Preliminary Results from the Evaluation of Different Seasons and Intensities of Grazing on the Erosion of Intermittent Streams at the San Joaquin Experimental Range[1]

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Abstract: *A study was initiated during summer 1994 to evaluate the effect of season and intensity of grazing on erosion along intermittent streams at the San Joaquin Experimental Range. Five treatments (no grazing, dry season moderate, dry season heavy, wet season moderate, and wet season heavy) were applied on three different streams. Change in channel cross-sectional area, following one season of treatments, was determined and evaluated. There was no significant difference (*P *= 0.236) between treatments. Erosion and deposition resulting from heavy rainfall and streamflow may have masked treatment effects. Treatments will continue to be applied annually for an additional 4 years.*

Grazing-derived sediment impacts on the beneficial uses of water are a continual concern among conservation groups and regulatory agencies, such as the Regional Water Quality Control Board (George 1992, 1993). While crucial salmonid water bodies receive a great deal of attention, little attention is given to sediment delivery from low-elevation intermittent streams in California's Central Sierra Nevada foothills. Field observations suggest that sediment delivery from these streams can be high during runoff periods. Sediment from grazed watersheds can come from several sources including inadequate vegetative cover, cattle trails, and roads. In addition, miscellaneous surface disturbances in the uplands or streambank erosion and stream degradation in the intermittent stream channels can contribute to the sediment load.

The objective of this study was to demonstrate and evaluate the impact of different seasons and intensities of grazing on streambank and channel erosion along intermittent stream channels. In addition, monitoring of runoff and sediment load relationships for a small watershed was begun.

Site Description

The 4380-acre San Joaquin Experimental Range (SJER) has been a USDA Forest Service research facility since the 1930's. The station lies in the lower central Sierra Nevada foothills in the oak (*Quercus* spp.) savanna vegetation type (*fig. 1*).

Currently SJER is managed by California State University Fresno (CSUF), for research and education purposes under a long-term agreement with the USDA Forest Service, Pacific Southwest Research Station. A herd of 210 beef cattle is maintained at the station by CSUF.

The station has a Mediterranean climate with annual precipitation ranging from 10 to 32 inches with a mean of 19 inches, mostly coming between October and March. Mean monthly air temperatures range from 42˚F in January to 80˚F in July.

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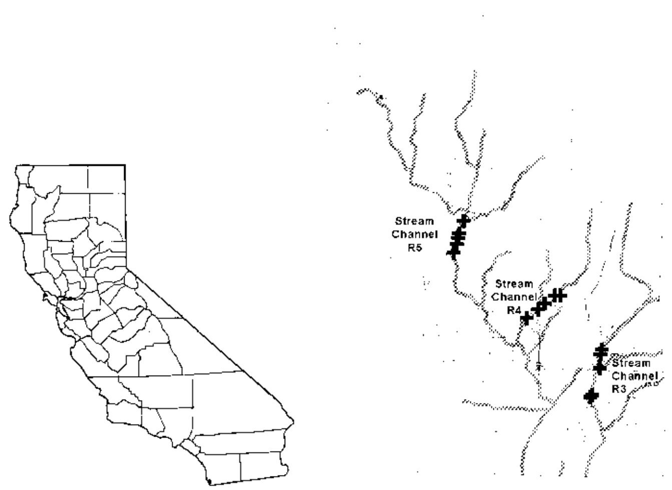

Figure 1—Location of five treatments on three intermittent stream channels at the San Joaquin Experimental Range in Madera County, California.

Elevation ranges from 700 to 1700 feet. Soils are coarse sandy loam derived from granitic rocks, and most are less than 2.5 feet deep. The Ahwahnee series (Mollic Haplustalf) are common, covering about 96 percent of SJER. The Visalia series soils (Cumulic Haploxeroll) are found on alluvial or swale sites.

The station is dissected by first-, second-, and third-order intermittent stream channels. Stream flow occurs during the rainy season and for a few weeks into the dry season. While granitic rocks, oak trees, and other woody vegetation provide some stability, the majority of the stream banks are vegetated by shallow-rooted annual grasses and forbs. The stream bottoms are predominantly sand with some granitic rock and boulders. The channels are 2 to 10 feet wide and 1-3 feet deep. The study reaches are low gradient with less than 2 percent slope.

The oak woodlands of SJER are dominated by blue oak (*Quercus douglasii*) and interior live oak (*Quercus wislezenii*). The understory vegetation is dominated by annual grasses and forbs. Wedgeleaf ceanothus (*Ceanothus cuneatus*) is a common understory shrub.

Methods

Five grazing treatments were replicated on three different first-, second-, and third-order intermittent streams that are tributaries to Cottonwood Creek. Cottonwood Creek is a fourth-order stream that drains into the San Joaquin River just below Friant Dam. The three stream channels designated R3, R4, and R5 are 1 to 2 miles apart and at an elevation of 900 to 1350 feet (*fig. 1*).

The five treatments consisted of no grazing (NG) (control), dry season moderate (DSM), dry season heavy (DSH), wet season moderate (WSM), and wet season heavy (WSH). Wet Season grazing treatments were applied in December or January and maintained through the remainder of the rainy season by reapplication to remove regrowth to maintain the treatment target. Dry Season grazing treatments were applied once in late summer before the rainy season. Because this is the dormant period, reapplication of dry-season treatments was not necessary.

Each of the treatments were applied to a 200- by 200-foot area centered over the stream channel (*fig. 2*). Each treatment was applied to a randomly selected location (experimental unit) within the stream reach (*fig. 2*). These treatments were replicated on the three different stream channels as a randomized complete block design.

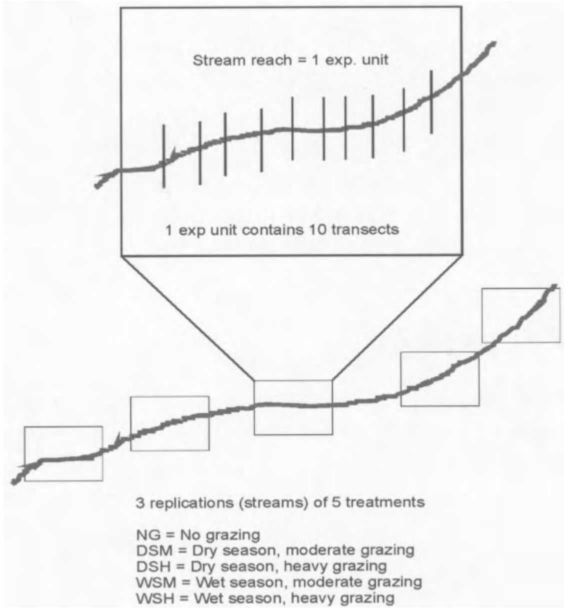

Figure 2—Stream channel treatment layout.

Permanent fences were built to exclude grazing from the no-grazing treatment. Temporary electric fences were used as needed during periods following application of moderate or heavy grazing. Residual dry matter (RDM) targets of 700-1000 pounds/acre and <600 pounds/acre were used to define moderate and heavy grazing, respectively. The RDM levels were estimated visually following methods described in Clawson and others (1982). Supplemental feeding adjacent to treatment sites was used to achieve desired intensity when ambient grazing intensities were inadequate.

Stream Channel Measurements

Channel cross-sections were measured using methods outlined by Bauer and Burton (1993). For each stream reach 10 permanent cross-section transects, 20 to 30 feet long, were placed perpendicular to the stream channel, a distance of 1 to 1.5 times the channel width apart (*fig. 2*). The transects were marked with permanent stakes that were referenced to a permanent benchmark, generally a large boulder nearby, at each stream reach. Stream elevation was determined every 6 inches along the transect. The elevational readings were used to calculate the cross-sectional area of each transect. The cross-sectional area was subtracted from the baseline values to obtain the change in cross-sectional area. The averages for each experimental unit (10 transects) were used to evaluate the grazing effects. A one-way analysis of variance was used to analyze the data.

Runoff and Sediment Monitoring

Stream reach R4, which drains a 342-acre watershed (*fig. 1*), was gauged with a 3-foot H flume. Stream flow was calculated from stage height. A tipping bucket rain gauge was installed near the flume. Stage height and rainfall values were recorded hourly using a data logger.

Suspended sediment load was estimated from taking water samples near the flume. The samples were filtered, dried, and weighed, and suspended sediment concentration was calculated. Water samples were collected several times a day during rainstorms and subsequent high runoff periods. Samples during low flows were collected only once every 1-2 weeks.

The maximum peak flow for the year was estimated using the cross-sectional area of the farthest downstream set of cross-section treatments and Mannings equation (Branson and others 1981). The *n* value for Mannings equation was estimated by measuring velocity and calculating n during high flows when we were present. The high water marks were then used to estimate the maximum peak flow for the year.

Three sets of paired runoff plots were established within the watershed. Each set of runoff plots was on different slope classes of 10 percent, 20 percent, and 30 percent. These plots were 6 feet wide and 70 feet long. Surface water runoff and sediment were collected for each storm event.

Results and Discussion

Above-average rainfall promoted the evaluation of stream bank and channel erosion following one year of grazing treatment. Total rainfall recorded at the study site (R4) was 30.93 inches (163 percent of normal) for September 1994 - August 1995. The majority of the rainfall at SJER came during January (9.4 inches) and March (9.1 inches). The largest single storm event was 4.85 inches occurring in a 48-hour period during March 9-11, 1995 (*fig. 3*).

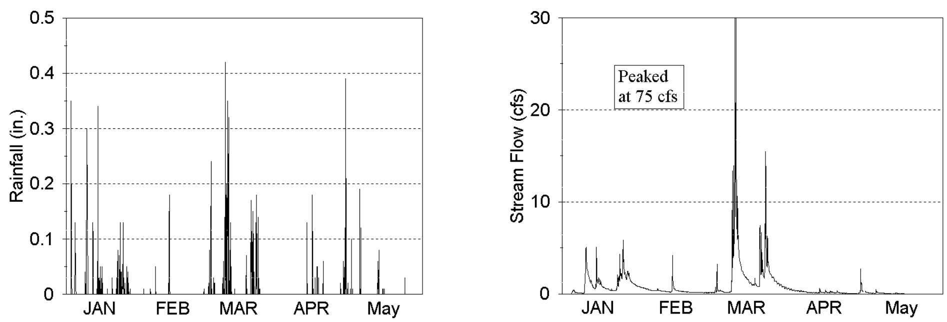

Figure 3—Hourly rainfall and stream flow (cubic feet per second) for watershed R4 at the San Joaquin Experimental Range during winter 1995.

This large storm event occurred on saturated soil conditions and produced a large estimated peak flow on each of the three study stream reaches. Stream reach R3 had an estimated peak flow of 136 cubic feet per second. The flume on stream reach R4 was exceeded by an estimated peak flow of 76 cubic feet per second. Stream reach R5 had the largest peak flow which was estimated at 366 cubic feet per second.

Stream Bank and Channel Erosion

The mean differences in cross-sectional area between baseline and first-year treatment are shown in *table 1*. There were no significant differences ($P = 0.236$) between grazing treatments. However, some small differences were detected. The greatest erosion occurred in the NG treatment. In contrast, the DSH treatment had the highest deposition rate. The average changes following one year were as follows; NG = -2.9 percent, WSH = -1.4 percent, DSM = -0.3 percent, WSM = 1.1 percent, and DSH = 2.1 percent. The greatest change for any treatment site was -6.1 percent for the NG treatment on stream reach R3. Interestingly, soil erosion and deposition was not correlated with any treatment effect. Erosion and deposition resulting from heavy rainfall and streamflow may have masked treatment effects.

Unfortunately, very few studies have compared season, intensity, or frequency of grazing treatments to assess grazing impacts or to test grazing management practices. Studies of grazing impacts on riparian zones and fishery

Table 1—Cross-sectional area differences between baseline and first season grazing treatments[1] at the San Joaquin Experimental Range.

Treatment[2]	Area difference Mean	Percent
	ft^2	
Dry season heavy	0.65	2.1
Wet season moderate	0.48	1.1
Dry season moderate	-0.11	-0.3
Wet season heavy	-0.54	-1.4
No grazing	-0.85	-2.9

[1]Positive values = deposition; negative values = erosion

[2]Replicated on three different stream reaches. There was no significant difference among grazing treatments (P = 0.236).

habitat commonly focus on adjacent comparisons of grazed and ungrazed reaches on the same stream. Many of these studies were recently reviewed by George (1994).

Buckhouse and others (1981) reported differences in streambank erosion between several grazing treatments including no grazing. Siekert and others (1985) reported that spring grazing had no significant effect on channel cross-sectional area, with degree of these impacts varying with climatic differences. Marlow and Pogacnic (1985) reported that the greatest amount of bank alteration in an ephemeral stream in Montana occurred when soil moisture exceeded 10 percent.

Observations of Sediment Movement in Watershed R4

The watersheds at SJER are flashy in nature, as shown by the hydrograph of stream R4 in *figure 3*. During saturated conditions, peak flows occur rapidly following rainfall initiation, then recede quickly following storm cessation. This condition allows for high peak flows. High peak flows can be responsible for movement (erosion and deposition) of sediments within a stream channel.

Runoff from watershed R4 began January 4, 1995 and ended on May 17, 1995 (*fig. 3*). Monthly totals for rainfall, runoff, and suspended sediment load are shown in *figure 4*. There were 30.9 inches of rainfall with 8.6 inches of runoff for the season on watershed R4. There was an estimated 24.2 tons of suspended sediment for the whole runoff season. This is an average of 0.07 tons/acre for the whole watershed. There was movement of sediments (erosion and sedimentation) throughout the entire stream. However, the actual amount of sediment transported out of the watershed was small.

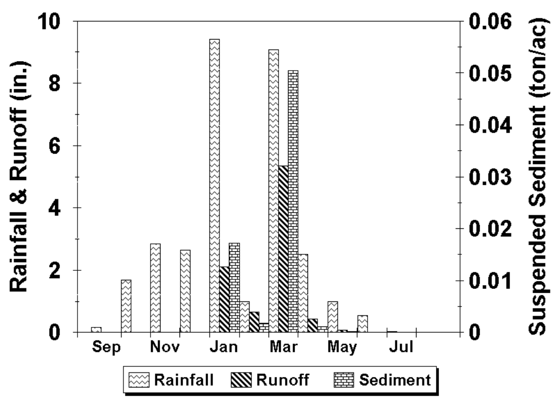

Figure 4—Monthly rainfall, runoff, and suspended sediment from watershed R4, water year 1994-1995.

The seasonal surface runoff from the paired plots was highest at the 10 percent slope (>9 inches), least for the 20 percent slope (3.6 inches), and moderate for the 30 percent slope (5.4 inches). The value for the 10 percent slope was estimated. It is believed that subsurface water from upslope was transported through rodent burrows within the paired plots. Water from these plots flowed approximately 3 days following the major storm event in March. However, sediment loss from these plots was very low. The greatest amount of sediment loss was from the 30 percent slope (0.022 ton/acre), moderate from the 20 percent slope (0.012 ton/acre), and the least from the 10 percent slope (0.008 ton/acre). These small amounts of soil erosion would suggest that most of the suspended sediment load in the stream came from the stream channel itself, and not from surface erosion from the uplands.

Plans

The grazing treatments will continue to be applied annually for another 4 years to increase the chances of finding a significant treatment effect. Hand sampling of suspended sediment load has been replaced by an automatic water sampler. An additional set of paired plots was installed on a 10 percent slope in a permanent exclosure. The paired plots will continue to be monitored for another 2 years. One plot from each of the pairs will then be fenced to evaluate grazing impacts on upland surface erosion by differing slope classes.

Acknowledgments

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