Streambank Response to Simulated Grazing

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Abstract.—Simulated grazing techniques were used to investigate livestock impacts on structural characteristics of streambanks. The treatments consisted of no grazing, moderate early summer grazing, moderate mid summer grazing, and heavy season-long grazing. The heavy season-long treatment resulted in a 11.5 cm depression of the streambank surface, while the moderate treatments depressed the streambank surface about 3 cm. There were no differences between no grazing and moderate grazing treatments on bank angle, bank retreat, or stream width. The heavy season-long treatment produced significant changes in these variables during the 2-year study.

Introduction

Concern about the impacts of livestock grazing, particularly cattle, in riparian zones is widespread across the public lands of the Western United States. Although there are multitudinous anecdotal accounts and observations of cattle breaking down streambanks (Adams and Lorne 1995, Martin and Schumaker 1998), there is little quantification of the actual impacts necessary to damage streambanks (Trimble and Mendel 1995). In the present study, simulated grazing techniques were used to investigate the stress level necessary to damage streambanks in a mountain meadow setting in central Idaho. The data presented here are part of a larger investigation.

Study Area and Methods

This study was conducted on 3 streams in central Idaho's Sawtooth Valley north of Stanley. Stanley Creek and Park Creek are in the Sawtooth National Forest and Thatcher Creek is in the Challis National Forest. Stanley Creek and Thatcher Creek soils are classified as Fluventic Ustochrepts, loamy, cryic and Park Creek soil is classified as Fluventic Haplaquoll, loamy, cryic. The A horizon of Stanley Creek is dark yellowish brown, of Park Creek is black, and of Thatcher Creek is brown. Thatcher Creek had the highest amount of rock fragments, while Park Creek had the highest amount of clay. All 3 study sites have buried soil horizons at 18 to 33 cm below the surface (D. Gilman, personal communication). Streamside vegetation at the study sites was dominated by water sedge *(Carex aquatilis)*, beaked sedge *(C. rostrata)*, Jones sedge *(C. jonesii)*, small-winged sedge *(C. microptera)*, Baltic rush *(Juncus balticus)*, field woodrush *(Luzula campestris)*, and Kentucky bluegrass *(Poa pratensis*).

The treatments applied were intended to simulate no grazing (treatment 1), moderate early summer grazing (treatment 2), moderate mid summer grazing (treatment 3), and heavy season-long grazing (treatment 4). Eight main plots were established per stream; 2 per treatment. Each main plot had two 1 m^2 subplots, each overlapping the streambank. A half meter buffer zone was established around the subplots for protection and access.

Grazing simulation treatments were patterned after those in Clary (1995) with initial suggestions contributed by Al Medina (RMRS, Flagstaff, AZ, personal communication 1988) and refinements from Pat Momont (Caldwell Research and Extension Center, Caldwell, ID, personal communication 1995). The moderate treatments were applied once in either late June or late July. Vegetation was defoliated to a height of 10 cm, trampling was simulated by 50 random impacts by a hoof imitator (14 kg steel weight with impact surface area of 100 cm^2 dropped from 75 cm), urine was represented by 0.8 g of urea in 1/4 liter of water, and fresh manure was applied at a rate of 66 g m^{-2}. The heavy season-long treatment was applied in late June, late July, and late August. Vegetation was defoliated to 1 cm in height, 120 random hoof imitator impacts were applied, urine was represented by 2.0 g urea in 1/4 liter of water, and fresh manure was applied at a rate of 165 g m^{-2}. Treatments were initiated in the spring of 1996 and ended in the fall of 1997. Final measurements were taken in the spring of 1998.

Changes in soil surface and bank profile were determined by a bankometer patterned after a rillmeter. A 1.3 cm conduit pipe, 3 m long with 0.6 cm holes drilled on 2.5 cm centers, was anchored to rebar stakes. Stainless steel rods, 0.6 cm in diameter, were positioned through the drilled holes in the conduit pipe and lowered to the soil surface (figure 1). The length remaining above the conduit was recorded for each rod position. Determination of treatment effect on streambank elevation was a function of the change in readings over time. Bankometer readings, bank angle from water's edge to top of bank, wetted

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Figure 1. Bankometer positioned on study plot.

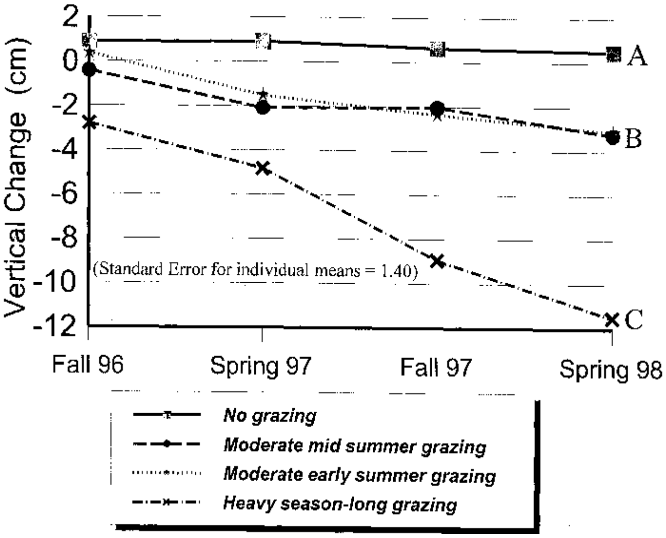

Figure 2. Mean depression of bank top related to time and treatment. Letters indicate significant differences.

stream width, and average stream depth were measured each spring and fall during the study. Bank retreat at water's edge during the treatment period was recorded at the end of the study. Moisture in the top 15 cm of soil was sampled gravimetrically with two 2.5 cm cores per subplot during each treatment period.

A mixed-model analysis of variance was used to analyze bank retreat data and a mixed-model analysis of variance with AR(1) error structure was used for the repeated measures analysis of bankometer, bank angle, and stream-width data. Effects of soil-moisture content and root-strength index were examined through correlation with response variables. Probability values of 0.05 or less were considered significant.

Results

Streambank elevations experienced a highly significant effect from the treatments ($P<0.01$). During the study, the plots receiving simulated grazing treatments had a cumulative reduction in average surface elevation as the streambank became progressively more deformed and broken (figure 2). The 2 moderate intensity treatments had about 3 cm of average surface depression, while the heavy season-long treatment had about 11.5 cm of average surface depression as the edge of the bank become severely deformed (figure 3).

Bank retreat, or the retreat of the streambank face at water's edge, demonstrated a treatment response ($P=0.01$). Treatments 1, 2, and 3 were comparable averaging about 3.5 cm bank retreat at the water's edge, but treatment 4 resulted in substantially greater bank retreat of about 12 cm over the study period.

Stream width, measured at the plot locations, changed differentially with treatment ($P=0.04$). Treatments 1, 2, and 3 had about 1/5 m narrower stream wetted-widths, reflecting lower stream depths at the end of the study (stream depth through control sections averaged 17 cm in 1998 versus 24 cm in 1996). However treatment 4, which caused the most severe impact, differed significantly and resulted in no reduction in stream width. No width reduction with lower stream depths suggested a relative increase in channel width.

Bank angle also experienced a significant change related to treatment ($P=0.05$). Treatments 1 and 3 had an average reduction in bank angle of less than 1 degree, while treatment 2 had an increase in bank angle of 7 degrees. Treatment 4 had an increase in bank angle of 27 degrees producing a substantial flattening of the bank face and creating a "laid back" appearance.

Discussion

One factor affecting the vulnerability of streambanks to trampling damage is the soil-moisture content. Montana researchers found a substantial correlation between changes in stream-channel area and streambank soil moisture, and little correlation between channel area and ob-

Figure 3. View of subplots following heavy, season-long treatment in 1997.

served cattle presence in the riparian area (Marlow and Pogacnik 1985, Marlow et al. 1987). They suggested that a primary guideline for grazing riparian areas would be to limit use to the seasonal periods of dry (<10% moisture) streambanks. Conversely, we found relatively limited correlation between variations in streambank soil moisture and streambank damage in this study. Perhaps one reason for the lack of a relationship was that the banks of the current study streams remained well above the 10% moisture threshold for bank toughness suggested by Marlow and Pogacnik (1985). The late summer streambank moisture in our study rarely dropped below 20%; Stanley Creek averaged 35%, Thatcher Creek averaged 39%, while Park Creek averaged over 100% in its rather boggy, high organic matter soils. No correlations were found with changes in bank angle, stream width, or elevation of the soil surface. A significant correlation occurred between streambank moisture and bank retreat on treated plots, but not those untreated.

Another factor that influences susceptibility of streambanks to deformation is vegetation. Herbaceous roots and rhizomes provide much of the compressive strength and soil stability for streambanks in meadow situations such as our study area (Dunaway and others 1994, Kleinfelder and others 1992). Streambanks on our sites were well vegetated with a variety of plant species. The graminoids most prevalent on 54% (Stanley Creek), 58% (Park Creek), and 90% (Thatcher Creek) of the plots were species with mid to low root strengths such as small-winged sedge and Kentucky bluegrass (USDA Forest Service 1992). The remaining plots were dominated by strongly rooted species as water sedge and Baltic rush. Thus, our study sites were not particularly resistant nor susceptible to streambank damage. Surprisingly, we found no correlation between an index of root strength for the dominant species (USDA Forest Service 1992) and bank response. Several possible reasons include: root-strength index confounded with soil moisture content and soil characteristics; and individual plots typically contained a mixture of species.

Although the benefits to plant composition using rotational or other specialized grazing systems are cited for many conditions (Heitschmidt and Taylor 1991, Holechek et al. 1989), the actual grazing system used has little effect on the total trampling impact (Guthery and Bingham 1996). Since the streambanks in our study did not dry to the level that could potentially allow seasonal protection from trampling damage, the specific grazing system used probably would not have great importance in the study area. Thus, since several of our streambank measures differed little between no grazing and moderate seasonal grazing, while heavy season-long grazing resulted in severe bank deformation within only 2 years, the primary way to control of streambank deformation on our sites is to concentrate on controlling the total animal use of streambank areas rather than to concentrate on manipulation of the grazing system. Control of livestock activity on streambanks is usually easier to accomplish in the spring when livestock are often attracted away from the wetter streamside areas to the floodplain and upland sites (Clary and Booth 1993, Siekert et al. 1985).

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