features: (1) living perennial vegetation ground cover greater than 50%; or (2) roots of deeply-rooted vegetation such as shrubs or sedges covering more than 50% of the streambank; or (3) at least 50% of the streambank surface protected by rocks of cobble size or larger; or (4) at least 50% of the bank surface protected by logs of 10 cm diameter or larger (Bauer and Burton 1993). Otherwise streambanks were rated "uncovered". Cover estimates were based on visual assessment of the vertical projection of a polygon drawn around extremities of above-ground parts onto the ground (Daubenmire 1968). Platts et al. (1987) reported that streambanks rated more than 50% covered were stable or received only moderate alteration, while those rated 50% or less received major or severe alteration.

Streambanks were rated "unstable" if they exhibited any of these features: (1) blocks of banks broken away and lying adjacent to the bank breakage ("bank breakage"); (2) bank sloughed into stream channel ("slump"); (3) bank cracked and about to move into stream ("fracture"); (4) bank uncovered as defined above and exhibited an angle visually estimated steeper than 80 degrees from horizontal ("vertical bank") (Bauer and Burton 1993). Otherwise, streambanks were rated "stable".

Each step of the observer was thus rated according to streambank cover and stability, and grouped into 4 classes: (1) covered/stable; (2) covered/unstable; (3) uncovered/stable; and (4) uncovered/unstable. A single observer conducted the survey to avoid the variability of multiple observers reported by Platts et al. (1987).

Uncovered or unstable banks can lead to accelerated erosion (Marlow and Pogacnik 1985). To assess erosion potential of streambanks, an "erosion index" was calculated by first assigning a numerical score to each cover/stability class as follows:

Cover/Stability Class	Erosion Index
covered/stable	1
uncovered/stable or covered/unstable	2
uncovered/unstable	3

The erosion index was then calculated for each treatment pasture:

$$\text{Erosion Index} = \frac{(1Xn_1) + (2Xn_2) + (3Xn_3)}{N_{total}} \quad (1)$$

where $n_{1\text{-}3}$ = number of plots with erosion index 1-3, respectively and N = total number of plots/treatment pasture. The erosion index could vary from1.0 (least erosion potential) to 3.0 (highest erosion potential). Plots rated 2.0 were vulnerable to erosion because they lacked either cover or stability.

Statistical Analysis

To test the hypothesis of grazing impacts on streambank cover and stability, data were summarized by treatment with 3 replicates (one per block) per treatment. Parameters examined were frequency of hoof prints; observed changes between June and September in each of the 4 cover/stability classes; and the erosion index. These parameters were analyzed using 1-way ANOVA with block (n = 3) as a fixed factor and treatment (n = 3) as the random factor (total df = 8). Means were compared using LSD ($p \leq 0.05$).

Results

Following removal of cattle in September 1997, the percentage of streambank plots having cattle hoof prints averaged 0 (SE ± 0), 26 (SE ± 4) and 31 (SE ± 5)% in control, supplemented, and non-supplemented pastures, respectively. While there was a trend ($p > 0.05$) for supplemented pastures to have a lower frequency of hoof prints in the greenline compared to non-supplemented units, the 2 treatments did not differ statistically ($p \leq 0.05$). Neither streambank cover nor stability differed significantly between supplemented and non-supplemented pastures (Table 1). However, compared to the non-grazed control, providing off-stream water and salt did prevent the significant loss of streambank cover observed in non-supplemented pastures.

Significant treatment effects on cover/stability classes of streambank plots included changes in proportions of the covered/stable, covered/unstable, and uncovered/unstable (Table 1). There were no block effects or block X treatment interaction effects in the proportion of change in cover/stability classes. The greatest change resulting from grazing, compared to non-grazed controls, was the significant decrease in the proportion of streambanks classified as covered/stable. Although non-supplemented pastures averaged 14% decrease in the covered/stable class, compared to 10% for supplementedpastures, the 2 grazing treatments did not differ statistically. The pattern of change, however, did differ between the 2 grazing treatments, with non-supplemented pastures gaining significantly ($p < 0.05$)

Table 1. Proportions of streambank class (m /100 m of streambank) before grazing (June), after grazing (September) and change, 1997. Change within streambank parameter with different superscripts are significantly different (lsd; $p < 0.05$; n = 3).

Streambank Parameter	Non-grazed Pastures			Supplemented Pastures			Non-supplemented Pastures		
	Before	After	Change	Before	After	Change	Before	After	Change
	(m /100 m of streambank)								
Covered	92	92	0^{a}	94	90	-4^{ab}	89	83	-6^{b}
Stable	91	91	0^{a}	95	85	-10^{b}	93	76	-17^{b}
Covered/Stable	90	90	0^{a}	89	79	-10^{b}	82	68	-14^{b}
Uncovered/Stable	3	3	0^{a}	5	6	$+1^{a}$	10	8	-2^{a}
Covered/Unstable	5	5	0^{a}	5	11	$+6^{ab}$	8	15	$+7^{b}$
Uncovered/Unstable	2	2	0^{a}	1	4	$+3^{b}$	0	9	$+9^{c}$
Erosion Index	1.18	1.18	0^{a}	1.10	1.23	$+0.13^{b}$	1.17	1.39	$+0.22^{b}$

[1]Cattle grazing supplemented pastures were provided free-choice off-stream water and trace mineralized salt; cattle grazing non-supplemented pastures received no off-stream water or salt supplement.

more of the uncovered/unstable class. Proportionally, there were larger changes in stability than cover resulting from grazing (Table 1). Therefore decreases in stability likely contributed more to change in the uncovered/unstable class than decreases in cover. This is further reflected by the fact that the uncovered/stable class did not change in relation to controls, while the covered/unstable class changed significantly. The bank instability factor contributing the largest proportion of change resulting from grazing *per se* was slumping of the bank into the stream channel (Table 2). There was a trend ($p > 0.05$) toward less stable banks in non-supplemented pastures compared to supplemented pastures, but streambank stability in the 2 grazed treatments did not differ statistically.

While erosion potential (reflected by the erosion index) increased significantly because of grazing, there was no significant difference in this metric between the 2 grazing strategies (Table 1) suggesting off-stream water and salt supplement may not be helpful in preventing accelerated erosion.

Discussion and Conclusions

Grazing *per se* resulted in (1) decline in streambank stability, (2) decline in the covered/stable streambank class with concomitant increase in the uncovered/unstable class, and (3) increase in soil erosion potential. Previous work on this project indicated off-stream water and trace mineralized salt supplement attracted cattle toward uplands (Dickard 1998, DelCurto et al. 1999). This redistribution of livestock was enough to significantly ($p \leq 0.05$) reduce development of uncovered/unstable streambanks to 3% in supplemented pastures compared to 9% in non-supplemented pastures. Off-stream water and mineral supplements may be combined with other management tools to help keep livestock away from sensitive riparian areas. The degree to which livestock can be attracted away from riparian areas depends on season, topography, vegetation, weather and behavioral differences (Bryant 1982, Stuth 1991). For example, successful use of off-stream water to adjust distribution late in the season may not be observed for early season grazing (Miner et al. 1992) because of changes in weather and forage quality. Pastures with steep slopes may be less amenable to provisioning with off-stream water (Bryant 1982, Dickard 1998). The relative quality of forage between riparian and upslope portions of a pasture may also be more important for determining livestock distribution patterns (Skovlin 1984). Finally, individual cattle can be expected to respond in a variety of ways, based on innate as well as learned behaviors (Bryant 1982, Skovlin 1984).

The observed decline in streambank stability and increase in erosion potential resulting from grazing in our study prompt the question: would the magnitude of these effects result in eventual changes in channel morphology or contribute to declines in native fish populations? The answers depend upon whether or not streambanks recover over the course of the year, and whether or not streambank slumping along Milk Creek created enough sediment to cause permanent changes in aquatic habitat quality. Several studies have reported significant channel morphology effects as a consequence of chronic, heavy livestock grazing (Marlow et al. 1987, Rinne 1988), but few have

Table 2. Mean proportions (±SE) of streambanks (m/100 m of streambank) in the various instability classes before grazing (June), after grazing (September) and change, 1997. Instability classes are "bank breakage" (B) in which blocks of banks are broken away and lying in the stream; "slump" (S) in which the bank has sloughed into stream channel; "fracture" (F) in which the bank has cracked and is about to move into the stream; and "vertical bank" (V) in which the bank has an angle visually estimated steeper than 80 degrees from the horizontal (Bauer and Burton 1993). Change in bank instability classes among grazing treatments (columns) with different superscripts are significantly different (lsd; $p < 0.05$; n = 3).

Grazing Treatment	Before				After				Change			
	B	S	F	V	B	S	F	V	B	S	F	V
-	(Bank Instability Class (m/100 m of streambank)											
Non-grazed Pastures	0 (±0)	4 (±1)	<1 (±1)	5 (±2)	0 (±0)	4 (±1)	<1 (±1)	5 (±2)	0 (±0)	0^{a} (±0)	0 (±0)	0 (±0)
Supplemented Pastures	1 (±1)	0 (±0)	0 (±0)	4 (±1)	2 (±1)	9 (±3)	0 (±0)	4 (±1)	+1 (±1)	$+9^{b}$ (+5)	0 (±0)	0 (±0)
Non-supplemented Pastures	1 (±1)	1 (±1)	0 (±0)	5 (±1)	2 (±1)	17 (±4)	0 (±0)	5 (±1)	+1 (±1)	$+16^{b}$ (±4)	0 (±0)	0 (±0)

[1]Cattle grazing supplemented pastures were provided free-choice off-stream water and trace mineralized salt; cattle grazing non-supplemented pastures received no off-stream water or salt supplement.

attempted to follow recovery rates year to year, especially after moderate grazing intensity. Kauffman et al. (1983), working on a stream adjacent to Milk Creek (Catherine Creek), found that stocking rates of 1.3–1.7 ha/AUM (compared to 0.8 ha/AUM measured in our study) caused significantly greater bank erosion compared to non-grazed controls during 2 seasons of grazing. They also found that while over-winter erosion did not differ among treatments, livestock grazing was enough to cause an overall increase in streambank losses over the study period. Conversely, some authors suggest moderate streambank damage is mitigated by natural processes the following year. Buckhouse et al. (1981) reported that while moderate cattle grazing caused measurable streambank effects in a single season, any differences between grazed and non-grazed treatments were erased the following year by ice effects and peak flows for this study. While their experiment did not isolate cattle grazing effect per se, results underscore the difficulty in understanding the role of grazing for sediment production in the context of the annual cycle of sediment release. Similarly, Marlow et al. (1987) reported that streamflow and cattle use were both correlated with degree of change in stream channel profile. In particular, streambank alteration resulted from a combination of high soil moisture, high streamflow, and cattle use. Thus, cattle impacts could only be judged within the context of the annual cycle of natural events typical of their study site. In our study, the only observed changes in streambanks between June and September occurred in the grazed pastures (Tables 1 and 2). Flows in Milk Creek average about 0.5 m^3 sec^{-1} in early June, 0.1 m^3 sec^{-1} in early July and 0.6 m^3 sec^{-1} in mid-September. Under this flow regime, grazing-induced reductions in streambank cover and stability could result in accelerated erosion during high flows of the subsequent spring. In general, because at least 30 variables are involved in the sediment transport process (Heede 1980), few studies have isolated the effects of ungulate grazing from the natural background of erosion that occurs over the course of a year (Skovlin 1984). While these studies and others suggest that cattle grazing strategies can reduce impact on sensitive riparian areas, what is really needed are experiments that link cattle grazing intensity, streambank breakdown, sediment release, and instream habitat effects. Such studies are essential if we are to understand the thresholds beyond which cattle-induced streambank breakdown become a problem.

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