Riparian Stubble Height and Recovery of Degraded Streambanks

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Improper livestock management can affect small-stream riparian habitats by reducing or eliminating riparian vegetation, typically causing channel widening or incising, changing streambank shape, and as an accumulative result often lowering floodplain water tables (Platts 1991). Improved riparian management appears essential to the recovery and environmental restoration of many areas degraded from improper livestock grazing. Grazing management practices should provide for regrowth of riparian plants after use, or should leave sufficient vegetation at the time of grazing to meet the requirements for maintenance of plant vigor, streambank protection, and sediment entrapment (Clary and Webster 1990).

A small stream in a montane riparian area under natural conditions is illustrated in Figure 1a. However, 100 feet upstream the channel has been degraded from extensive livestock grazing and subsequent bank collapse (Figure 1b). Improved management is needed to allow the stream system to evolve back to the original condition. A key element for restoration of stream channel form is the entrapment and retention of sediment at or below bank top. Sediment deposition in a degraded stream system is an essential building material for the natural recovery of channel form.

Fig. 1a. *Riparian-stream system in natural state.*

Deposition must often be induced since the sediment load may be small compared with the stream sediment-carrying capacity. Although herbaceous vegetation enhances sediment deposition, the relationship between vegetation characteristics and sediment retention is not well documented. Pearce et al. (1994) concluded that riparian vegetation height may not be a significant factor in trapping sediment from shallow overland flow. These results are not directly applicable to deeper flows occurring during peak runoff periods.

A laboratory study was conducted to better understand how the presence of vegetation affects sediment deposition and retention in stream channels and on streambanks.

Approach

A simulated meandering stream channel was constructed in the Hydraulics Laboratory at Colorado State University (Thornton 1994). The stream channel configuration was based upon stream characteristics typically found in the Intermountain area. The simulated stream channel was fab-

Fig. 1b. *The same riparian-stream system 100 feet away depleted from overuse.*

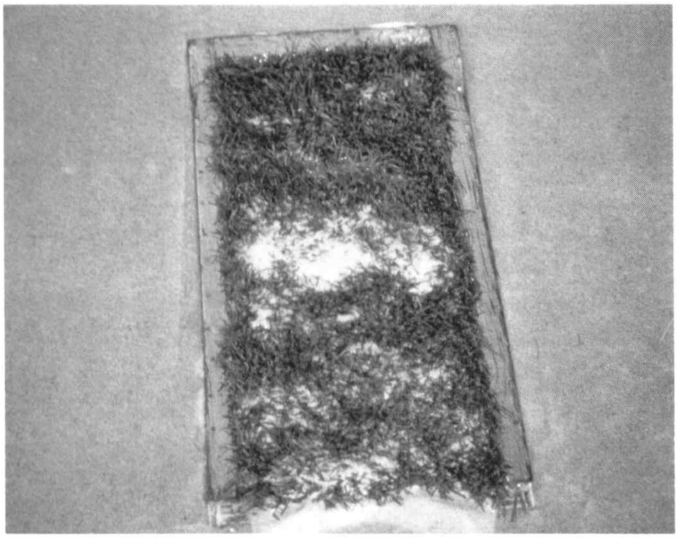

Fig. 2. *Bluegrass sod mat illustrating sediment deposition.*

ricated in an area approximately 62 feet long by 18 feet wide. The channel reach was approximately 48 feet in length, trapezoidal in shape and formed in a laid-back or "dished-out" bank. Shallow cavities were installed into the channel bed for placement of live vegetation mats. Each cavity was 12 inches wide by 24 inches long by 1 inch deep. The installation of vegetation mats allowed the evaluation of sediment deposition in areas influenced by vegetation (Figure 2).

Sediment, in the form of very fine sand, was injected at the upstream portion of the channel. Three discharges, 3.0, 5.0, and 6.8 cubic feet per second, were selected to simulate low-flow, medium-flow, and high-flow in the stream, respectfully. These discharges were consistent with conditions found in the small headwater streams of the Intermountain region (Mosko et al. 1990).

Four types of vegetation were evaluated for their sediment deposition and entrapment capabilities. Kentucky bluegrass was the most intensively studied plant, while other vegetation studied included silver sedge, native sod of mixed species, and corn seedlings. The native sod was comprised primarily of needle-and-thread, junegrass, Parry clover, and Thurber fescue. The vegetation was selected based upon the unique size and structure of each type. It was important to represent both flexible (bluegrass and native sod) and stiff (sedge and corn) stem characteristics. Average stem densities ranged from 437 to 1,115 per square foot and individual stem areas ranged from 0.002 to 0.006 square inch for the four types of vegetation (Table 1). Flexible stem vegetation was tested at blade lengths of 0.5, 3.0, 8.0, and 14.0 inches. Rigid stem vegetation lengths were 3.0, 8.0, 10.0, and 14.0 inches.

The simulated stream system was initially operated without vegetation in the channel. The areas of natural deposition were identified and sediment amounts were measured thereby establishing the base deposition condition. Subsequent simulations repeated the tests with vegetation in the channel and we recorded sediment amounts trapped in the vegetation during the six-hour sediment loading

Table 1. Summary of average density and stem area for vegetation tested.

Vegetation type	Average stem density (No./ft^2)	Average stem area (in^2)
Kentucky bluegrass (*Poa pratensis*)	1496	0.002
Sedge (Carex *praegracilis*)	885	0.004
Native sod	1115	0.002
Corn seedlings (*Zea mays*)	437	0.006

phases. In a second series of tests, after the sediment injection was stopped, the water flow continued for another six hours thereby flushing a portion of the sediments through the system. A total of 77 simulations were performed to evaluate sediment entrapment and retention potential of vegetation.

For illustration the sediment deposited for each vegetation length was normalized (expressed as a proportion of the maximum sediment deposited) and averaged. Sediment retention during the flushing phase was expressed as a proportion of initial peak deposit and averaged.

Results

Except for the inside of stream bends, the presence of vegetation significantly increased sediment entrapment–in some locations as much as 700% (Figure 3). The shorter the vegetation length, the greater the sediment deposition potential, at least down to 0.5 inch in length (Figure 4). The shorter and stiffer lengths of *flexible* vegetation created a turbulent zone that most enhanced deposition. Shorter

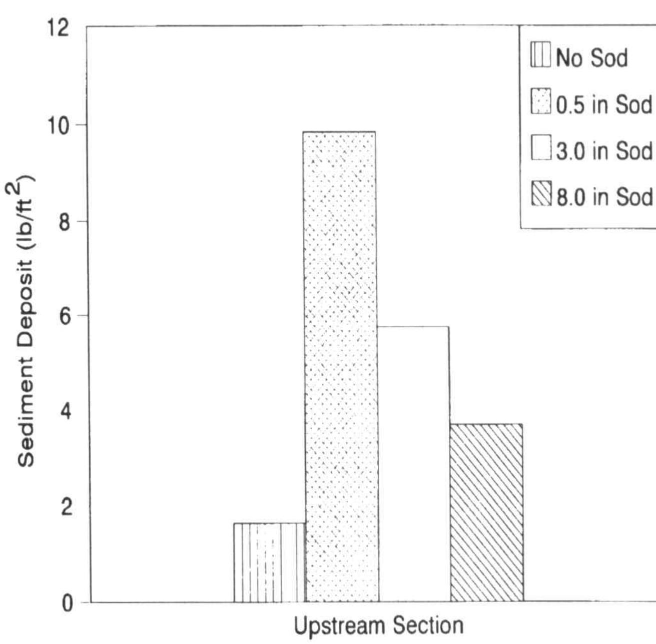

Fig. 3. *Sediment deposition in bluegrass sod with varying leaf lengths.*

lengths of *rigid* vegetation also enhanced deposition. The taller rigid vegetation tended to deflect the water flow and thus reduced the potential source of deposited sediments.

The amount of initial sediment deposition, however, was not the only consideration. The proportion of sediment retained during flushing after initial deposit was equally important. The longer the length of flexible vegetation, the greater the proportion of sediment retained after flushing (Figure 4). The longer vegetation tended to bend in the flow in the downstream direction thereby protecting the sediment from entrainment and transport. A similar sediment protection relationship to length was observed for the rigid vegetation tested, except sediments were retained because the taller rigid vegetation tended to deflect water flow.

When the values of the two curves are multiplied together, one can see that total sediment retention is at or near maximum for flexible stubble heights in the range of about 0.5 to 6 inches (Figure 5). Total sediment retention declined in the presence of flexible stubble lengths greater than 6 inches. Stiff vegetation had less sediment retention capability in our tests (Figure 5). These overall results, however, applied only to individual deposit-retention cycles.

A limited number (4) of multiple-cycle tests were conducted with flexible vegetation (Thornton 1994). After 4 cycles of sediment loading and flushing the total amount of sediment retained continued to increase under the 8.0 and 12.0 inch stubble heights, but not under the 0.5 and 3.0 inch lengths. The net result after 4 cycles was that the 8.0 and 12.0 inch stubble heights retained similar amounts of sediment as did the 0.5 inch length stubble.

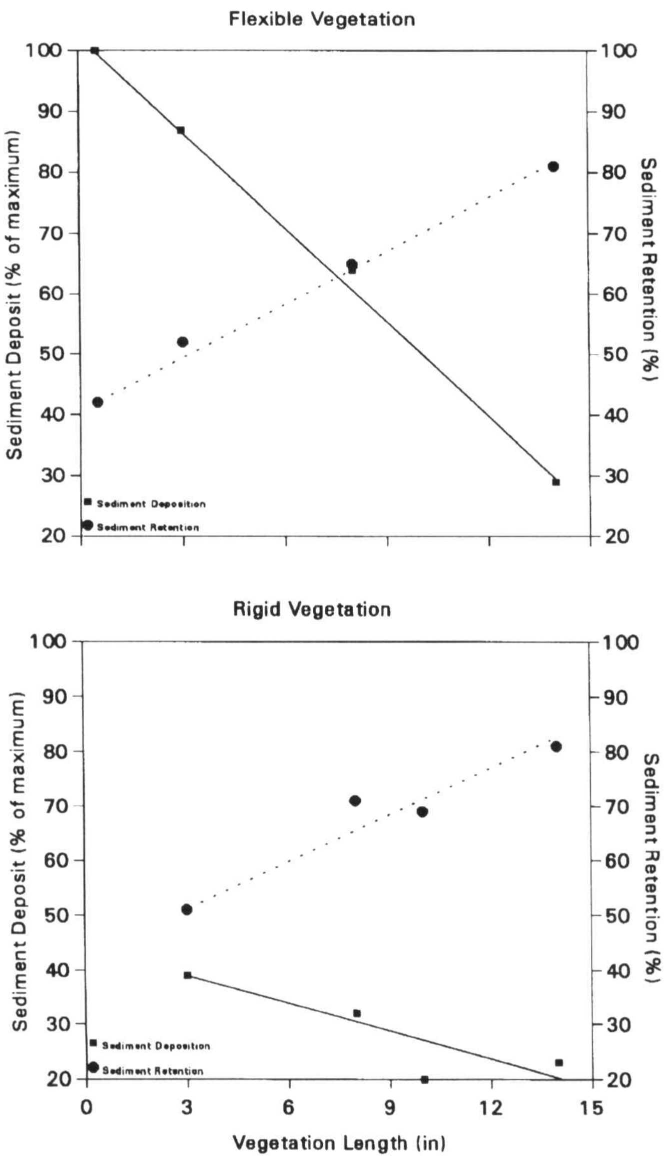

Fig. 4. *Sediment deposition and retention for flexible and rigid vegetation.*

Discussion

Restoration of degraded small-stream riparian channels is dependent upon two distinct phases of the hydrologic processes–sediment deposition and sediment retention. Maximum potential for sediment deposition occurs when the annual peak runoff transports the available sediment from the tributary drainage basin through the riparian-stream system. Restoration begins when a portion of the seasonal sediment load is deposited in the degraded area (deposition phase). Once the streamflow peaks, sediments deposited on the bed and banks are routinely subjected to water flows with reduced sediment loading. The sediment transport capacity of these flows is typically greater than the available sediments, thereby newly deposited sediments are often entrained and flushed downstream from the area of initial deposits (flushing phase). Streambed and bank restoration is dependent upon both deposition and subsequent retention of sediments during flushing. Our results illustrate that different vegetation characteristics are required to maximize these two processes.

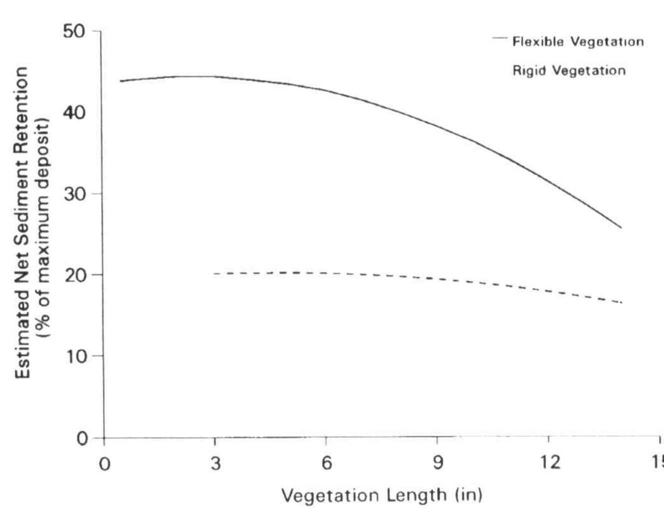

Fig. 5. *Estimated net sediment retention as determined from deposition and retention data.*

Conclusions

The presence of herbaceous vegetation enhances sediment deposition and the channel restoration process in small-stream systems. The shorter length vegetation is most effective in improving sediment entrapment during the deposition phase. The longer length vegetation retains a larger portion of the deposited sediment during the flushing phase. Both the deposition and retention of sediments are building blocks in the stream restoration process. From our work in a simulated channel it appears that short-to-mid length flexible vegetation (0.5 to 6 inches) may be the most effective in supporting the bank rebuilding process within a single cycle of sediment loading and flushing. However, limited tests suggest that, under multiple cycles of sediment loading and flushing, the longer stubble lengths (8 to 12 inches) entrap substantial sediments also.

It is imperative that an optimal vegetation length is determined for specific stream conditions that will allow continued grazing yet not counter the stream restoration process. The frequency of sediment loading and flushing cycles as well as vegetation type play a role in determining the optimum stubble height.

As one considers incorporation of these or similar results on sediment entrapment into riparian management, be sure to remember other factors are important also. The ability of a particular species' roots and rhizomes to stabilize and strengthen streambanks and the amount of trampling occurring on those streambanks are highly significant components in management to improve or maintain the integrity of small-stream channels.

(A list of references describing detailed portions of this study is available from the authors)

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