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Effects of Sheep Grazing on a Riparian-Stream Environment

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ABSTRACT

A stream section in a meadow receiving high intensity grazing from sheep was almost five times as wide and only one-fifth as deep (average) as an adjoining stream section where the meadow received light or no grazing. In the heavily grazed area, undercut banks were eliminated, streambanks were outsloped, and water depth at the stream surface-stream channel interface was only one-thirteenth as deep as in the lightly or nongrazed area. To hold sheep on meadows for long periods of time is probably detrimental to the riparian-stream ecosystem.

KEYWORDS: streamside vegetation, fishery, stream morphology, streambank erosion.

A valid assessment of the result of sheep grazing on riparian-stream habitats is not possible because of the lack of quantitative data for evaluation (Meehan and Platts 1978). Some data are available which describe the effects on stream ecology of cattle grazing (Platts 1978a, 1978b), but only rough, subjective information that describes the effects of sheep grazing on aquatic ecosystems is available.

When evaluating the effects of livestock grazing on streams, it must be recognized that different classes of livestock graze the watershed in different ways. Sheep are often classified as grazers that use slopes and upland areas, while cattle are usually thought of as grazers that have more tendency to use the lesser slopes or bottomlands which usually include riparian habitats. Because sheep grazing on public lands is usually controlled by herding, it is possible to graze a watershed without exerting significant influences on riparian habitats. This situation appears to be the case in my study sites (fig. 1) on Frenchman Creek in the Sawtooth National Recreation Area, Idaho, where sheep are herded and managed under a deferred rotation system. In the nearby Pole Creek study site, however, also under a deferred system, past driveway use has put additional heavy grazing pressure on the riparian and stream environments. The traditional heavy use has been from driveway sheep using the meadows for forage and bedding while awaiting shipment.

This report quantitatively describes the changes in a riparian-stream system in the Pole Creek meadows under this sheep-holding grazing strategy. A future report will compare this type of grazing strategy to a herding-deferred rotation-grazing strategy now being used on the Frenchman Creek study sites.

Figure 1.--Study Area locations.

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STUDY AREA

The study was conducted in the Pole Creek drainage in the headwaters of the Salmon River drainage in Idaho. This river supports most of the chinook salmon (*Oncorhynchus tshawytscha* [Walbaum]) and steelhead rainbow trout (*Salmo gairdneri* Richardson) that enter Idaho to spawn. Waters in the Salmon River drainage are usually low in mineral content because of the predominance of granitic bedrock. The study site is on a small spring-fed stream; a tributary to Pole Creek, at 6,200 feet (1 890 m) elevation, that flows in meadows formed by extensive Pleistocene glacial deposits. The sediment forming the meadows was transported from higher elevations by glaciers and deposited as an outwash train. Subsequently, the streams passing through the meadows have reworked the sediment and evolved the meadows to their present morphology in quasi-equilibrium with climatic change.

The study stream has a gravel bottom with lesser amounts of rubble and fine sediments. Small numbers of brook trout (*Salvelinus fontinalis* [Mitchill]), sculpin (*Cottus* spp.), and possibly rainbow trout occupy the stream. Because of the stream's small size, fish numbers per unit of stream length are low; brook trout average only one per 100 ft (30.5 m) of stream.

GRAZING HISTORY

Prior to European man entering the Salmon River drainage, the study site was grazed mainly by wild ungulates, rodents, and insects. Upon settlement of the Snake River Plain, the white man quickly recognized the possibility of using the rangelands in the Idaho batholith for summer forage. As a result, the number of livestock brought into the Upper Salmon River drainage for summer forage quickly increased. During the late 1800's the use was predominantly sheep, with cattle entering in the early 1900's to graze the lower elevation pastures. Since the late 1800's, the Pole Creek drainage has been grazed primarily by sheep with minor grazing by domestic horses.

By the late 1800's and early 1900's, sheep numbers grazing the Pole Creek meadows had mushroomed because the area was on the Ketchum-Stanley sheep driveway. William Horton, District Ranger at the Pole Creek Station, reported in 1910 that 200,000 sheep were using the sheep driveway each year. The bands of sheep that historically used the Pole Creek meadows exerted more grazing pressure on the riparian-stream environment than was normally found under the most commonly used sheep grazing strategies.

In 1910, a 30-acre (12.2-hectare) section of Pole Creek meadows was fenced and used as a Forest Service Guard Station (fig. 2 and 3). Thus, sheep were restricted from grazing the administrative site (Guard Station), but heavy grazing continued in the remainder of the meadow until the mid-1960's when sheep numbers began to decline. In 1910, Ranger Horton reported that inside the fenced ungrazed area, pine and fir seedlings had excellent survival, while outside the fenced site there was little or no survival. By 1934, the meadow adjacent to the fenced area received such heavy use that 150 acres (60.7 hectares) had to be reseeded. From 1959 to 1975, the meadow continued to receive heavy use for sheep forage and bedground. The USDA Forest Service took action in 1964 to close the sheep driveway from Ketchum to Stanley to spring travel. That action resulted in much less grazing pressure on the meadows.

The fence around the guard station was not entirely effective in keeping out all sheep. In 1936, it had to be reconstructed to further exclude sheep grazing. From 1964 to 1974, 10 horses and mules were grazed in the fenced area for about 1 month each summer. Throughout recent years, however, grazing within the fenced area was low and had an insignificant effect on most of the stream within the fenced portion of the meadows.

The past annual heavy sheep grazing on the meadows compared to the light or nonexistent grazing of recent years provides an ideal example by which we can quantify riparian and stream reactions to heavy sheep grazing.

Figure 2.--The lay-down fence separating the heavily grazed area from the lightly grazed area. Note the wide, shallow stream in the heavily grazed area narrowing as it enters the fenced area.

Figure 3.--Looking from the fenced lightly grazed area into the heavily grazed area. Note the narrowness of the stream in the lightly grazed area.

METHODS

To determine riparian and aquatic habitat conditions, a group of 121 channel cross sections were located within the study site. The cross sections were at 10-ft (3.05 m) intervals covering 600 ft (182.9 m) of stream in the lightly grazed area immediately downstream from the fence separating the two areas, and 600 ft (182.9 m) of stream immediately upstream from the fence in the heavily grazed area (fig. 4). Cross sections ran from bank to bank, perpendicular to the main flow of the stream. Aquatic habitat measurements were taken in July, August, and September; and riparian measurements were taken in October after the grazing season had ended.

The following environmental conditions were evaluated:

1. Stream channel materials
2. In-stream vegetative cover
3. Substrate embeddedness
4. Channel gradient
5. Stream width and depth
6. Bank-stream contact water depth
7. Pool area and quality
8. Riffle area
9. Streambank alteration
10. Streambank rock content
11. Streambank angle
12. Streamside vegetation
13. Streamside cover stability
14. Vegetative overhang
15. Stream channel profile
16. Stream velocities
17. Streambank undercut

A brief summary of the procedures used in this study follows. A more detailed description of the methodology used appears in Platts (1974), Platts (1976), and Ray and Megahan (1978).

Stream Channel

Channel materials were classified into five classes by visually projecting each 1-foot (0.305-m) division of a measuring tape to the streambed surface and assigning the major observed sediment class to each division. Sediments were classified as: large boulder, 24 inches (610 mm) or larger in particle diameter; small boulder, 12 to 23.9 inches (305 to 609 mm); rubble, 3 to 11.9 inches (76 to 305 mm); gravel, 0.19 to 2.9 inches (4.8 to 76 mm); and fine sediment, less than 0.19 inch (4.8 mm) in particle diameter.

In-stream vegetative cover was a direct measurement of the vegetative cover on the channel intercepted by the transect. Stream channel substrate embeddedness measured the gasket effect of fine sediment around the larger size substrate particles. The rating ranged from a high of 5 (less than 5 percent of the larger substrate covered or contacted by fine sediments) to a low of 1 (over 75 percent of the larger substrate covered with fine sediment). Channel gradient was taken at each transect using an engineer's level and sighting rod.

Figure 4.--Sketch of study site.

Water Column

Stream width was a horizontal measurement of that area of the transect covered by water. Stream depth was the average of four water depths taken at selected intervals across the transect from the water surface to the channel bottom. Water depth at the intersection of the streambank or stream channel with the edge of water was a direct measurement from water surface to channel bottom. Pools were classified as that area of the water column usually deeper than riffles and slower in water velocity. The remainder of the water column was designated "riffle." Pool quality rating was based on the pool's ability to provide certain rearing requirements needed by fish. A top quality pool rated 5 (over 3 feet [0.91 m] deep or over 2 feet [0.61 m] deep with abundant fish cover) and a poor quality pool rated 1 (shallow and small with little cover).

Streambanks

Streambank alteration reflected the quantity of natural and artificial change occurring to the streambank and was ranked from zero to 100 percent. Streambank rock content provided a measure of the percentage of rock in the streambank over 0.19 inch (4.7 mm) in particle size. The streambank angle was measured with a clinometer, which determined the downward slope of the streambank to the water. Streambank undercut was a direct horizontal measurement, parallel to the stream channel, of the erosion of the bank at the water influence area.

Riparian Vegetation

Streamside cover was categorized according to the dominant vegetation as "tree," "brush," "grass," or "exposed." Streamside cover stability was a four-group rating of the ability of the cover on the streambanks to keep water flows from eroding streambanks. A rating of 4 is excellent (over 80 percent of the streambank is covered by vegetation in vigorous condition preventing erosion), and a rating of 1 is poor (less than 25 percent of the streambank is covered by vegetation with little erosion control). Vegetative overhang directly measured the length of the vegetation overhanging the water column within 12 inches (0.301m) of the water surface.

Hydrologic Geometry

An engineer's level and measuring rod were used to profile the cross sections. Twenty of the 121 cross sections, 10 in each study site, were selected to represent the study area. A sag tape was stretched across the transect and from this tape, vertical and respective horizontal measurements were made across the transect from the tape to the streambank, stream channel, and water level. Using a sag tape program developed by Ray and Megahan (1978), a computer was used to plot cross sections. Water velocities were taken at selected intervals across the transect.

RESULTS Geomorphic

WATER COLUMN

Significant differences occurred in stream width and depth between the fenced (lightly grazed) and unfenced (heavily grazed) study areas (table 1). Stream width was over four times as wide in the heavily grazed area as in the lightly grazed area. Sheep use on the streambanks in the heavily grazed meadow caused the banks to erode away from the water column; so over four times as much surface was exposed to solar radiation in the heavily grazed meadow versus the lightly grazed meadow.

Average stream depth was almost five times as great in the lightly grazed area as in the heavily grazed area. The depth of the stream at its interface with the streambank or stream channel was almost 13 times as great in the lightly grazed meadow as in the heavily grazed meadow.

Percent riffle and percent pool were not significantly different between the sites. Mean pool quality was slightly higher in the lightly grazed area than in the heavily grazed area, but not significantly. Mean stream velocity was higher in the lightly grazed area than the heavily grazed area, but the significance was at the 90 percent level.

Table 1. A comparison of variable means and their 95 percent confidence intervals between the lightly grazed and heavily grazed sites

Item	Area			
	Fenced		Unfenced	
	Mean	Interval	Mean	Interval
Water column				
Stream width (ft)	1.8	1.3- 2.3	7.8	7.3- 8.3
Stream depth (in)	6.2	5.7- 6.6	1.3	.9- 1.7
Riffle (percent)	83.3	76.2- 90.4	85.2	78.1- 92.3
Pool (percent)	16.7	9.6- 23.8	14.8	7.7- 21.9
Pool quality	1.9	1.4- 2.4	1.5	1.1- 1.9
Bank water depth (in)	5.1	4.5- 5.8	.4	.0- 1.1
Stream velocity (cfs)	1.3	1.0- 1.5	.8	.7- 1.0
Channel				
Embeddedness	3.2	2.9- 3.5	4.8	4.6- 5.1
Boulder (percent)	.0	-	.0	-
Rubble (percent)	2.5	.0- 7.2	.0	-
Gravel (percent)	69.3	61.0- 77.0	98.2	90.0- 100.0
Fines (percent)	5.3	1.5- 9.1	1.2	.0- 5.0
In-stream vegetative cover	.2	.0- .4	.5	.3- .7
Gradient (percent)	.7	-	1.2	-
Streambanks				
Bank angle (degrees)	82.0	75.0- 90.0	132.0	125.0- 140.0
Bank undercut (in)	1.7	1.3- 2.1	.6	.2- 1.0
Streambank alteration natural	3.5	2.1- 4.9	5.8	4.4- 7.1
Streambank alteration artificial	5.7	1.4- 9.9	86.1	81.9- 90.4
Vegetative cover type	2.1	2.0- 2.2	1.9	1.9- 2.0
Bank stability	3.9	3.9- 4.1	3.8	3.8- 3.9
Vegetative overhang	6.9	6.1- 7.8	7.3	6.7- 8.4
Vegetative use	2.3	.0- 5.0	37.3	34.6- 20.8
Habitat type	17.7	17.7- 18.2	14.0	13.4- 14.7
Streambank rock content	1.0	1.0- 1.0	1.0	1.0- 1.0

STREAM CHANNEL

Percent gravel in the stream channel was significantly higher in the heavily grazed area than in the lightly grazed area. Channel rubble was lacking in the heavily grazed area and almost lacking in the lightly grazed area. There was no significant difference in fine sediments, and boulder material did not appear in any of the areas. Fine sediments in the channel had a higher gasket effect (embeddedness) around the gravels in the lightly grazed area than they did in the heavily grazed area.

Because of the much wider stream channel in the heavily grazed area, there was about twice as much in-stream vegetation covering the stream channel in the heavily grazed area as in the lightly grazed area. Percentage-wise, however, in-stream vegetative cover was higher in the lightly grazed area. Mean channel gradient was higher in the heavily grazed area.

STREAMBANKS

Streambanks in the heavily grazed area were modified from their natural condition by the high utilization of forage. The streambanks were eroded away from the water column, outsloped, and had little undercut bank (overhang bank) (fig. 5 and 6). The angle the bank made with the channel was much higher in the heavily grazed pasture, the lightly grazed area had about three times as much undercut in the streambanks.

Natural streambank alteration was about the same for both areas. But, streambank alteration was about 15 times greater in the area heavily grazed in the past than in the area lightly grazed.

Measurements showed no difference between areas in bank stability, which is a rating of the vegetative cover and of the erodibility of the banks. This validates the observation that as the banks are eroded away and become setback and increasingly sloped, the widened channel accepts most of the stream flow energy and vegetation is continually established as the banks are eroded and cut back. Streambank rock content ratings showed streambanks in both areas were composed mainly of fine sediments. No significant differences were noted between areas for vegetative cover types and vegetative overhang. The difference, however, in percent of water surface covered by vegetative overhang was large. The percent of surface covered was higher in the fenced area. Vegetative use, of course, was high in the heavily grazed area. But, use was higher than expected in the lightly grazed area because of a few sheep were able to pass through the fence and graze the fenced meadow area in 1978.

Figure 5.--Typical stream channel cross section in the lightly grazed site.

Figure 6.--Typical stream channel cross section in the heavily grazed pasture.

Habitat condition is a rating of the cover or lack of cover on the streambank. Theoretically, the higher the habitat condition rating the more favorable the streambank would be for fish. The habitat condition rating was significantly higher in the lightly grazed area.

Cross Sections

Channel cross sections exemplify conditions that the data in table 1 indicate (fig. 5 and 6). Channels in the heavily grazed area have widened, streambanks have been set back, stream depth has been greatly reduced, more surface area has been exposed to solar radiation, and water depth at the water surface-channel interface has been reduced. The changes occurred over a long period and it may take an even longer time for the stream to revert to its natural condition.

DISCUSSION

Sheep are often said to prefer slopes and upland areas for grazing; so, under proper management, they would be expected to have little onsite effect on riparian-stream environments. This study shows, however, that when sheep are forced to concentrate on riparian-stream areas they adversely affect these environments. Heavy, concentrated sheep grazing can make streams wider and shallower, can increase the slope of streambanks, eliminate undercut banks, change riparian habitat type, expose the stream to more solar radiation, and decrease water depths at the stream surface-streambank interface.

The study stream was small and did not carry a sufficient fish population for analysis; so this report does not say whether these changes are good or bad for fish. Only 18 brook trout and fewer sculpin occurred in the 1,620 feet (493 m) of stream sampled. Fishery biologists generally agree, however, that the documented changes do tend to decrease fish populations (Duff in press; Marcuson 1977). Therefore, to concentrate sheep on meadows for long periods would be detrimental to the riparian-stream ecosystem. Under a grazing strategy, such as deferred use combined with good herding, there would be fewer harmful effects. The present management of sheep on Pole Creek meadows is considerably better than that used in the past. Our ongoing studies will determine the effect of these better management practices on riparian-stream systems.

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