Caribou National Forest Riparian Grazing Implementation Guide Version 1-2

Riparian Process Paper

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Introduction

Riparian areas are those lands adjacent to water bodies that are considered to be the transition between water bodies (aquatic systems) and uplands (terrestrial systems). They have distinct vegetation and soil characteristics that are influenced by high water tables or the presence of near-surface water. Riparian ecosystems are characterized by a combination of high species diversity and densities and high productivity. Continuous interactions occur between riparian, aquatic and adjacent terrestrial ecosystems through exchanges of energy, nutrients and species (Windell, *et al*, 1986).[1]

Stream systems develop a dynamic equilibrium with the variables of climate, geology, vegetation and surrounding land uses. Any change in any one of these variables can evoke an adjustment response in streams and their valleys (Fitch and Adams, 1998). Nelle (2004) found that a properly functioning creek, along with its riparian floodplain can help ameliorate and buffer irregular pulses of water over space and time and can help keep water more evenly distributed on the land longer. He stated that the essence of riparian function is to efficiently catch, store and release floodwaters, while capturing sediment and improving water quality. Even though these lands may make up a minor (1%-2%) portion of the landscape, they are important for a variety of reasons (Chaney, *et al* 1991, US GAO 1988). Vegetation found within these areas not only provides habitat for wildlife species but exercises important controls over physical and biological conditions and functions in the stream environment.

Vegetation acts as a roughness element that reduces the velocity and erosive energy of water flowing down the channel, reducing not only channel erosion, but assisting in reducing peak flow levels and improving low flows (Fitch and Adams, 1998). Riparian vegetation produces the bulk of the detritus that provides up to 90 percent of the organic matter and 99 percent of the energy necessary to support headwater stream communities. Large woody debris and other obstructions assist in the detention and concentration of organic matter locally, rather than being washed downstream, and serve as substrates for microbial and invertebrate organisms.

Riparian vegetation also provides shade that moderates water temperature fluctuations. The roots of trees, shrubs and herbaceous vegetation assist in stabilizing streambanks, provide cover for wildlife and act as a filter to reduce or prevent upslope sediment from entering the stream system (Kaufman *et al* 1984).

Cattle may spend from five to thirty times the amount of time in riparian areas as in adjacent xeric upland areas. Factors for this disproportionate time include: higher forage volume and relative palatability of riparian plant species; distance to available water; distance upslope to upland grazing sites; and microclimatic features (Clary & Webster 1989).

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[1]In Mosley, Jeffrey C., Philip S. Cook, Amber J. Griffis, and Jay O'Laughlin, *Guidelines for Managing Cattle Grazing in Riparian Areas to Protect Water Quality: Review of Research and Best Management Practices Policy*, Report No. 15, Idaho Forest, Wildlife and Range Policy Analysis Group, University of Idaho, 1997, pg.6.

This is not to say that grazing is totally incompatible with riparian areas. In fact, proper grazing may co-exist with sustainable riparian systems (Larsen *et al* 1998; Elmore & Kauffman, 1994[2]; Buckhouse 2000; Armour, *et al*, 1994), or even in some cases is beneficial for plant density and vigor, which assists in stabilizing soil, slowing erosion and decreasing in-stream sediment (WDEQ 1997). Leonard *et al* (1997) also found that livestock grazing can be a compatible use in riparian areas when managed in harmony with land management objectives, and when the function, capability, and potential of the site and the needs of the riparian vegetation guide the development of the grazing management prescription.

For example, in a Kentucky bluegrass meadow peak production occurred after six years of rest then declined until production was similar to that in an adjacent area grazed season-long (Clary & Webster 1989). In other studies, removal of apical dominance in grass tillers caused more shoots to grow, resulting in a thickening of the grass stand (Mosley *et al* 1997). Hayes (1978)[3] found that in the absence of livestock utilization, species richness and species diversity decreased in dry and moist meadow communities. In "brittle" environments, especially those in low rainfall areas, Savory (1999) found that lack of grazing actually had a worse impact on some upland watersheds than grazing. Under certain circumstances he found the grassland vegetation either shifts toward woody vegetation and "weeds" or to algae and lichens if not grazed.

Laycock (1994)[4] suggested that many vegetation types on public lands are currently in a stable state condition and even if livestock were completely removed, overall watershed condition would change little. Green and Kauffman (1995) found that after ten years of non-grazing in dry meadows, bluegrass remained the most dominant species while the abundane of other species declined. In moist meadows, they found *Carex rostrata* to remain dominant, while other species declined.

However, literature suggests that if **excessive** disturbances are allowed to continue through improper management, detrimental impacts may outweigh benefits (Clary & Webster 1989). Mathews (1996) found that trout density and biomass per unit area were significantly higher in ungrazed than in grazed areas in three of four comparisons. She found that ungrazed areas consistently had greater canopy shading, stream depths and bankfull heights and smaller stream widths than grazed areas. Effects of adverse grazing impacts can be long lasting, requiring a channel system to evolve through an evolutionary process that may take a significant period of time (Rosgen 1996).

The effects of livestock grazing on riparian areas, including stream channel stability, aquatic habitat, and water quality, have been studied and documented by numerous authors. Most agree that livestock can and do have impacts if improperly managed and can adversely affect the general characteristics and functions of riparian areas (Chaney *et al* 1991; Fitch and Adams 1998). Belsky *et al* (1999) concluded there were no positive effects of grazing and, at best, grazing had neutral effects. He found that livestock grazing negatively affects water quality and seasonal quantity, stream channel morphology, hydrology, riparian zone soils,

[2] In Vavra, Martin, William A. Laycock and Red D. Pieper eds. 1994. Ecological Implications of Livestock Herbovory in the West. Society for Range Management, Denver, CO.

[3] In Green, DM. and Boone Kauffman. 1995. Succesion and livestock Grazing in a Northeastern Oregon Riparian Ecosystem. Journal of Range Management. 48:307-313.

[4] Ibid

instream and streambank vegetation, and aquatic and riparian wildlife.

Effects include:

- Higher stream temperatures from lack of sufficient streamside cover;
- Excessive sediment in the channel from bank and upland erosion;
- High coliform bacteria counts from upper watershed sources;
- Channel widening from hoof-caused bank sloughing and later erosion by water;
- Change in the form of the water column and the channel it flows in;
- Change, reduction or elimination of vegetation;
- Elimination of riparian areas by channel degradation and lowering of the water table;
- Gradual stream channel trenching or braiding depending on soils and substrate composition with concurrent replacement of riparian vegetation with more xeric plant species (Clary 1989).

In addition Winegar (1977)[5] found severe icing conditions existed on a stream in Oregon within a reach grazed by livestock, but observed only light channel icing conditions within an adjacent ungrazed reach containing ungrazed riparian vegetation. He also observed that streamflows in an ungrazed stream reach changed from ephemeral to perennial conditions. Similar changes in flow conditions from intermittent to perennial have also been observed in Goodheart Creek, located on the Caribou National Forest after a reach was protected from grazing by fencing (Leffert, 2000).

EPA (1994) has also summarized grazing effects on riparian areas, as well as Chaney, *et al,* 1991; Myers (no date); Platts, *et al,* 1984, 1985 and 1991; Hall & Bryant 1995; and others.

Vegetation and ecosystem responses can be highly site-specific. No single formula or template can be used to anticipate or evaluate success or failure in all situations (Elmore & Kauffman 1994). The interacting factors that drive change, desired future vegetation and channel structure and condition, and how ungulates interact with the entire system should be the foundation of any practical grazing management strategy or restoration effort (Larsen *et al* 1998).

Riparian areas cannot be looked at as an entity in itself. A fundamental interdependence exists between upper watershed condition and riparian health and function (Chaney *et al* 1991; Elmore & Kauffman 1994)). Livestock grazing in the upland, for example, can increase soil compaction, decrease plant cover and soil surface litter that can reduce water infiltration capacities, which in turn, can increase overland flows and the volume of eroded material moving into riparian areas. Reduced conditions of the surrounding uplands may act to increase sediment-laden streamflows and increase stream erosive power, which can greatly impact riparian areas (Clary *et al* 1996a).

Streamside Vegetation and Stream Morphology

Streamside vegetation serves many ecological roles. These include reducing surface water flows, increasing water

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[5] In Platts, William S. and Fred J. Wagstaff, *Fencing to Control Livestock Grazing on Riparian Habitats Along Streams: Is it a Viable Alternative?* North American Journal of Fisheries Management 4:266-272, 1984.

infiltration, decreasing erosion, capturing sediments, moderating soil and water temperatures, moderating seasonal stream flows, and facilitating nutrient cycling and energy flows (McInnis 1997). Riparian vegetation can have a significant influence on the stability of certain stream types (Rosgen 1996).

For many stream channels, a combination of riparian vegetation with woody root systems, deep rooted grasses and other vegetation provides a physical barrier to the effects of high water velocities and stream energy, which can control channel shape and function (Fitch and Adams 1998). The controlling influence of riparian vegetation can vary from low to high, depending on the stream type. Changes in the composition, vigor, and density of riparian vegetation produce corresponding changes in rooting depth, rooting density, shading, water temperature, physical protection from bank erosion processes, terrestrial insect habitat and contribution of detritus to the channel.

Water quality and aesthetic values are also affected by changes in riparian vegetation (Rosgen 1996). Where excessive livestock impacts occur, there is often a lowering of the surrounding water table (Clary *et al* 1996).

Summer solar radiation accounts for about 95 percent of the heat input into Rocky Mountain streams during midday. The presence of streamside vegetation can substantially reduce the amount of solar radiation reaching a stream, which serves to moderate summertime stream temperatures. Conversely, the same streamside vegetation can act as an insulator and preserve wintertime heat. Clary, *et al,* (1997) observed thick buildups of anchor ice in a reach of an Oregon stream where streamside vegetation was reduced by grazing, where an ungrazed reach had only light icing.[6]

The potential for change within a riparian system is related to the amount and kind of stress it receives. For example, a stream system with highly erodible banks has a high degree of potential natural stress. In this situation, management induced stresses (e.g. heavy livestock grazing) should be limited to avoid adjustments by the stream system into a lower or less stable successional state (McInnis 1997).

Indicators of stress include widening channel, channel downcutting, more than 10 percent eroding banks, increasing frequency of new streambars, noxious weeds or unvegetated streambanks, encroaching upland shrub species, lack of shrub and tree regeneration, and/or hedged shrubs (Harper *et al* 2000).

Conversely, stream morphology can have a direct influence on the type and densities of vegetation that may grow along a streambank. Knowing the stream type can assist in determining the potential succession of riparian vegetation communities (Overton *et al* 1995). The understanding of this interrelationship is critical to the proper management of livestock.

For example, when deep-rooted woody species are converted to shallower rooted grass/forb communities, the ability of plants to protect the bank from flow sheer stress changes, and a series of channel adjustments can take place. This can include an increase in sediment deposition, bank erosion, sediment supply, changes in channel shape, and channel slope, and decreases in meander

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[6]In Platts, William S. and John N. Rinne, *Riparian and Stream Enhancement Management and Research in the Rocky Mountains*, North American Journal of Fisheries Management, Vol. 5, No. 2A, 1985.

length ratios and sinuosity. The resultant channel instability is often followed by a degradation of fish habitat (Rogsen 1996). Rosgen (1996) has described channel sensitivity to disturbance, recovery potential, streambank erosion potential and vegetation controlling influence by channel type (See Table 7, page 61)

Recent studies have indicated that the contribution of streambank erosion to total sediment yields has been greatly underestimated (Rosgen 1996). Rosgen (1996) identified five basic variables that influence the amount of potential bank erosion:

- Bank Height/Bankfull Height ratio;
- Root Depth/Bank Height ratio;
- Root Density;
- Bank Angle; and
- Surface Protection.

Of these five variables, three either directly or indirectly relate to the species and density of plants growing along the stream. Once a streambank begins to erode, two basic kinds of stream system adjustment responses occur in terms of erodibility characteristics: vertically and laterally (USDI 1990).

Vertically unstable streams will cut down causing an incised channel and lowered water tables. Henszey (1993)[7] explored the relationship of riparian plant communities to depth-to-groundwater. He found that the Wet Meadow type supported mostly a tall sedge plant community, where a Moist-Wet Meadow type supported tall and short growing sedges and tufted hairgrass. A Moist meadow consisted of mostly tufted hairgrass and Kentucky bluegrass, where a Dry Meadow contained mostly bluegrass. All communities were flooded about the same, but the Moist-Wet, Moist and Dry Meadows had increasingly longer periods of sub-surface water below the rooting depth of the plants. This suggests that depth to groundwater, rate of drainage, and availability of water to plants may cause a change in plant species composition along stream channels as they evolve through a successional sequence from mature to degraded.

Laterally unstable streams will not cut down, because of a restriction, such as rock, but can expand laterally through bank erosion (McInnis 1997). Lateral migration rates of the stream channel can be accelerated when variables, such as vegetation, are altered, especially those variables affecting detachment of bank material and flow stresses in the near-bank region (Rosgen, 1996). Some channel types are naturally armored and have an inherent ability to resist erosion and corresponding channel adjustment (Rosgen 1996; Elmore & Kauffman 1994). Channels containing bedrock or boulder substrate are examples.

However, in most stream types, the ability of streambanks to resist erosion is determined by:

- The ratio of streambank height to bankfull stage;
- The ratio of riparian vegetation rooting depth to streambank height;
- The degree of rooting density; the composition of streambank materials;
- Streambank angle;
- Bank material; and

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[7]In Heitschmidt, Rod, Kenneth D. Sanders, E. Lamar Smith, W.A. Laycock, G Allen Rasmussen, Quentin D. Skinner, Frederick C. Hall, Richard Lindenmuth, Larry W. Van Tassell, James W. Richardson, et. al., *Stubble Height and Utilization Measurements, Uses and Misuses*, Agricultural Experiment Station, Oregon State University, Station Bulletin 682, May, 1988.

- Bank surface protection afforded by debris and vegetation.

If any of these variables are altered, a corresponding adjustment in the channel may be initiated (Rosgen 1996). The response of a given channel to stress depends on the inherent level of resilience of the system and how much stress is placed on the system (Elmore & Kauffman 1994).

Several methods of rating riparian and channel condition, stability, and stress have been developed. These include: Channel Stability (Pfankuch) Evaluation and Stream Classification Summary (Level III) (Rosgen 1996); Bank Erosion Hazard Index (BEHI) (Rosgen 1996); and the Properly Functioning Condition assessment procedure (Prichard 1998). Table 8 (page 63) describes desirable channel features. These features are designed after INFISH Riparian Management Objectives (RMOs).

Grazing Strategies in Riparian Areas

Stream channels, in association with adjacent riparian zones, adopt forms and modes of function that allow efficient transport of water and sediment (Leopold and Langbein, 1962).[8] Stream and channel form, in turn, contributes to the physical and biological makeup of the riparian system (Brussock, *et al*, 1985).[9] Channels continuously respond to changes in controlling factors such as discharge, sediment delivery, or changes in channel bed and/or bank conditions (BLM 1990). Increased channel sediment reduces channel capacity, increases width/depth ratios and induces bank erosion and other instabilities. Alternatively, excessive water reaching a stream system without additional sediment loading can erode the channel bottoms, thus incising the channel (Clary *et al* 2000). These adjustments can be rapid or evolve over a long period of time. Adjustments can also be nominal or severe, depending on a variety of factors (BLM 1990).

Riparian areas should be managed within the context of the entire watershed. A balance exists between health, diversity and productivity of riparian communities and the watershed conditions where they are contained. All tributary effects accumulate to influence riparian health and stability. Upland watersheds in satisfactory condition absorb storm energies, provide stormflow regulation through the soil mantle and contribute stability to the entire watershed. In contrast watershed that have experienced past abuse often have developed channel systems, including gully networks, throughout the watershed in response to the increased surface flows. These gully networks cause rapid, concentrated surface runoff with increased peak flows and sediment loads. In general, small streams are more affected by hillslope activities than larger streams, and, as adjacent slopes become steeper, the likelihood of disturbance from in-stream effects increases (Clary *et al* 2000).

In general, channel adjustments are characterized by either downcutting or widening. Excessive downcutting may not directly remove vegetation from the riparian zone, but may lower the water table, effectively de-watering the riparian zone,

[8] In Bureau of Land Management. 1990. *Riparian Management and Channel Evolution,* Course Number SS1737-2, Phoenix Training Center.
[9] Ibid

which effects the vegetation. A second scenario is channel widening, which can directly affect riparian vegetation through the loss of the channel bank and flood plain (Leffert 2000).

Throughout the western United States, deeply downcut channels are widespread and frequently occur in fine-grained, deep alluvial deposits where streambeds are unconstrained and non-resistant. These downcut channels result from either downstream base-level lowering or localized gullying initiated by changes in runoff rates or lowered resistance to erosion. Advancing gully systems may increase peak discharges, making the stream more efficient at scouring channel beds and banks (Wallace and Lane, 1976)[10]. Channel bed degradation produces a corresponding drop in the local water table, which imposes a subsequent water stress on the riparian vegetation (Groeneveld and Griepentrog 1985). A loss of riparian vegetation in turn lowers the resistance to flow, allowing higher flow velocities which increases scouring, which perpetuates the cycle (Schumm and Meyer 1979)[11].

In comparison, coarse alluvial channels or channels with structurally controlled beds tend to respond to direct riparian impacts by becoming wider and shallower with less-steep banks (Kauffman, *et al*, 1983, Duff 1977). In addition to providing poor aquatic habitat attributes (Kauffman & Krueger 1984), channels impacted by lateral scouring may become less capable of properly transporting high flows and may directly impact riparian areas through bank cutting or channel realignment during high flow periods. Riparian area problems caused by this type of channel condition are aggravated by increased in-stream sediment loads resulting from upstream erosion (Jackson 1984)[12] which may cause further channel adjustments, perpetuating the cycle.

Management options will vary depending on the type of channel adjustment (downcutting vs. channel widening). Deep, narrow downcut channels, especially those still active that have not reached a firm or resistant bed level, are the least responsive to various management options. Designed structures can be very expensive to install and the probability of improving the overall condition is minimal. Removing or reducing livestock impacts also provides minimal response. Once in this condition, the channel must be allowed to progress through the evolutionary process to the next phase or stage (BLM 1990; Rosgen 1996).

On the other hand, channels that have bed controls and adjust laterally tend to respond directly to riparian vegetation conditions. Stream banks and floodplains generally can be rehabilitated relatively rapidly, provided the water table has not been affected by excessive channel downcutting. In this scenario, elimination or reduction of livestock grazing in the riparian zone generally results in quick recovery (Platts and Rinne 1985). The need to understand the cause of stream/riparian degradation, and work with the natural recovery process operating in a stream system needs to be emphasized (Cairns, *et al*, 1979)[13].

Rehabilitation should emphasize establishing the physical and biological conditions that favor rapid recovery by natural processes. Stream systems undergoing major channel adjustments should not be treated with extensive habitat improvements until the channel has reached a new dynamic equilibrium (BLM 1990). Dynamic

[10] In BLM 1990
[11] Ibid
[12] Ibid
[13] Ibid

equilibrium has been described by Rosgen (1996), Prichard (1998), and others.

For example, Magilligan and McDowell investigated four gravel-bedded, steep alluvial streams in eastern Oregon, with cattle exclosures greater than 14 years old. Results indicated that significant changes occurred, with reductions in bankfull dimensions and increases in pool area being the most common and identifiable changes. At the four sites, bankfull widths narrowed by 10% to 20%, and the percentage of the channel area occupied by pools increased by 8% to 15%. Increase in pool area was offset by a reduction in the percent glide area. However, they also stated that not all channel properties demonstrated adjustment, indicating that not all variables may show a significant change in that time period. Platts and Nelson (no date) noted a substantial difference in stream morphology between grazed and ungrazed pastures, as did Clifton (no date). Platts and Nelson (no date) also noted channel improvements were observed after 4 years of removing livestock from the pasture. Kondolf (1993) noted that channel adjustment to grazing pressure may lag behind plant changes because of the time required to erode and deposit sediment along the banks of a stream channel.

Strategies for grazing in riparian areas vary somewhat between authors, but most have a common theme. These themes include: Limit grazing intensity, frequency, and/or season of use, thereby providing sufficient rest to encourage plant vigor, regrowth and energy storage and minimize compaction of soil; control the timing of grazing to prevent damage to streambanks when they are most vulnerable to trampling; and ensure sufficient vegetation during periods of high flow to protect streambanks, dissipate energy and trap sediments (Leonard *et al* 1997; Platts & Nelson 1985; Ehrhart & Hansen 1998; Chaney, *et al,* 1991; Mosley, *et al,* 1997).

Reduction or elimination of negative livestock impacts to streambanks within western riparian zones requires an understanding of the interaction between climatic patterns, riparian zone soils and livestock behavior (Marlow 1987). Before a specific grazing strategy is implemented in response to an observed channel condition, several items must be known to properly apply the most beneficial and cost/effective management approach. Normal channel adjustments associated with water/sediment processes may actually serve to enhance or rejuvenate riparian conditions. Excessive adjustments, however, associated with rapid responses to changes may temporarily or permanently impair normal stream channel and riparian conditions (BLM 1990). Management responses or strategies in turn require: a) a description or classification of riparian area degradation; and b) an identification of the cause(s) of impaired riparian conditions (BLM 1990).

Passive, continuous grazing rarely improves deteriorated riparian areas or maintains riparian areas in good condition. Grazing must provide an adequate cover and height of vegetation on streambanks and overflow zones to promote natural stream functions (sediment filtering, bank stability, aquifer recharge and water storage) (Leonard, *et al,* 1997).

Platts (1991)[14] highlights three major considerations for maintaining or restoring riparian areas. First, grazing management must consider the needs of those plant species that establish riparian function.

[14] In Meehan 1991. Influences of Forest and Rangeland Management on Salmonid Fishes and their Habitats. AFS Spec. Publ. 19, Bethesda, MD. p. 289-423

Species with deep fibrous roots provide sod mats, plant diversity provides multi-layered vegetation cover, and woody species provide roots and large woody debris. Second, there must be adequate plant cover and residue to attenuate high flows. Third, protection from grazing is required during vulnerable periods when banks are saturated and easily damaged or in autumn when woody species are most vulnerable to browsing.

Perry (2005) suggested several ways to manage livestock impacts within riparian areas. He emphasized that fencing must remain as a possible alternative, but it should be the **last** choice, after every other management option has been considered. Other options include:

- Develop off-stream watering in as many places as possible.
- Create "hardened crossings" where there are steep banks which are vulnerable to livestock damage, or during muddy conditions.
- Provide culverts or bridges as an easy way for cattle to cross a stream without needing to ford the stream.
- On wooded or densely brushed streams, a physical barrier made up of felled trees or logs may work in places where animals are causing damage.
- Graze in the spring in areas susceptible to bank damage.
- Locate salt and nutrient blocks well away from the riparian zone.
- Riding to move animals away from water, works well in many cases.
- Burn, mow or intensively graze or in some other way remove some old, un-grazed forage on suitable sites away from streams, making palatable re-growth more accessible.
- Remove animals from the herd that habitually hang in the riparian zone, and conversely, keep older animals that do not.

Davison & Newfield (2005) suggested that constructing off-riparian shade structures in rangelands lacking shade would also assist in reducing livestock impacts in riparian zones.

Monitoring Parameters

In order to assess the condition and use of riparian areas by livestock and other users and impacts, various authors have suggested several parameters that could be effectively monitored. Stocking rates, percent utilization of plants and stubble heights have all been used to describe grazing intensity. Each measurement has its purpose, benefits, and shortcomings (Mosley *et al* 1997). Rosgen (1996) and others have suggested other parameters, such as bank stability and soil disturbance. The following section details the most popular parameters.

Stubble Height

The height of grassy and herbaceous vegetation on a site has been termed "stubble height" (Heitschmidt *et al* 1998). Stubble height is a surrogate for plant vigor and streambank and riparian protection/rebuilding capabilities. It is not only a way to measure utilization by grazing, but it also has value in evaluating how well vegetation and grazing management meets channel stability goals and objectives. Several researchers have advocated specific residual stubble heights following grazing to maintain plant vigor and protect or improve stream banks (Heitschmidt *et al* 1998).

Plant growth occurs from meristematic tissue. The growing points of grasses are located in the crown of the plant close to the ground, until the culm elongates to produce a seedhead. During the seedhead stage, the growing point is elevated and is exposed to grazing animals. When a grass is grazed without removing the growing point, leaf growth will continue so long as there is adequate soil moisture and nutrients. When grazing removes the growing point, growth of that tiller stops and the plant must begin growth from a new bud. Development of these tillers will be slower than ungrazed tillers. Growth, form, palatability and vigor of these tillers may be different between grazed and ungrazed plants.

Some grasses, such as Kentucky bluegrass do not elevate their growing points until just before the reproductive phase. These plants are more resistant to close grazing than other species that elevate their growing point earlier in their development (McInnis 1997). As a result, different plants may require different grazing strategies to maintain plant health and vigor (Marlow 2001).

Plant vigor can be measured or evaluated in many different ways. One common way is to measure the change in the relationship or the ratio of underground biomass to above-ground biomass over time. Studies show that grazing can alter above-ground biomass to such an extent that undergound biomass is reduced. Not only is the photosynthesizing capacity of the plant diminished, but the carbohydrate root reserves that support growth and regrowth are reduced. Research offers strong support for measuring stubble height to monitor grazing effects on plant vigor (Heitschmidt *et al* 1998).

Clary & Webster (1989) recommended that a minimum herbage stubble height be present on all streamside areas at the end of the growing season, or at the end of the grazing season if grazing occurs after frost in the fall, to maintain plant vigor and health. They suggest residual stubble or regrowth should be at least four to six inches to provide sufficient herbaceous forage biomass to meet the requirements of plant vigor maintenance, bank protection and sediment entrapment. The stubble height criterion should be adhered to regardless of the grazing system used (Clary & Webster 1989). Clary & Webster (1995) suggested that a stubble height of ten centimeters (four inches), or about 30 percent utilization, appears to be required to ensure full biomass production in high mountain meadow (greater than 1,900 meters) sedge communities.[15]

Clary (1999) found that most measurements of streamside variables moved closer to those beneficial for salmonid fisheries when pastures were grazed to a ten centimeter (four inches) graminoid stubble height, while virtually all measurements improved when pastures were grazed to fourteen centimeters (six inches) stubble height.

The Rocky Mountain Region, Watershed Conservation Handbook, (September 1996) advocates removal of livestock from riparian areas when average stubble height on key species reaches four inches in early-use pastures and six inches or more in late-use pastures. Hockett and Roscoe (1993) advocate greenline end-of-season stubble heights of at least twenty centimeters (eight inches) and ten to fifteen centimeters (four to six inches) for riverine systems of high to low sensitivity levels, respectively, and more than 75 percent and 35-50 percent of ungrazed plant height for high and low sensitivity level palustrine systems,

[15]In Clary, WP, *Vegetation and soil responses to grazing simulation on riparian meadows*, J. Range Management 48, 18-25, 1995; in USDI, BLM, List of References on the Use of Utilization Guidelines and on the Effects of Lower Stocking Rates on the Recovery of Rangelands, 17 September, 1997.

respectively, in southwest Montana that are designed to comply with State of Montana water quality standards.

Caution should be used when working with different plant communities. Existing Forest Service guidelines (Clary & Webster 1989) are based largely on minimum stubble heights in communities dominated by Kentucky bluegrass. If the riparian area is dominated by taller grass species, like timothy, mountain brome, streambank wheatgrass, tufted hairgrass, fowl Mannagrass for fowl bluegrass, adherence to the recommended stubble heights will lead to 80 percent or more utilization. In these situations, eight to nine-inch stubble heights equate to about 50 percent utilization (Marlow 2001).

If the channel has been degraded and streambanks need to be rebuilt, a key element for the restoration process 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 (Clary *et al* 1996). Streambank vegetation has been shown to increase channel roughness. Increased channel roughness, in turn, dissipates energy and promotes sediment deposition (Heitschmidt *et al* 1998). Total sediment retention appears to be at or near maximum for flexible stubble heights up to six inches during the depositional phase (when sediment is being deposited) of the hydrograph, although longer length vegetation appears to retain a larger portion of the sediment deposited during the flushing phase (when sediments are being flushed through the system) of the hydrograph (Clary *et al* 1996).

In addition to the physical attributes of stubble height, palatability of vegetation species also changes as stubble height is lowered. Because of their preferred eating habits, cattle prefer vegetation greater than three inches high. As stubble heights are grazed below three inches for the most palatable species, vegetation preference will change, forcing cattle onto less desirable areas or eating less desirable species, such as changing from grass to sedges to shrubs (Hall & Bryant 1995).

Other researchers found a shift in preference from herbaceous vegetation to shrubs below a stubble height of four to six inches, or about 45 percent utilization. Stubble heights below two to four inches induced excessive browsing of willows (Mosley *et al* 1997, Pelster *et al* in press). This in turn can influence the vigor and distribution of riparian vegetation, which in turn can directly affect channel stability. Therefore, stubble height not only has a direct correlation to physical channel stabilizing attributes but reflects a point at which livestock may change from consuming grassy and herbaceous species to other species such as sedges and willows. This switch may not be preferable in relation to channel maintenance features, water quality and/or fisheries habitat (Hall & Bryant 1995).

Platts (1991)[16] suggests that trees, brush, grasses and forbs each play an important role in building and maintaining productive stream ecosystems. Grasses and grass-like plants, especially sod-forming types, help build and bind bank materials, and reduce erosion. As well-sodded banks erode, they create the undercuts important as hiding cover for fish. Even though he does not suggest specific stubble heights, he emphasizes the importance of streamside

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[16] In Meehan, William R., *Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats*, American Fisheries Society Special Publication 19, Bethesda, MD, 1991

vegetation for cover. This suggests that one-inch or even six-inch stubble heights may not be enough to provide needed protection, but longer stubble heights that bend over the bank may be needed for cover and protection as well as provide thermal moderation in smaller streams.

In 2004, the University of Idaho issued "Stubble Height Study Report". In responding to requests of both the Forest Service and Bureau of Land Management, the University put together a team to review the use of stubble height and make recommendations on its use. The 33 page report thoroughly examined 10 questions: 1) What agency objectives are we trying to achieve with stubble height? 2) What is the appropriate use of stubble height? 3) How are the agencies in fact using it? 4) What are the limitations of its use? 5) How appropriate is it to use to address annual long-term management strategies? 6) What additional research might be needed, if any, to affirm or refine this measure? 7) What other measures might be used in its place? 8) What other measures might be needed to achieve management objectives in riparian areas? 9) How much rest or change in management is needed when stubble height objectives are not met? and 10) Can we adjust the stubble height objective if a grazing management system is in place? Conclusions of the report are as complex as the questions.

Conclusion

Stubble height appears to be an appropriate parameter to monitor potential effects on plant vigor, bank stability and regeneration, and movement of livestock to other plant types and species. Maintaining a minimum stubble height helps preserve forage plant vigor, retain sufficient forage to reduce cattle browsing of willows, stabilize sediments, indirectly limit streambank trampling, maintain cattle gains and provide an easily communicated management criterion (Clary and Leininger 2000).

It appears that stubble heights less than two to three inches is an indicator of detrimental effects to plant vigor, movement to other plant species, bank stability and bank building. Maintenance of plant vigor, which includes roots, is extremely important for bank stability. High elevation (greater than 1,900 meters) mountain meadow sedge communities appear to require at least four inches residual to ensure full biomass production. Other species at lower elevations with longer growing seasons could withstand clipping down to two inches and still maintain vigor depending on the regrowth from the end of the grazing period to the end of the growing season. Changes in palatability and preference begin to appear below six inches and appears to be profound below two inches. Clary and Leininger (2000) recommend a four-inch stubble height be a minimum starting point. Monitoring should be conducted to determine if adjustments are needed.

Bank sediment holding capacity is diminished below two inches and maximized during the sediment deposition phase of the hydrograph at six inches. Therefore, two inches appears be an absolute minimum allowable stubble height under any circumstances, no matter what the channel type or overall riparian condition. For most applications, four to six inches residual appears to be all that is necessary to maintain bank-building process and reduce livestock migration to less palatable species. As a result, a range in stubble heights between two inches and six inches appears to be appropriate to maintain bank stability, plant vigor and riparian plant integrity, with a medium range of four to six inches being appropriate for most circumstances.

However, Clary and Leininger (2000) also found that stubble heights may have little application where streambanks are naturally stabilized by coarse substrates, or where the channels are deeply incised.

In some situations, such as fish cover, water quality protection and thermal moderation, stubble heights in excess of six inches may be needed. This may be especially important along smaller or non-forest streams where overhead shrub and tree cover may be lacking. Hockett and Roscoe (1993) appeared to recognize this and advocated an end-of-season stubble height of at least eight inches on sensitive streams.

Stubble height is NOT an appropriate performance standard to be used as a management standard as a desired condition, end-point or trend. It can be used, however, as a guideline or indicator for evaluating and/or changing annual management in Annual Operating Instructions. Stubble height is appropriately used as a short-term indicator of grazing effects on meeting long-term riparian management objectives, such as channel stability or vegetation composition. Stubble height criteria can vary depending upon local environmental variables, condition and trend of the stream, species composition on the greenline and the season, frequency and duration of livestock use. Stubble height criteria not only can but should be adjusted through adaptive management, based on riparian conditions and trend (University of Idaho 2004).

Percent Plant Utilization

The impact of grazing on plant communities may be estimated in two ways: by estimating the height of vegetation that remains after grazing (stubble height), or by the amount of vegetation that has been consumed (utilization) (Heitschmidt *et al* 1998). Some authors argue that individual plants differ in physiology and have different inherent growing heights. For example, 35 percent utilization might result in a 5-inch stubble height for Agsp (bluebunch wheatgrass), a 2-inch stubble height for Feid (Idaho fescue) and Pose (sandberg bluegrass), and a 2.5-inch stubble height for Koer (junegrass) (USDA 1999). A 50 percent utilization of taller grasses like timothy, mountain brome, streambank wheatgrass, etc. will equate to an eight- to nine-inch stubble height (Marlow 2001). Further, during some seasons or periods with low moisture levels, some plants may not achieve a specific stubble height. Therefore, in these situations, the percent of the plant used may be a better indicator of use than the physical height of the plant remaining (Clary & Webster 1989) unless specific on-site correlations can be made.

Determining percent utilization can be a time-consuming process and subject to error, depending on a variety of factors. By definition, measuring utilization requires knowing the total production for the year for the species in question. This requirement makes a true measurement of utilization difficult. Total yearly production cannot be effectively measured before the end of the growing season. The best that can be done in a one-time effort prior to that time is to estimate peak standing crop of current-year production. Measurement before the point of peak standing crop results in a low estimate of total biomass, because annual production has not been completed. Low estimates can occur after peak growth due to losses from weathering, insects and decay (Heitschmidt *et al* 1998). Because of these factors, it is difficult for the manager to use percent utilization as an accurate and effective tool during the growing season to indicate allowable conditions have been achieved and livestock should be moved.

Nevertheless, some researchers and authors have suggested specific utilization standards. Clary & Webster (1989) suggested a maximum utilization of riparian herbaceous vegetation during spring, summer and fall grazing periods not to exceed 65 percent, 40-50 percent, and 30 percent respectively, within riparian pastures in good to high ecological status. Clary & Webster (1995) also found that if utilization guidelines are used, those rates that do not exceed 30 percent of the annual biomass production in mountain meadow sedge communities will likely maintain production the following year. Clary (1999) found that light grazing (20-25 percent) utilization, and medium grazing (35-50 percent) during late June, improved stream channel width/depth ratios and channel bottom embeddedness over conditions resulting from past traditional heavier use rates. The Rocky Mountain Region's (R-2) Water Conservation Practices Handbook advocates a maximum use of 40-45 percent of annual production in riparian areas (USDA 1996). Hockett and Roscoe (1993) advocate allowable utilization levels of less than 30-45 percent along high sensitivity streams, lakes and wetlands and 45-60 percent utilization along moderate and low sensitivity waterbodies. Fitch and Adams (1998) state that recommended utilization levels reviewed in literature tend to fall in the range of 25-65 percent, but levels should be set to maintain herbaceous productivity, leave adequate protective cover during high runoff periods to protect banks, filter or trap sediment and dissipate stream energy. Clary (1999) equated light grazing to 20-25 percent utilization and medium intensity grazing to 35-50 percent utilization during late June. Both the light and moderate grazing intensities resulted in improved riparian and stream channel conditions that resulted from past heavy grazing.

Upland utilization levels have been well documented. For example, Beale (1984) tested the effects of various sheep utilization levels on animal production per unit area in semi-arid rangelands west of Queensland, Australia. They found the optimum utilization rate appeared to be about 30 percent. Gray (1968) concluded that net returns on rangelands are highest when the grazing rate is moderate (30-50 percent). Holechek (1988) summarized acceptable stocking rates as those that resulted in utilization of 30-40 percent within semi-desert grasslands and shrublands, coniferous forests, mountain shrublands and oak woodlands.

Higher utilization levels can be allowed on ranges in good condition, while lower utilization levels should be used on poorer rangeland conditions. Holechek (1994)[17] suggested that moderate (40- 45 percent) utilization appears more profitable and less risky than heavy (60-65 percent) on shortgrass ranges in New Mexico. Houston (1966)[18] concluded that utilization of both western wheatgrass and needle-and-thread grass should not exceed 33-37 percent by weight for optimum productivity. Hyder (1951)[19] argued for utilization levels of 30-40 percent for most sagebrush-grass rangelands. Johnson (1953)[20] found that average herbage production decreased with heavy grazing (greater than 50 percent), while production increased with light to moderate grazing (less than 40 percent) in central Colorado. Klipple

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[17] In Willoughby, John, Letter and enclosed *List of References of Utilization Guidelines and on the Effects of Lower Stocking Rates on the Recovery of Rangelands*, to Dr. Jerry Holechek, College of Agriculture and Home Economics, Department of Animal and Range Sciences, Las Cruces, NM, USDI, BLM, Sacramento, CA.,Sept. 25, 1997.
[18] Ibid
[19] Ibid
[20] Ibid

(1960)[21] concluded that 60 percent utilization was too heavy, either for maintaining satisfactory range condition or making best gains by the cattle, while 40 percent utilization maintained or improved range condition and maintained the cattle in thrifty condition. Vallentine (1990)[22] suggested proper use of 35-45 percent for western mountain grasslands, shrublands and coniferous forests. Holechek (1988) found percent use of key species for moderate grazing ranges between 30-40 percent in semidesert grass and shrublands, sagebrush grasslands, coniferous forests, mountain shrublands, and oak woodlands. He also suggests a percent reduction of grazing capacity based on slope. For example, slopes ranging from 31-60 percent should have grazing capacity reduced by 60 percent. Lacey (1988) suggested most plants can maintain vigor if no more than 30-50 percent of their growth is removed during the growing season. Although plants may tolerate 60-65 percent utilization during non-growth periods, sufficient litter and stubble must be left to reduce evaporation, protect growth buds, catch snow, protect plant crowns from freezing and retard soil erosion. He suggests overall range condition will usually improve or be maintained under a moderate (31-60 percent) degree of grazing use.

Several authors have described the relationship between stubble height and percent utilization. Clary & Webster (1989) described an approximate relationship between percentage utilization and stubble height of riparian graminoids based on a 1988 study from the Stanley Creek (mountain meadow ecosystem) and Pole Creek (sagebrush ecosystem) studies. These data suggest that average utilization levels of 24-32 percent were obtained when riparian graminoids were grazed to a six-inch stubble height, use levels of 37 to 44 percent equated to a four-inch stubble height, and use levels of 47-51 percent were obtained at a three-inch stubble height. Heitschmidt, *et al*, (1998) found that 50 percent utilization of Kentucky bluegrass, tufted hairgrass and Nebraska sedge equated to 3 inches, 2 inches and 6 inches respectively.

The reason for the differences is the physiology of the plants. Herbage weight of leaves and shoots of Nebraska sedge is somewhat evenly distributed from the plant's crown to its top. In contrast, most herbage weight of Kentucky bluegrass and tufted hairgrass is near the ground surface as leaves and only a small portion of the overall biomass is elevated as stems and flowers. Forest Service Handbook 2209.21 (1993) describes average utilization levels of riparian graminoids of 24-32 percent equated to a six-inch stubble height, 37-44 percent equates to a four-inch stubble height, and 47-51 percent equates to a three-inch stubble height.

Conclusion

Percent utilization, as stubble height, is a surrogate for plant vigor and streambank protection/rebuilding capabilities. The inherent difficulties of measuring percent utilization aside, the literature appears to support utilization rates less than 50 percent for most riparian herbaceous vegetation types in most climatic and geographic areas. The better the range site condition, the more allowable utilization. Acceptable utilization rates appear to be somewhat higher across-the-board in riparian areas than on some upland ranges, primarily because of the available moisture that supports regrowth. In riparian areas, because of the increased

[21] Ibid
[22] Ibid

moisture levels, it appears that utilization rates can be adjusted by season of use (early, mid, late) that allows for plant regrowth potential following use. Clary & Webster (1989) suggested a maximum utilization of spring, summer and fall grazing periods not to exceed 65 percent, 40-50 percent, and 30 percent respectively, within riparian pastures in good to high ecological status. He does not specifically suggest any use rates for areas in less than acceptable condition, other than citing other researchers such as Ratliff.

Ratlif, *et al*, (1987) suggested utilization rates for site protection should be 35-45 percent on excellent condition meadows, down to 20-30 percent on poor condition meadows (condition descriptions for 'excellent' and 'poor' are undefined). Hockett and Roscoe (1993) suggested utilization levels between 30 percent and 60 percent, depending on the system and sensitivity level. Clary (1999) suggested that riparian and stream condition improved with light to moderate utilization with levels ranging from 20-50 percent. Burkhardt (1997), suggested that proper season of use and just plain rest are far more effective for dealing with most riparian grazing problems than are utilization use limits.

Several authors have described the relationship between percent utilization and stubble height. The relationship between percent utilization and stubble height shows continuity between recommendations of 30-50 percent utilization and recommendations of leaving three to six inches stubble height for maintenance of plant vigor.

For example, Kovalchik, *et al* (1992)[23] equated 45 percent riparian herbaceous vegetation utilization to four- to six-inch stubble height, and two to four inches to 65 percent utilization. Schmutz (1978) described the relationship between southwestern upland species using photographic guides to compare portions of plant remaining to percent utilization. Lacey (1988) also evaluated upland range grass stubble height to percent utilization. Forty-five percent utilization (moderate use) had corresponding stubble heights ranging from two inches (Blue grama) to nine inches (Indian Ricegrass), depending on the species and site. However, most evaluated species had corresponding moderate use stubble heights in the five-inch to six-inch range. As is the situation with stubble height, it should be used as a short-term indicator, not as an end-point, condition or trend.

Bank Disturbance (Alteration) and Stability

The cornerstone for proper stream function is stability (Kaufman 1984; Marcuson 1977; Platts *et al* 1983). Various stream types have different inherent channel stabilities which must be considered when determining potential effects of livestock grazing or any other uses or activities on water quality or aquatic habitat (Rosgen 1996). Consideration must not only be given to damage potential but to the recovery potential of affected channels. Overgrazing can cause bank slough-off creating false setback banks and accelerated sedimentation

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[23] In Mosley, Jeffrey C., Philip S. Cook, Amber J. Griffis, and Jay O'Laughlin, *Guidelines for Managing Cattle Grazing in Riparian Areas to Protect Water Quality: Review of Research and Best Management Practices Policy*, Report No. 15, Idaho Forest, Wildlife and Range Policy Analysis Group, University of Idaho, 1997.

and subsequent silt degradation of spawning and food producing areas. This can result in decreased fish biomass and percent of salmonid fishes in the total fish composition (Kaufman, *et al* 1984, Platts 1990).

Myers and Swanson (1992) found that bank damage from ungulates had different effects on different stream types and even on different parts of their cross-sections. Vegetation is more important for stability on certain stream types than on other types. Streams with non-cohesive sand and gravel banks are most sensitive to livestock grazing. They concluded that range managers should consider the stream type when setting local standards, writing management objectives or determining riparian grazing strategies.

High forage removal, high amounts of foraging time along banks, and heavy uses of palatable sedges along the bank have been shown to significantly increase the probability of bank slough-off occurring during the grazing season (Kaufman *et al* 1984). Duff (1979)[24] found the stream channel width in a grazed area was 173 percent greater than the stream channel not grazed for eight years.

Platts & Rinne (1985) found that streamside grazing probably does as much or more damage through bank alteration than through changes in vegetative biomass. Further, he suggested that bank conditions do not improve during a single rest period, but rather, regrowth of vegetation tends to mask unstable reaches. He found that prolonged use of streamside vegetation not only will alter a bank but will also retard the rehabilitation of previously altered banks.

Similar conclusions have been reported by other authors, where overgrazing and excessive trampling caused a decrease in bank undercuts, increases in channel widths, and a general degradation of fish habitat (Kaufman *et al* 1984). For example, VanVelson (1979)[25] found rough fish made up 88 percent of a fish population before relief from grazing and only 1 percent of the population after eight years of rest. Kaufman *et al* (1984) had similar observations.

Geomorphologists, such as Rosgen (1996), have determined sensitivity to disturbance, streambank erosion potential, and vegetation controlling influences for each major channel type. Rosgen determined that bank erosion is a factor of physical bank features such as bank angle, percent surface protection and plant root depth/bank height ratios, and near-bank sheer stresses. This information can in turn be used to determine potential short-term and long-term implications of various impacts, such as grazing, on stream channels.

Platts & Rinne (1985) found that rest-rotation grazing in Idaho had a higher use rate in the stream-side zone than on the remainder of the allotment. He also observed that stream-bank alteration occurred soon after cattle were turned into ungrazed meadows. Clary *et al* (1996) found that vegetation protection potential of some streambanks is extremely important, and lack of rhizomatous grass-like species left streambanks poorly protected. As a result, all grazing intensities, except no grazing, under these conditions, experienced an increase in stream channel width-depth ratios. He concluded that recovery of the degraded riparian zone of the subject study

[24] In Kaufman, J. Boone and W.C. Krueger, *Livestock Impacts on Riparian Ecosystems and Streamside Management Implications Review*, Journal of Range Management 37(5), Sept. 1984, pg 430-438.

[25] In Kaufman, J. Boone and W.C. Krueger, *Livestock Impacts on Riparian Ecosystems and Streamside Management Implications Review*, Journal of Range Management 37(5), Sept. 1984, pg 430-438.

area would require many years, if not decades to recover. Further, simply resting an area may or may not be sufficient to restore more natural conditions.

One study showed that existing herbaceous plant species increased in growth and vigor under reduced grazing (ungrazed and moderate grazing) but there was no measurable increase in occurrence of bank protecting rhizomatous wetland species (Clary *et al* 1996). Therefore, if a species is not on site, at least in limited numbers, or if there is no seed source, one cannot expect to reestablish desirable deep-rooted species simply by resting. However, if the species is already on site, the presence of wetland species can be expected to increase through resting (Clary *et al* 1996).

The Beaverhead National Forest (USDA BNF, undated) conducted a thorough review of livestock impacts on streams. They concluded that a number of researchers recognize that livestock can have an effect on streambank stability. For example, Clifton (1989) stated "Livestock impacts can be divided into impacts on streamside vegetation and impacts on the adjacent channel. Impacts on the stream channel include increased channel bank instability, channel shape adjustments and changes in sediment and discharge volumes."

Platts, *et al,* (1989) stated "Considerable [streambank] structural difference was observed between grazed sites and sites where grazing had been suspended or greatly reduced..." Platts (1990) stated "Streambank effects are trampling, shearing and overhanging bank caving." Trimble, *et al,* (1995) stated "The net results of grazing in riparian areas... can be: 1) direct modification of stream channels and banks; and 2) reduction of resistance to higher flows which promotes channel erosion. Trampling in the stream may break up armored layers and expose the substrate. When resistance is breached by grazing, it is conceivable that such reaches may degrade even with no change in streamflow regime."[26]

The inherent stability of stream banks has not been thoroughly explored in the literature. Rosgen (1996) describes sensitivity levels of various channel types, but does not define inherent stability. Overton *et al* (1995) described bank stability for streams representing natural conditions within the Salmon River basin by gross channel type as defined by Rosgen (1996) and others (e.g. A, B, C, etc.), but did not further define channel type by substrate, though geological descriptors were included. They found the mean inherent stability for "A" channel types was 97 percent; for "B" channels was 87 percent, and "C" channels 85 percent.

The Beaverhead National Forest (BNF, 1997) developed allowable disturbance founded on existing vegetation communities and sensitivity levels based on soil/vegetation biodiversity, fisheries, recreation, wildlife and water considerations. A table determines an allowable percentage of natural stability that should be maintained to ensure a stable system persists. Natural stability is based on vegetation communities present along the streambank, ranging from 20 percent to 100 percent (Bengeyfield and Svoboda, 2000).

INFISH (1995) states as a Riparian Management Objective that all non-forested streams, regardless of the geographic setting or channel type, should have banks greater than 80 percent stable. No bank stability objective is set for forested systems.

[26] In USDA Forest Service, *Allowable Streambank Alteration and the Beaverhead Riparian Guidelines*, Beaverhead National Forest, USFS R-1, undated.

Riparian Management Objectives can be modified through a site-specific analysis. Harper (2000 b) agrees that at least 80 percent of the streambank should be in stable condition, though total vegetative cover can be as little as 50 percent of the total stream area. Bauer and Ralph (1999) advocate 90 percent bank stability to maintain water quality and aquatic habitat. Again, these are generic values, without regard to any specific geophysical features.

Forest Service Region Two (USDA-FS R2, 1996) has a Standard that states: "Maintain the extent of stable banks in each stream reach at 80 percent or more of reference conditions. Limit cumulative stream bank alteration (soil trampled or exposed) at any time to 20-25 percent of any stream reach." Forest Service Regions 1 and 4 Soil and Water Conservation Practices Handbook states: "The appropriate percent stream bank disturbance to be allowed for each riparian area is established using vegetation condition and soils information coordinated with stream types (Rosgen), to estimate the amount of streambank that should be stable under ungrazed conditions. The percent will vary, depending on site-specific conditions. An example of the percent disturbance that might be identified may be a range from as low as 10 percent above what occurs naturally on the areas with most sensitivity to 40 percent disturbance on areas of least sensitivity" (USDA-FS, 1995).

The Handbook further states: "The overriding concept behind measuring bank disturbance is making sure that the integrity of the streambank remains." "Physical alteration of the bank by trampling results in widening of the stream channel, and leads to a scenario that eventually results in a loss of riparian functions." "Bank alteration should be approached not only by asking, 'Is it causing erosion?' but 'is it preventing recovery'?"

Hockett and Roscoe (1993) advocate maximum allowable bank disturbance standards of 10 percent or less for sensitive streams and 10-25 percent for moderate to low sensitivity streams. Rosgen (1996) does not advocate any specific standards, only that "Grazing standards should focus... on percentage allowable bank damage seasonally..." and "... allowable annual bank damage by hoof shear by stream type."

Channel adjustment will occur if sufficient channel modifications and disturbances occur. These modifications include changes in: the ratio of streambank height to bankfull stage; the ratio of riparian vegetation rooting depth to streambank height; the degree of rooting density; the composition of streambank materials; streambank angle; and bank surface protection afforded by debris and vegetation (Rosgen, 1996).

Besides the physical attributes of bank stability, Williams *et al* (2004) studied the economic benefits of bank stabilization. They concluded that net gains are realized from the value of hectares not lost erosion. Conversely, it would follow that economic gains would be realized by not having to clean out downstream diversion facilities and reservoirs that serve as a depository for upstream erosion.

Conclusion

Streambank “stability” and streambank “disturbance/alteration”, though two different concepts, have been used interchangeably by many authors and managers. The two parameters, however, are substantially different. Streambank “stability” is an indicator of the effectiveness of management in achieving **long-term** goal and objectives for stream, riparian and aquatic resources. It is usually defined in four to six categories, evaluated as a percentage: Covered Stable;

Uncovered Stable; Covered Unstable; Uncovered Unstable; and may include False Bank and Unclassified, or Other. The "stability" is the result of all or cumulative impacts to a stream, not just livestock. Bank "disturbance/ alteration", on the other hand, is used for annual or **short-term** monitoring that may be used to make annual adjustments to livestock grazing management practices to meet long-term stability goals and objectives. It describes the linear percentage of a streambank that is altered by animals walking along the streambank. Hoof sheering is the most obvious form of alteration. Shearing exposes bare soil, which increases the risk of erosion to the streambank (Cowley and Burton 2005).

Little specific research was found in reference to inherent natural bank stability by channel type or the amount of acceptable or allowable bank disturbance to maintain overall channel stability.

The Beaverhead National Forest found a correlation between vegetation communities and inherent stability. Stream types are used in the determination of Sensitivity Levels. Using their information, desirable deep-rooted carex and salix communities can be 80-100 percent stable under unimpaired conditions. Overton *et al* (1995) found A, B, and C reference channel types to be 97 percent, 87 percent and 85 percent stable respectively within the study area. Observations by Leffert (2000) found that if an adjustable channel is more than about 20-30 percent disturbed, channel adjustment processes begin to occur. This is not an 'instantaneous' or specific threshold-induced adjustment, rather it initiates a more continuous series of channel adjustments over time to accommodate changes in channel dimension, sediment loading and/or flow changes (Rosgen 1996).

INFISH advocates greater than 80 percent of any channel type should be stable, while R-2 states that a channel should be within 80 percent of reference conditions. R1/R4 states that possible allowable disturbance could range between 10 percent and 40 percent, depending on sensitivity. Hockett and Roscoe (1993) advocate allowable levels between 10 percent or less to 25 percent, depending on stream sensitivity.

Monitoring on the Beaverhead National Forest found that channel disturbance criteria were normally met before other parameters, such as stubble height or percent utilization (Dallas 1997). For example, with only a minor exception noted in a meadow complex with a C (low gradient) stream channel, the streambank disturbance guideline was found to be the limiting factor across the entire Upper Rubby allotment. The allotment riders have become so adept at managing streambank disturbance, other parameters, such as stubble height, were discontinued. Maintaining the bank disturbance guideline resulted in stream improvement, and in some cases, significant improvement of streams throughout the allotment.

It appears that inherent, undisturbed bank stability of channels functioning at full potential ranges from about 70 percent to near 100 percent, depending on the type of channel and streamside vegetation. The literature suggests that allowable disturbances may range from less than 10 percent to as much as 40 percent, depending on the type of channel and residual vegetation. Streams that contain smaller bank particle sizes (gravels, sands, silts/clays) are more sensitive to disturbance than banks containing larger materials (Rosgen 1996). Therefore, banks consisting of smaller particle sizes may not tolerate as much disturbance as banks containing larger particle sizes. Further, banks that have only a few plants with shallow root systems cannot protect banks as well as many plants with deeper and denser rooting systems. Banks having fewer plants with shallow roots may need more protection from impacts than banks containing many, deeper rooted plants. Therefore, a range of disturbances, based on channel type and residual vegetation may be appropriate. Platts & Meehan (1977) suggested the following guidelines:

1) Most stream surfaces should have 80 percent or more canopy cover to prevent unacceptable water temperatures;
2) Streambanks should be well vegetated to hold soil in place, and to keep livestock trampling damage to a minimum; and
3) Overhanging vegetation (within one to two feet of the stream surface) should be available on 50 percent or more of the streambank to provide fish cover.

This is especially important on the outside bends of streams. Though this doesn't specifically address the morphology of a stream channel, it suggests a minimum range of physical conditions needed to support aquatic dependent species and it roughly coincides with the range of desired morphological conditions described above.

As is the situation with stubble height, bank disturbance/stability should be used as a short-term indicator, not as an end-point, condition or trend.

Soil Disturbance

The condition of the soils within the riparian area is a key for plant vigor and density, as well as hydrologic processes that occur through the soil profile. Changes in the soil structure can adversely affect plant condition and distribution, as well as stream/riparian area interactions and functions.

Trampling of the soil surface by grazing animals can impact soil properties by:

1) Reducing vegetative cover and decreasing soil surface protection;

2) Churning or tilling the soil by hoof action;

3) Degrading surface crusts (both physical and biological); and

4) Compacting the surface and sub-surface soils (Kaufman, *et al,* 1984).

Gosz (no date) found trampling may seriously affect the productivity and nutrient uptake capability of upper soil layers under an aspen canopy. Soils under an aspen canopy are more nutrient rich than that under conifers. Disturbance of aspen-influenced soils often cause significant losses of nutrients. This resulted in a marked difference in the density and composition of the understory vegetation and highly significant reductions in total understory biomass. Soil compaction decreases water infiltration and hydraulic conductivity, and increases erosion rates by decreasing macropore space.

Rauzi and Hanson (1966)[27] found soil compaction increased linearly with increases in grazing intensity, and after twenty-two years of grazing, found soil properties had been changed. Willatt and Pullar (1984) found that grazed pastures with various stocking rates showed increases in bulk

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[27]In Kaufman, J. Boone and W.C. Krueger, *Livestock Impacts on Riparian Ecosystems and Streamside Management Implications..A Review*, Journal of Range Management 37(5), Sept. 1984, pg 430-438.

density and bearing capacity of the soil, and decreases in hydraulic conductivity occurred with increased stocking rates. They also found pasture plant composition was also changed over time. Coarse-textured soils are least susceptible to bulk density increases, while fine-textured soils appear to be most susceptible.

Trampling of moist or wet soils may produce surface crusts, which can further impede infiltration (USDA DNF, 1995). Valentine (1970)[28] suggested that maintenance of stubble height and seedstalks remaining after grazing relate directly with maintenance and reproduction of the plants and protection of the soil. Thurow (1988)[29] concluded that pastures that had moderate continuous and high-intensity, low frequency grazing were able to recover from drought and maintain initial infiltration rates and interrill erosion. In contrast, infiltration rates decreased and interrill erosion increased on heavily stocked pastures, both continuous and short duration. The stocking rate, rather than grazing strategy, is a major factor influencing hydrological responses. Yong-Zhong (2005) found that continuous grazing resulted in a considerable decrease in ground cover, which accelerates soil erosion, leading to further coarseness in surface soil, loss of soil organic C and N, and a decrease in soil biological properties.

Residual litter is important both to promote infiltration and to protect against rill erosion.[30] Bare ground in riparian areas is exposed to water erosion in two ways. The first is channel erosion. The second, which affects all rangelands, is rain-splash. The top layer of soil is usually the most permeable and fertile and often the most resistant to detachment. Loss of this layer reduces fertility and infiltration. This results in a downward trend in plant productivity and increases overland flows, which leads to accelerated erosion (Warren *et al* 1986; Holechek no date). The closer the impact is to the steam channel, the less distance detached soil particles have to travel before entering a water way and adding to the sediment loading of the stream.

Significant amounts of sediment can cause a channel to adjust, which in turn can create more streambank erosion, which can cause more channel adjustments. Scholl (1989) concluded that all soil textural classes except sand show significant compaction from trampling in both spring and fall, with a tendency for spring trampling to cause greater compaction. Compaction altered bulk density and macroporosity in all textures but sand and sandy loam, and hydraulic conductivity was substantially reduced on sandy loam and loam sites. Warren *et al* (1986) concluded that short-term, high intensity livestock trampling on silty clay soil had a negative effect on physical properties, with negative effects increasing with increasing stocking rates. Trampling on dry soil caused disruption of naturally occurring aggregates and compaction of the surface soil layer. Trampling on moist soil deformed existing aggregates and led to the creation of a flat, comparatively impermeable surface layer composed old dense, unstable clods.

Region 4 has developed soil quality standards for Forests in Idaho, Utah, Nevada and portions of Wyoming (USDA FS R4, 1995). One standard deals with soil disturbance.

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[28]In Willoughby, John, Letter and enclosed *List of References of Utilization Guidelines and on the Effects of Lower Stocking Rates on the Recovery of Rangelands*, to Dr. Jerry Holechek, College of Agriculture and Home Economics, Department of Animal and Range Sciences, Las Cruces, NM, USDI, BLM, Sacramento, CA.,Sept. 25, 1997.

[29]Ibid

[30]Ibid

"Detrimentally disturbed soil is soil that has been detrimentally displaced, compacted, puddled, or severely burned. At least 85 percent of the total area within an activity area must have soil that is in satisfactory condition." An activity area can be interpreted as a riparian area.

Forest Service Handbook 2209.21 also describes effects of livestock on soils. The handbook describes two major effects: disturbance of litter, and compaction. Some results of compaction are reduced infiltration capacity and slower water movement in the soil, an increase in surface runoff, accelerated soil erosion and reduced pore space which restricts air circulation, resulting in poor aeration of the plant roots. Researchers Kaufman *et al* (1984), Willoughby (1997), and Scholl (1989) have shown that the main factors related to declines in soil productivity are losses in site organic matter and soil porosity. Livestock have been observed to adversely affect both factors (Scholl 1989; Warren *et al* 1986).

Noble (1963) researched potential soil erosion along the Wasatch range in Utah. He concluded that in the Intermountain West, a minimum of 60-70 percent ground cover[31] is needed to effectively control surface runoff of water and erosion associated with summer storms. He found that when ground cover was reduced to less than 60 percent, overland flow and soil losses increased at extremely increased rates. For example, in watersheds containing "good" ground cover (greater than 60 percent), only 2 percent of an intense rainfall resulted in surface runoff, and soil loss was about 0.05 tons per acre. Conversely, watersheds with "poor" ground cover (about 90 percent bare ground) had over 70 percent of the rainfall become overland flow, with a 5.5 ton per acre soil loss.

Hervivory is also thought to influence the mycorrhizal associations between plants and their fungal symbionts by limiting the amount of photosynthate available to the fungus. Klironomis *et al* (2004) found that previous studies of the herbivory/mycorrhizal relationship have not yielded consistent results. They studied this relationship in Canada and concluded the same findings found in the literature – that it is difficult to generalize the effects of herbivory on plant and fungal responses, even when dealing with the same plant species.

Conclusion

It appears livestock can, and in certain situations, do have negative impacts on soil properties and hydrologic function. R-4 soil quality standards limit the amount of an area that can have detrimental soil disturbance in order to protect the overall integrity and function of the soils. If these standards are exceeded it appears that degraded soil properties could result. Different soil types and moisture conditions appear to play important roles on determining the amount of detrimental impacts to the soils within the riparian area.

For example, Scholl (1989) concluded that all soil textural classes except sand show significant compaction from trampling in both spring and fall, with a tendency for spring trampling to cause greater compaction. However, coarse-textured soils appear to be least susceptible to bulk density increases, while fine-textured soils appear to be most susceptible. Therefore riparian areas containing fine-textured soils should have limited wet-season grazing. Grazing impacts on other soils should be limited to the capacities of the soils and associated

[31] Ground cover is defined as basal vegetation, litter, moss lichen or rock greater than ¾ inch diameter (O'Brien *et al* 2003)

vegetation to withstand the influences of trampling and compaction. The R4 guidelines offer such limitations.

At least 60 percent ground cover appears to be needed to control runoff and soil loss. If grazing reduces ground cover below 60 percent through foraging and trampling (either on the uplands or within the riparian area), erosion and runoff rates increase exponentially. Therefore, it appears that maintaining at least a 60 percent ground cover within and adjacent to the riparian area is essential to maintain riparian health and channel stability.

Riparian Zone Ground Cover and Plant Utilization

To this point, literature has concentrated on impacts and utilization in the "near-bank" area – that is that area directly adjacent to the stream channel. Impacts of livestock within a "zone of influence" have not been thoroughly explored. This zone is extremely important and has been recognized as a critical area by some.

For example, INFISH (1995) establishes a Riparian Habitat Conservation Area (RHCA) that has specific established Goals, Objectives, Standards and Guidelines. The intent is to recognize the importance of these areas and control land management activities that could reduce the important associated values. INFISH identifies specific widths or boundaries based on the kind of waterbody and the presence or absence of fish. However, INFISH is silent on specific criteria that must be maintained within RHCAs, such as vegetation utilization or ground cover. Rather, the focus is on stream channel habitat features and generic Goals for the RHCA address water quality, stream channel integrity, instream flows, water tables and overall plant productivity and diversity (INFISH, 1995).

Geomorphologists, such as Leopold (1994, 1997) and Rosgen (1996) have long known how streams develop and the value of the flood prone area adjacent to the stream channel. Different kinds of streams have different kinds of floodplains of varying widths, characteristics and importance (Rosgen 1996). The shape of any stream is a function of the flow, the amount of sediment in motion through the channel, and the character or composition of the materials (including vegetation) that make up the bed and banks of the channel. When flows exceed the capacity of the channel, water overflows into the floodplain (Leopold 1994). If the floodplain is unprotected or damaged, the channel can respond quickly, sometimes with undesirable results (Leopold 1994).

The health, vigor, density and diversity of vegetation within the streamside zone holds the key to maintaining channel stability and providing quality water for aquatic species and human uses (Brinson *et al* 1981). The hydrology of riparian systems can have an effect on the metabolism and growth of vegetation in three basic ways. First is water supply. Second, is nutrient supply, and third is facilitation of soil ventilation and gaseous exchange such as oxygen, carbon dioxide and methane (Brinson *et al* 1981). Implications for removal of riparian vegetation include the disruption of coarse particulate matter input, which in turn shifts energy flows and balances, accompanied by changes in channel hydrology, sediment and nutrient loading and physical water quality changes, such as temperature. The shift to a higher energy, more eutrophic environment will produce conditions to which only a few of the existing species of aquatic invertebrates and fishes may be adapted. Leaving a protective buffer of riparian vegetation will help to maintain the integrity of at least some of the energy sources and organic matter processing mechanisms (Brinson *et al* 1981).

Maintaining a healthy streamside zone will also serve to buffer sediment and other pollutants from upland sources. Belt *et al* (1992) discussed five functions of effective buffer areas. These include:

- Trapping sediment or nutrients;
- moderating stream temperatures;
- Providing food and cover for wildlife;
- Providing large organic debris for channel processes and aquatic habitat; and
- Moderating cumulative watershed effects.

These characteristics are essentially echoed by Lawrance *et al* (1985). Cited benefits include streambank stabilization, sediment filtering, temperature regulation, and uptake and long-term storage of nutrients. Braun (1986) added increased groundwater recharge, near-bank water exchange, and bank cover that provides habitat, food and cover for aquatic species

The literature is relatively silent on the effects of livestock grazing on the characteristics and effectiveness of buffers. Most of the available literature deals with logging activities and associated roads (e.g. Belt *et al* 1992; Swift 1986; Ketcheson and Megehan 1996). Observations and findings of these authors can be applied to grazing activities.

For example, Belt *et al* (1992) found that as surface roughness increased, filtering capacities of buffers for non-channelized surface flows also proportionally increased. This can be applied to grazing. In general, the more vegetation left on-site, the greater the buffering ability. As vegetation is consumed or trampled, the roughness coefficient can be reduced, reducing the capability of the area to provide desired functions and processes.

Pfankuch (1978) characterized channel stability based on several features. One feature is what he terms the "upper bank," which is described in general terms as the floodplain zone and adjacent landforms. Vegetation is one component of the evaluation. "Excellent" is defined as trees, shrubs, grass and forbs combined cover more than 90 percent of the ground. "Good" has 70-90 percent ground cover. "Fair" has 50-70 percent ground cover, and "Poor" has less than 50 percent ground cover.

A standard in the Targhee National Forest Land Management Plan specifies that within the riparian zone, away from the direct streamside, at least three inches of stubble will be left for key riparian plant species at the end of the grazing period (Targhee NF 1997).

In 1993, FS Region 4 issued Range Management Standards for the Region. Standards for key species grass and herbaceous plants in riparian rangeland ecosystems were divided into season-long grazing and rotation grazing schemes, and subdivided with standards for satisfactory and unsatisfactory range conditions for each of the systems. For pastures that have season-long grazing, unsatisfactory condition standards are 30 percent utilization and a six-inch stubble height. For satisfactory range conditions, 55 percent utilization and four-inch stubble height. Pastures with rotation grazing have 50 percent/four-inch, and 65 percent/four-inch for unsatisfactory and satisfactory range conditions, respectively. If there is a conflict between percent utilization and stubble height, stubble height prevails.

Holechek (1999) researched "classic" grazing studies and provided a brief synopsis of findings. When averaging all the studies, they found that "heavy" grazing averaged 57 percent use of the primary forage species. "Moderate" grazing averaged 43 percent use, and "Light" grazing averaged 32 percent. They defined "heavy" as a degree of herbage utilization that does not permit desirable forage species to maintain themselves. "Moderate" grazing is a degree of herbage utilization that allows the palatable species to maintain themselves, but usually does not permit them to improve in herbage producing ability. "Light" grazing allows palatable species to maximize their herbage producing ability. Heavy stocking consistently caused a downward trend in ecological condition, light stocking caused an upward trend and moderate stocking maintained or slightly improved condition.

FSH 2209.21-93-1, R4 Amendment Effective 5/18/93 describes six classes of herbaceous utilization. They are: No Use – 0-5 percent; Slight – 6-20 percent; Light – 21-40 percent; Moderate – 41-60 percent; Heavy – 61-80 percent; and Severe – 81-100 percent. The Handbook states that removal of half or more of the foliage during the growing season upsets the functioning of the root system and the plant as a whole. The reduction of growth in grass plants after cutting or grazing is due partly to the inability of defoliated plants to absorb water.

Conclusion

Relatively little information is available concerning the needs of the entire riparian zone. The literature, however, is clear that this zone is extremely important for a variety of functions and processes needed for aquatic habitat, channel integrity, water quality, wildlife and so forth. Without healthy riparian zones, these functions and processes can be jeopardized, reduced, or even eliminated.

The width of these influence zones to provide needed functions is also in question. Fixed widths are relatively easy to define and administer (Belt *et al* 1992) but may not provide adequate protection in some situations and may be too comprehensive in others. INFISH defines variable widths depending on several factors including channel and floodplain characteristics, actual extent of riparian vegetation, or a minimum fixed width, which ever is greater.

For controlling the influence of livestock grazing within these influence zones, it appears as a buffer zone using the actual extent of riparian vegetation would be in order, along with some kind of minimal ground cover and/or vegetation utilization that could equate to stubble height. However, depending on the channel type, the actual extent and influence of riparian vegetation can be and is highly variable (Rosgen 1996). The extent of riparian vegetation can vary greatly along the same stream and even vary on either side of the channel.

For example, a C-type channel (Rosgen 1996) can be cutting into a terrace on one side and have a well-developed point bar on the other. On the terrace side, it is possible that no riparian vegetation will exist at all. On the point bar side, riparian vegetation could be well developed, extending well away from the side of the channel. Potential ground cover on the upland terrace side may not exceed 60 percent, while potential ground cover on the point bar may be 100 percent. Potential stubble height of un-grazed grasses on the terrace may not exceed six inches, with moderate grazing utilization stubble heights residuals only an inch or two (See Percent Utilization section). On the other side of the channel, potential stubble height may be several feet, with moderate utilization stubble heights exceeding six inches. Further, a deeply downcut channel may have no associated riparian vegetation on either side of the channel, whereas an E-type channel (Rosgen 1996) or an extended beaver complex could have associated riparian vegetation extending hundreds of feet on either side of the channel.

It appears as variable criteria for zone width, and disturbance limitations, such as ground cover, and plant utilization is appropriate. Variable zone widths as defined in INFISH for the different waterbody types and the presence or absence of fish appears to be suitable and sufficient to maintain the integrity of this zone and protect associated values of aquatic habitat and water quality. Even though channel types vary in their ability to promote and sustain riparian vegetation, there are too many physical and biological variables to try to isolate zone widths to specific channel types.

Plant stubble heights and allowable utilization rates, along with ground cover requirements, should vary according to plant community types. For ease of management and monitoring, these community types can be subdivided into two main categories – riparian and upland.

For riparian plant communities, allowable utilization and stubble heights should not exceed those normally associated with light to moderate grazing. The literature generally supports utilization rates less than 50 percent for riparian vegetation. Clary & Webster (1989) suggest a maximum streamside utilization of 65 percent for spring, 40-50 percent for summer and 30 percent for fall grazing, which allows for regrowth. Clary (1999) defined "moderate" grazing as up to 50 percent use. Ratlif *et al* (1987) suggests maximum allowable use up to 45 percent for meadows in "good" condition and 20-30 percent for areas in poor condition. Therefore, a maximum allowable use of 50 percent for spring grazing in areas in "good" condition may be appropriate, reduced to 20 percent for late season grazing on areas in poorer condition. Kovalchik & Elmore (1992)[32] equated 45 percent utilization to four- to six-inch stubble height, depending on the plant species.
Upland plant utilization should follow similar levels as riparian vegetation. Holechek (1988) found percent use of key species for moderate grazing ranges between 30-40 percent (FSH equivalent is "Light"). Lacy (1988) found that most upland plants can maintain vigor if no more than 50 percent of their growth is removed during the grazing period, and should not exceed 60 percent (FSH equivalent is "Moderate). FSH 2209 states that plant function is upset with utilization levels greater than 50 percent, which falls into the FSH definition of "Moderate" grazing. Unlike riparian vegetation, the potential for regrowth of upland vegetation following grazing is reduced, depending on the plant species and available moisture. Therefore, a utilization rate by season is probably not appropriate.

Factors and techniques that affect the distribution of livestock and resource impacts

The use of forage by livestock is dependent on a number of factors. These include: season of use; physical conditions of forage and relative palatability; distance to water and salt; sideslope steepness and microclimatic features. In riparian areas, the biomass of wet meadow herbage is often ten

[32] In W.P. Clary, ED. Proceedings – Symposium on Ecology and Management of Riparian Shrub Communities. USDA Forest Service General Technical Report INT-289. Ogden, Ut.

to twenty times higher than that of surrounding uplands; the distance to water is minimal, the terrain is flatter and summertime temperatures can be cooler. Therefore, animals expend less time and energy in obtaining their daily intake in riparian areas than on adjacent upland range (Skovlin 1984).

Even though riparian meadows often cover only 1-2 percent of the range area, they may produce up to 20 percent of the available forage, and in some areas 80 percent of the forage consumed within a pasture may come from these meadows (Clary & Webster 1980).

There are also seasonal differences in the way livestock utilize their environments. Cattle tend to be more widely distributed early in the grazing season compared to later when they may concentrate in riparian areas (McInnis 1997); although it has been found that cattle will also distribute themselves during the latter, cooler, portion of the grazing season as well (WDEQ 1997). Clary & Webster (1990) found that cattle may consume most of the forage in the riparian zone in the first four weeks (30 days) of the grazing season. However, even when a majority of the forage has been consumed, cattle traditionally will not voluntarily venture up the slopes, away from the riparian zone during the warmer portion of the grazing season. Clary & Booth (1993) also observed that spring grazing of riparian areas may be a good management strategy because of a reduced tendency for cattle to concentrate along streams during that season. Streamside graminoid utilization averaged about 24 percent (4.5- to 5-inch stubble height) under light stocking, and about 37 percent (3- to 4-inch stubble height) under medium intensity grazing. Parsons *et al* (2003) found that during early summer, cattle were further from the stream than during late summer. Cows were observed closer to the stream when ambient air temperatures were higher. Forage quality varied between seasons, with early summer forages having lower dry matter, greater crude protein, lower fiber and greater in situ dry matter disappearance compared with late summer forages. Utilization of riparian vegetation was lower and use of upland vegetation was greater during early summer than late summer.

Some studies show that livestock distribution combined with timing, duration and frequency of grazing are often the main factors in utilization patterns within riparian areas. Stocking rate problems are usually not a factor, and simply reducing total numbers is usually not a solution for proper riparian management.

Cattle form family groups and like to stay together. When they are split up forcibly for better distribution, they tend to return to a place of gathering, which more likely than not is in the riparian area. Leonard *et al* (1997) suggested successful grazing strategies that protect or improve riparian condition include techniques that:

1) Attract, not force, livestock away from riparian areas, including stock water developments, alternate or improved forage, and careful salt and supplement placement outside of riparian areas;

2) Restrict livestock use in riparian areas, which includes fencing, barriers such as thickets or brush wind rows, water gaps in erosion resistant stream reaches and relocation of bed grounds and management facilities; and

3) Provide herd management and animal husbandry practices that promote mobility, including herding and culling practices and managing the kind and class and breed of livestock.

Platts (1991)[33] suggested five strategies:

1) Control of animal distribution and access to water;
2) Control of grazing intensity (forage utilization);
3) Control of grazing frequency and rest periods;
4) Control of timing of grazing use (season); and
5) Total exclusion of grazing.

Studies of cattle behavior in riparian zones during summer grazing in mountain pastures in east central Oregon found that 80 percent of the herbage used under moderate stocking came from streamside meadows that constituted 2 percent of the unit area. In heavier, more dissected terrain, even salting and additional alternate watering contributed little to draw cattle away from riparian meadows (Skovlin 1984). Roath (1980)[34] found that cattle exhibited distinctive home range patterns in which certain groups of cattle preferred upland sites, and other groups preferred riparian sites. As forage became limiting on stream bottoms, some cattle actually decrease intake rather than move away from the riparian zone. Roath (1980)[35] also suggested selective culling of these cattle and replacing them with those that prefer uplands may be beneficial for the livestock operator as well as for the riparian zone. He also found that herding livestock on a somewhat daily basis has been successful in limiting the number of livestock that visit stream bottoms, while improving utilization of upland areas.

Skovlin (1984) suggested ten options available to range managers for restoring riparian and stream habitats:

1) Do nothing;
2) Improve animal distribution;
3) Change season of use;
4) Implement specialized grazing seasons and strategies;
5) Rest entire grazing units for five years or longer until recovery occurs;
6) Fence the entire riparian zone;
7) Fence the streamside corridor;
8) Combinations of the above;
9) Revegetate with woody cover; and
10) Eliminate grazing.

Grazing strategies, such as rest rotation, are not an answer in themselves. Several authors have reported rest-rotation grazing systems increased vigor and increases in upland vegetation quality and quantity (Platts & Rinne 1985). However, Hughes (1979)[36] found no corresponding improvement in riparian conditions. One study found that streamside forage was 8-12 percent more heavily used than adjacent range forage on all studied allotments.

For example, Platts & Rinne (1985) found forage utilization along streams was about 50 percent greater during the late season than during the early season under similar grazing conditions. Consequently, if the allotment were managed for moderate (26-50 percent)

[33] In Fitch and Adams 1998. *Can Cows and Fish Co-Exist?* Canadian Journal of Plant Science; Vol 78, No. 2. Ibid p. 191-198.

[34] In Kaufman, J. Boone and W.C. Krueger, *Livestock Impacts on Riparian Ecosystems and Streamside Management Implications..A Review*, Journal of Range Management 37(5), Sept. 1984, pg 430-438

[35] Ibid

[36] In Platts, William S. and Rodger Loren Nelson, *Impacts of Rest-Rotation Grazing on Stream Banks in Forested Watersheds in Idaho*, North American Journal or Fisheries Management 5:547-556, 1985.

grazing intensity throughout the allotment, the streamside zone could easily accommodate heavy grazing (51-75 percent) utilization (Platts & Rinne 1985*)*. It was suggested that measures such as placing salt away from the riparian area, or the timing of grazing appeared to influence the use of streamside vegetation and would help in balancing vegetation uses.

Platts (1981, 1985) found that streamside grazing probably does as much or more damage through bank alteration than through changes in vegetative biomass. Further, he suggested that bank conditions do not improve during a single rest period, but rather, regrowth of vegetation tends to mask unstable reaches. He found that prolonged use of streamside vegetation not only will alter a bank but will also retard the rehabilitation of previously altered banks. He suggests that land managers "should give serious consideration to using special riparian pastures"... to "encourage a more equitable use of all available forage and would allow the intensity of use to be carefully controlled"...without the need for expensive fencing.

Even though fencing has been shown to provide the maximum protection and the best chance for rehabilitation in the shortest amount of time (with the exception of eliminating grazing), it has been estimated that the cost of fencing fish-bearing streams on BLM lands throughout the west would cost $90 million dollars and another $9.4 million for maintenance over a twenty-year period. Because of this, it has been suggested that the cost-effectiveness of management actions, such as fencing, be evaluated and the most valuable stream reaches be identified and necessary management strategies implemented that those streams deserve (Platts & Wagstaff 1984).

Rosgen (1996) suggested that channel types requiring the presence of deep-rooted plants to maintain channel stability (e.g. C3-6 stream types) should have grazing limited to early season, especially for large riparian pastures. He cited plant palatability, water availability, temperatures, nuisance insects, impacts to woody species, and post-grazing rest and plant regrowth as reasons.

Fitch and Adams (1998) suggest that proper riparian grazing strategies can improve wildlife habitat, help stabilize channels, improve water quality and shift intermittent streamflows to perennial flows. They state that the obvious primary benefit of a successful riparian grazing strategy is that the livestock operator can retain access to a dependable and productive forage supply, which will improve both the quality and quantity of forage for livestock. Improved riparian management may more than double forage availability over those riparian areas in poorer conditions. In short, if proper strategies are applied, cows and fish can co-exist.

Management strategies should be based on range type and condition, range site potential and soil type, plant growth rates, seasons of use, precipitation, stocking rates and type and class of livestock (WDEQ 1997). The FAO (2003) identified four world-wide grazing priorities. One priority was effective drought management policies. They found that land degradation in arid zones originates as a result of high stocking rates during droughts. They suggest managers de-stock as rapidly as possible during these periods, rather than seeking to maintain normal stock numbers and durations. Rosgen (1996) also recommended that channel type and inherent channel stability be factored into the equation. Some grazing management practices recommended by Clary and Webster (1990) include:

1) Grazing practices provide for regrowth of riparian plants after use, or should leave sufficient vegetation at the time of grazing for maintenance of plant vigor and streambank protection. A minimum herbage stubble height of four to six inches is recommended.
2) Springtime grazing of herbaceous vegetation should not exceed 65 percent and livestock should be removed when the primary forage plants are still in the vegetative state.
3) Summertime pastures should be used cautiously, as livestock tend to concentrate in riparian areas during the hot months. Forage utilization should not exceed 50 percent.
4) Fall grazing should be monitored carefully to ensure utilization standards are not exceeded, since there will be little if any regrowth. A four- to six- inch stubble height is recommended which equates to 30-40 percent utilization on most riparian herbaceous plants.
5) Limit season long grazing to situations where grazing can be strictly monitored and stubble heights can be met.
6) Special situations where critical fisheries habitat or streambanks are easily eroded, stubble heights greater than six inches may be appropriate.
7) The length of rest required to initiate a recovery process will depend on vegetative composition and streambank condition. It may take as little as one year or fifteen years or more. Degraded streambanks usually require more time to recover than vegetation.
8) Ensure **all** livestock are removed at the end of the specified use period. Recovery and/or maintenance of riparian ecosystems are not likely if even a few animals remain after the use period.

Other practices recommended by Meyers (no date) include:

1) Limit total time in pasture to 30 days or less; limit time in pasture during the hot season to less than 15 days.
2) Allow 30 or more days for plant regrowth.
3) Where deciduous woody species are important in the composition, limit the frequency of fall grazing to about 1 year in four. Limit duration of fall grazing to 21 days or less.

The following is a summary of suggested management practices described above and the anticipated functions or processes those practices are trying to address, as interpreted by this author.

Table A. Management Practices and Expected Benefits

Practice	Expected Benefit
Provide for regrowth of riparian plants after use, or leave sufficient vegetation at the time of grazing for maintenance of plant vigor and streambank protection. A minimum herbage stubble height of 4-6 inches is recommended	1) Increased plant vigor/health composition. 2) Improved streambank stability/rebuilding

Practice	Expected Benefit
Springtime grazing of herbaceous vegetation should not exceed 65 percent and livestock should be removed when the primary forage plants are still in the vegetative state.	1) Increased plant vigor/health/ composition.
Summertime pastures should be used cautiously, as livestock tend to concentrate in riparian areas during the hot months. Forage utilization should not exceed 50 percent.	1) Increased plant health/vigor/ composition 2) Improved bank condition 3) Improved soil condition
Fall grazing should be monitored carefully to ensure utilization standards are not exceeded, since there will be little, if any, regrowth. A 4-6 inch stubble height is recommended which equates to 30-40 percent utilization on most riparian herbaceous plants.	1) Increased plant health/vigor/ composition
Special situations where critical fisheries habitat or streambanks are easily eroded, stubble heights greater than 6 inches may be appropriate.	1) Decreased streambank erosion and improved stability 2) Aquatic habitat protection
The length of rest required to initiate a recovery process will depend on vegetative composition and streambank condition. It may take as little as one year or fifteen years or more. Degraded streambanks usually require more time to recover than vegetation.	1) Increased plant health/vigor/ composition; 2) Reduced soil compaction; 3) Improved streambank stability/protection; 4) Improved aquatic habitat 5) Improved water quality
Ensure all livestock are removed at the end of the specified use period. Recovery and/or maintenance of riparian ecosystems is/are not likely if even a few animals remain after the use period.	1) Increased plant health/vigor/ composition; 2) Decreased soil compaction; 3) Improved streambank stability/protection; 4) Improved aquatic habitat 5) Improved water quality
Limit total time in pastures to 30 days or less; limit time in pastures during the hot season to less than 15 days.	1) Increased plant health/vigor/ composition; 2) Reduced soil compaction; 3) Improved streambank stability/protection; 4) Improved aquatic habitat 5) Improved water quality
Allow 30 or more days for plant regrowth.	1) Increased plant health/vigor/ composition
Where deciduous woody species are important in the composition, limit the frequency of fall grazing to about one year in four.	1) Increased woody species health/vigor/ composition
Limit duration of fall grazing to 21 days or less.	1) Increased plant health/vigor/ composition; 2) Reduced soil compaction; 3) Improved streambank stability/protection; 4) Improved aquatic habitat 5) Improved water quality
Allow grazing on riparian vegetation only before July 1.	1) Increased plant health/ vigor/ composition; 2) Increased streambank protection
Implement stubble height standards.	1) Increased plant health/vigor/ composition; 2) Improved streambank protection
Implement utilization standards	1) Improved plant health/vigor/ composition; 2) Improved streambank protection
Implement streambank disturbance standards	1) Improved streambank protection; 2) Improved water quality; 3) Improved aquatic habitat
Close stream to grazing for up to five years.	All factors
Begin moving livestock before required standards are achieved so that by the time the standards are met, the last	All factors

Practice	Expected Benefit
animal is moved from the pasture.	

Additionally, besides the physical implications, economics also come into play. Stillings *et al* (2003) used a multi-period bioeconomic model to evaluate the long-term economics of management practices within a riparian zone. They found that restricting utilization to 35% for a 300 calf-cow operation, the cattle distributed more evenly and gained more weight. The economic impacts of this were increased annual net returns to the ranch in addition to improved riparian quality.

Water Quality and Aquatic Habitat

Maintenance of riparian areas is not necessarily an end in itself. Stable, healthy riparian areas are a means to other values, such as clean water that meets designated beneficial uses and high quality aquatic habitat that is capable of sustaining a variety of water-dependent species, including insects, fish and amphibians.

Livestock can affect several water quality parameters. Most noted are sediment, bacteria and nutrients, primarily nitrates and phosphates (Buckhouse 2000). Braun (1986) concluded that cattle are the cause or source of several types of water pollution. On uplands, cattle accelerate erosion when removing vegetation and trampling soil. Through runoff, eroded soil eventually finds its way into streams leading to sedimentation and turbidity. Sediment destroys stream habitat in at least two ways. Suspended sediment reduces light penetration causing reduction in aquatic plant photosynthesis and dissolved oxygen levels. Sediment clogs gravel areas used by spawning fish for egg deposition and can entomb various aquatic life forms that are major sources of food for fish. In addition, cattle discharge urine and manure, which produce chemical and biological pollution.

George *et al* (2004) surmised that in general, streams flowing through areas partly or fully covered with pastures were more contaminated than those flowing through forest and cultivated areas. Rainfall increased the suspended solid content of small streams as well as their fecal contamination, as bacteria are adsorbed on particles. In a study by Coltharp and Darling (1973)[37], three pastures were studied with different combinations of animals grazing and browsing: wildlife only, wildlife and sheep and wildlife and cattle. Highest concentrations of bacteria were found in the wildlife-cattle pasture. Carter (1999) in a study conducted on the Cache National Forest in Idaho and Utah, found elevated concentrations of fecal coliform bacteria within days of cattle entering a pasture. Immediately following removal of cattle, fecal coliform counts declined t much lower levels and eventually declined to zero. He also found that during the spring and early summer, prior to the introduction of livestock into the pasture, the numbers of fecal coliform bacteria gradually increased in response to runoff and increasing water temperatures. He concluded that organisms residing in the watershed and stream sediments since the previous grazing season contributed to the source. Biske and others (1988)[38] found that 90 percent of bacteria that reaches a stream channel precipitated to the steam bottom and attached to sediments. Sediment samples collected over a period of several weeks found that 90 percent that had lodged into the sediment died within forty days.

[37] In Buckhouse (2000)
[38] Ibid

Johnson (1978) studied two adjacent pastures in central Colorado and found that bacterial contamination significantly increased in the grazed pasture. Following removal of cattle from the grazed pasture bacterial counts dropped to levels similar to those in the ungrazed pasture. Platts (1981) also attributes high concentrations of coliform bacteria in study streams to livestock grazing. He concluded that bacterial concentrations did not directly affect the suitability of habitat for fish; they are nonetheless important indicators of water quality. This typifies the dynamic nature of the quality of surface water, particularly from nonpoint sources. Leffert (2000) sampled surface water quality in Arizona within a variety of grazing pastures. He observed that base streamflows contained very little fecal coliform bacteria content the majority of the time when samples were collected. However, during runoff flows, when rainstorms generated overland flow to the stream channels, fecal coliform levels increased exponentially, well in excess of state water quality standards. Following the runoff event, when the stream hydrograph returned to base flow rates, bacteria concentrations quickly returned to pre-event levels.

Vinten *et al* (2004) described the potential risk of coliform bacteria contamination from farm management practices. They summarized agricultural practices to mitigate the risk. They found that buffer strips, off-stream watering, grassed surface drainage channels, controlled walkways, etc, have potential for reducing coliform inputs to watercourses, all being related more to animal access to streams than to overall stocking densities within a pasture. This was echoed by Collins and Rutherford (2004). In upland situations, it was postulated that stream bed entrainment quickly exhausts the burden of stream bed E. *coli* bacteria and found no significant sedimentation of E. *coli* in water samples. They also found that transport through the soils is not the dominant route of E. *coli* transport at high flows.

Other water quality parameters that may be affected by livestock include suspended solids, temperature, dissolved oxygen, total dissolved solids, specific conductance, ammonia, orthophosphates, and nitrate nitrogen (Johnson *et al* 1978). Johnson *et al* (1978) in a Colorado study did not find any significant increases in any of these other parameters directly attributable to livestock grazing. Buckhouse (2000) cited a nutrient study on the Wood River in Oregon. There was a concern that nutrient loading would be increased when water flowed through grazed land due to fecal contamination. The data refuted this hypothesis, in fact, phosphate and nitrate levels actually decreased. It was speculated that the wetlands in the system acted as a natural nutrient sink, reducing the amount of free nitrate and phosphate concentrations in the water.

Platts (1981) cited studies by Clarie and Storch (1977) and others that found that removal of streamside vegetation contributed to increases in water temperatures in small headwater streams as well as influencing suspended sediment concentrations. Increased sediments have been found to diminish total productivity of the aquatic system, decrease water permeability of channel materials used by fish for spawning, smother fish embryos, and deplete the food supply for fish by filling channel interstices.
Harper (2000) suggested several riparian and channel conditions that contribute to optimum aquatic habitat:

1) At least 60 percent of the stream is shaded between 10:00 am and 4:00 pm during summer months;
2) At least 80 percent of the streambank is in stable condition;

3) Not more than 15 percent of the gravel/rubble substrate is covered by inorganic sediment;
4) At least 80 percent of the site potential for grass-forb, shrub, and trees is achieved;
5) Instream cover should be about 50 percent of the total stream area; and
6) Overhanging banks occur on at least 50 percent of the streambanks.

It should be noted that the ability of any specific stream to achieve one or more of these values depends on the channel type, geological and physiographic setting, riparian community type and serial stage (Leffert, 2000). Marcuson (1977) found floristic composition and density of herbaceous vegetation were markedly different between grazed and un-grazed pastures in Montana. The un-grazed area had a better soil profile and 80 percent less stream channel alteration. This resulted in a 256 pound per acre decrease of fish in the grazed pasture stream as compared to fish densities in the un-grazed area stream.

Platts (no date), discussed "Compatibility of Livestock Grazing Strategies with Fisheries". He evaluated and rated various common grazing strategies based on personal observations as related to stream-riparian habitats. The following summarizes those observations:

Table B: Grazing Strategies and Stream/Riparian Habitats

Strategy	Common Utilization Levels	Stream Bank Stability	Seasonal Plant Regrowth	Rehab Potential
Continuous Season Long (cattle)	Heavy	Poor	Poor	Poor
Short Duration/ High Intensity (cattle)	Heavy	Poor	Poor	Poor
Three Herd/ Four Pasture (cattle)	Heavy to Moderate	Poor	Poor	Poor
Holistic (cattle or sheep)	Heavy to Light	Poor to good	Good	Poor to excellent
Deferred (cattle)	Moderate to Heavy	Poor	Fair	Fair
Seasonal Suitability (cattle)	Heavy	Poor	Fair	Fair
Deferred Rotation (cattle)	Heavy to Moderate	Fair	Fair	Fair
Stuttered deferred rotation (cattle)	Heavy to Moderate	Fair	Fair	Fair
Winter (sheep or cattle)	Moderate to Heavy	Good	Fair to Good	Good
Rest Rotation (cattle)	Heavy to Moderate	Fair to Good	Fair to Good	Fair
Double Rest Rotation (cattle)	Moderate	Good	Good	Good
Riparian Preference (cattle or sheep)	Moderate to Light	Good	Fair	Fair
Corridor Fencing (cattle or sheep)	None	Good to Excellent	Good to Excellent	Excellent

Saunders and Fausch (2005) studied livestock grazing influence on terrestrial invertebrate prey for trout in Wyoming rangeland streams. Two grazing types were observed: high-intensity/
short-duration (HISD) and season-long grazing (SLG). They found there was both greater vegetative production and vegetation cover at sited under HISD management than at sites under SLG management and the biomass of terrestrial invertebrates falling into streams with HISD was 70% greater and more variable than that entering streams under SLG in June and July. Measurements of fish abundance during summer in rangeland streams suggested that sites under HISD supported higher density and biomass of trout than sites managed for SLG.

The Clean Water Act addresses water quality in streams and requirements to "restore and maintain the chemical, physical and biological integrity of the Nations waters." Section 303(d) of the act addresses water quality standards to support designated beneficial uses of waterbodies. Each state is required to sample all waterbodies within its boundaries and develop protocols for maintaining those waterbodies in good condition and improve those that are degraded. The development and application of Total Maximum Daily Loads (TMDLs) is required for all streams for which beneficial uses are not attained. The Forest is required, as are all other landowners, to comply with TMDL requirements. Depending on established requirements, action plans need to be developed that will specify specific actions taken to comply with the regulations and TMDL requirements. These requirements may override all other standards and requirements developed by the Forest, if TMDLs are more stringent than Forest Standards and Guidelines.

Similarly, the Endangered Species Act may dictate allowable activities within a watershed and specifically within a riparian area or waterbody. Currently there are no listed endangered or threatened aquatic or riparian dwelling species within the Caribou or Targhee National Forests.

The Yellowstone and Bonneville cutthroat trout have both been petitioned to be listed as threatened under the Act. The U.S. Fish and Wildlife Service dismissed the petitions stating, at the present time, listing is not warranted. However if these fish species, or other aquatic or riparian-oriented species are listed some time in the future, specific allowable standards would be established by the U.S. Fish and Wildlife Service, or other agencies, which could override any standards and guidelines established by the Forest.

Impact Guidelines

If interdisciplinary efforts and cooperation occur, reasonable approaches can be developed and implemented to provide forage for domestic livestock while improving and maintaining habitat for fish and wildlife (Armor *et al* 1991).

Grazing systems can be used without intractable damage to riparian ecosystems if key riparian plant species are monitored as indicators of forage production and use. This would allow plant vigor and density to be maintained, which, in turn, wildlife, fish and habitat abundance could be sustained and unstable streambanks and poor soils would be able to recover (Armor *et al* 1991). This is strengthened by Bengeyfield (in press). Through paired measurements of physical channel parameters at permanent sites over 5 to 7 years, he showed that moving livestock between pastures based on prescribed levels of annual streambank alteration led to channel improvement. Streams became less entrenched, had smaller width/depth ratios and lower levels of fine sediment.

Numerous management strategies are available to implement the following guidelines. Fencing, various rotation systems, riding, watering, salting, or other methods can all have an effect on resources within the riparian zone. How these guidelines are achieved are left to the manager and must be determined for individual situations and conditions. An alternative to these guidelines is non-use. For example, if a channel is in State B or E, complete rest for one or more years may be appropriate to restore a B State to an A State or accelerate improvement of an E State to an F State. Cowin (no date), based on his experience, concluded that it may take twenty or more years for a channel to reach Properly Functioning Condition if the channel is vertically unstable, more than 70 percent of the streambanks are actively eroding, and/or stabilizing herbaceous plants are limited in density or distribution.

Deferred or delayed use can also have other positive effects. For example, when willows are being affected by livestock, limiting or eliminating access to the riparian zone during the fall may reduce impacts on these woody species. Pelster *et al* (no date) suggested that spring grazing of riparian pastures was preferable to late-season use to minimize browsing on willows. They found that willow consumption increased substantially as herbaceous stubble height was reduced to 10 and 18 cm during the spring and early-summer grazing periods, respectively. Herbaceous stubble heights greater than 20 cm were needed to reduce willow consumption when they were most preferred during the late-summer and fall grazing periods in a tall sedge/willow riparian community. Conversely, if banks or riparian soils are being damaged during the early season, when banks and soils are saturated from the spring runoff, delaying grazing until the fall when the banks and soils are dry and less susceptible to sheering and compaction may be useful. If plant density and vigor are a problem, removing livestock early, while the plants are still growing and allowing adequate time for regrowth before dormancy may be an option.

<u>Goal</u>

Maintain or move toward desired riparian, stream channel, aquatic and water quality conditions. The desired condition is to preserve the function (both physical and biological) of riparian areas and stream channels, associated water quality and aquatic habitat, considering the inherent characteristics of the riparian areas and stream channels and their existing conditions and capabilities*. Additional desired conditions may be developed for specific watersheds or landscapes. This could include the preservation/restoration of native fish habitat or the maintenance/improvement of water quality in imperiled water bodies.

** Protection and enhancement of the resource is the primary goal. However, cost efficiency and practicability may have to be considered in the overall analysis process.*

Explanation

Standards are necessary to maintain or restore the function of riparian areas and stream channels. These standards are designed to protect or improve the integrity of water quality and aquatic habitat through the protection of riparian areas, stream channels and associated flood plains; to restore or enhance water flows, bank water storage and water table interchange, and sediment controlling functions; and maintain or increase the number and kind of riparian plant species, which reflect a variety of natural communities that would be expected to grow within a site, reach, watershed or landscape.

These riparian standards are based on inherent characteristics and capabilities as well as the exiting condition of the different stream types across the Forest as suggested by Myers and Swanson (1991). Stream type aggregates provide a context to integrate historical, existing and foreseeable future valley bottom features and associated stream and riparian characteristics and desired conditions.

Implementation

These riparian standards have five measurable parameters to monitor impacts in riparian areas. The parameters are bank disturbance, soil disturbance, grass/sedge stubble height, woody vegetation utilization and key vegetation species utilization. Allowable disturbance levels are tailored to specific stream-type groups depending on both similarity ratings and resiliency. Additionally, a time-related feature is provided for situations when monitoring time or intensity may be less than that needed to assure assigned parameters are fully met. This feature is intended to provide a reasonable and prudent alternative to situations or circumstances when time, personnel and/or monetary constraints restrict or preclude effective monitoring.

It needs to be emphasized that stubble height, streambank disturbance, woody stem use, etc. are all short-term indicators of grazing effects on meeting long-term management objectives. Each can be used in the appropriate situation, as indicators of good management, and as a target to achieve in the annual operating plan, with the objective of achieving the long-term riparian management goals.

Similarity refers to how similar the riparian area and stream channel are to desired conditions.

High Similarity:

Those areas that reflect characteristics within a natural range of variation. The soils reflect inherent properties and processes. The plant communities are generally those within a desired condition or trending toward a desired seral stage, ecological status or condition (See page 60 for a method of determining plant ecological status/similarity). The channels should be within the range of variation of the desired channel type as defined by Rosgen (1996). Aquatic habitat should reflect the capabilities of the desired channel type, as measured by percent fines in spawning gravel, pool habitat quantity and quality, cobble embeddedness, stream bank stability, particle size distribution, etc.

This can be equated with *Properly Functioning Condition* (Prichard 1998*).* This process considers hydrology, vegetative and erosion deposition components of riparian areas and stream channels. When all these components are in place and functioning, the system is considered to be in properly functioning condition.

***Moderate Similarity*:**

Those riparian areas that are midway between High Similarity and Low Similarity and may have characteristics of both. These areas may include areas that were disturbed at one time but are trending toward high similarity or the reverse.

This can be equated to the Functional-at-Risk category. This is described as areas that may be in a functional condition, but an existing, soil, water or vegetation attribute makes them susceptible to degradation, or an attribute is in less than a desirable condition, but not in degraded (low similarity) condition.

Low Similarity:

Those riparian areas that reflect characteristics below a natural range of variation. These areas have usually been disturbed and provide less than desirable characteristics. These characteristics include soils, vegetation, channel stability, floodplain condition and so forth. Detrimental soil disturbance can be evidenced by extensive puddling, compaction, trails and wallows, hummocky soils, topsoil displacement and bare ground. Plant communities have limited flora, which may contain weedy species. Shrub communities are often absent even where the site historically supported them, or are comprised of decadent individuals of species adapted to constant disturbance. Streams would display characteristics outside the range of variation normally associated with a particular channel type. Adverse stream features may include high width/depth ratios, shifted particle size distribution, trampled banks, increased percent fines in spawning gravel, pool habitat missing or shifted outside the natural range for desired channel type, raw or deteriorating stream banks, etc.

This can be equated to Functional-at-Risk, to Non-Functional, depending on the degree of disturbance. A Non-Functional system is one that clearly does not provide adequate vegetation, landform, or large woody debris to dissipate stream energy associated with high flows and thus are not reducing erosion, improving water quality, etc. There is an absence of certain physical attributes such as a floodplain where one should be.

Caveat - If the channel has deeply downcut and is evolving to another state of channel development (e.g. between state C and D as defined in Prichard (1998), standards for High Similarity may be applied).

This is because the time required for a channel to evolve from one state to another may take several decades, or more, to complete. Even if livestock are completely removed from the site, there may be no effect, either positively or negatively, on the evolution process. In this situation, since livestock grazing will not have any real impact on the evolution process, they may as well graze the site to the fullest extent allowable by the standards.

Resiliency is the ability of the riparian area/stream channel to resist impacts or to recover once disturbed. It is a factor of parent material soils, existing vegetation and stream characteristics.

Stream characteristics have been defined by channel type (Rosgen 1996). These include sensitivity to disturbance, recovery potential, sediment supply potential, streambank erosion potential and vegetation controlling influence. Each Stream type has been consolidated into groups containing like characteristics (See Table 6). These groups have been further consolidated into a High, Moderate or Low Resiliency rating. For example: The B2 stream type is within Stream Group 4 (See Table 6). Stream Group 4, by definition, has a High Resiliency to disturbance.

Measurement of the parameters described herein, except Riparian Disturbance, will usually be within the bankfull flow floodplain zone between the edge of the water and the riparian area, depending on the channel type, vegetation type and composition and the amount of protection needed. Three values are given for early, mid and late grazing seasons.

Movement of livestock within a pasture or to the next pasture will occur when a selected parameter level within these tables is reached. If, for example, the streambank disturbance parameter is reached before the stubble height parameter, livestock must be moved because one parameter has been attained. However, if livestock can be kept out of the stream area where a parameter has been reached, they may stay in the grazing pasture or unit until upland utilization is reached, but only if no other riparian parameters are exceeded.

Standards are set to either maintain the site in a high similarity situation or reverse the downward trend if in a low similarity situation. This in turn will protect water quality/wildlife values in those areas where they presently meet or exceed required or needed values, or improve degraded areas to meet those values. Those areas with low resiliency and low similarity have more conservative values for the parameters to be measured than high resiliency, high similarity areas. This is because once low resiliency areas are damaged they may take longer to recover. The speed at which a riparian area will recover depends on the resiliency of the site, the overall condition, and the magnitude and duration of impacts that continue to influence the site.

To use the following tables, determine the stream group (See Table 7) and the similarity rating for each stream or segment of interest. In the utilization and stubble height tables, three figures are shown for each combination of similarity and resiliency. (e.g. 40/30/20) These are in reference to the timing and use. The first number is early season use (normally the beginning of the growing season to mid July), the second is mid season (usually mid July to mid August), and the third is late season (normally mid August to the end of the growing season). Seasonal climatic and elevational variations will affect the exact dates or time periods of each of the seasons.

For instance, some observers of vegetation in Southeastern Idaho state that most of the cool season vegetation growth occurs during the first six weeks of the growing period, slowing in early to mid-July in "normal" years, followed by the growth of warm season vegetation. Late season (late August to the end of the grazing season) is normally when upland plants stop growing, through some riparian species may continue growing until hard freeze. As such, greater utilization is allowed for those plants grazed earlier in the season because of the re-growth potential. Those plants grazed in mid-season have a reduced re-growth potential and, therefore have a reduced amount of allowable utilization. Plants grazed in the late season have the least potential for re-growth, thus have the least allowable utilization. However, this rule-of-thumb should be used with caution. Smith (2001) studied sedge re-growth in a small spring-fed stream in southeastern Idaho. He found variability in plant re-growth even on the same stream. Two plots experienced over 10 inches re-growth, while two plots had no re-growth at all. He also concluded that consistent re-growth cannot be expected after mid-July and that managers should be cautions when prescribing early season stubble height criteria because of the variability in re-growth responses.

Some literature suggests that standards should be different depending on the socio-political class or sensitivity of the stream, or the kind of grazing, i.e. season-long vs. rest rotation. In these situations, stream classes or sensitivities are based on risk, the presence of certain uses, such sensitive species, and so forth. These concepts have merit. The purpose of the standards listed below is to protect all riparian areas and stream channels from degradation. However, socio-political factors, such as the presence of threatened or endangered species, or listing of the stream under section 303(d) of the Clean Water Act may warrant additional protection or accelerated restoration. As such, more restrictive standards may be justified than those advocated within the tables. For example Forest Service Handbook 2209.21 (1993) states that stubble heights of greater than 6 inches may be necessary to protect special riparian ecosystem functions, such as critical fisheries. FSH 2209.21 further states that where riparian and fishery habitats as well as other sensitive areas are involved, grazing animals must be totally removed from the grazing unit when proper use has been attained. Failure to do so could negate the objectives of the grazing system.

Table 1. Greenline - Key Species Forage Utilization (Percent).

Stream Group	Properly Functioning Condition	Functioning at Risk (High to Moderate)	Functioning at Risk (Low) to Non Functioning	Non Functioning (States C & D)
0,1,2,3,4, 12,16	55/45/35	45/40/30	40/30/20	45/40/30
5,6,9,10 13,14,15	50/40/30	40/30/25	30/25/20	40/30/25
7,8,11 17	40/30/20	30/25/20	20/20/20	30/25/20

Key Species Utilization:

This is the percent of total weight of **greenline** key species utilized by livestock while grazing the affected riparian area. In some areas of high similarity (PFC) it will be forage species, such as *Carex aquatilis*. Under lower similarity (Functioning at Risk to Non Functioning) the focus may be on all grass species present, since one would not expect to find an abundance of desired species if the area has been over-utilized by ungulates.

Table 2. Woody/Shrubby Species Utilization (Percent).

Stream Group	Properly Functioning Condition	Functioning at Risk (High to Moderate)	Functioning at Risk (Low) to Non Functioning	Non Functioning (States C & D)
0,1,2,3,4, 12,16	50/50/50	50/50/40	50/40/35	50/50/40
5,6,9,10 13,14,15	50/50/45	50/45/40	50/40/30	50/40/30
7,8,11 17	40/40/35	40/35/30	30/20/15	40/35/30

Woody/Shrubby Species Utilization:

This is the utilization of the annual growth of woody species such as willows, aspen, dogwood, etc. by livestock **and** wildlife within the riparian area. Emphasis will be on individual plants closest to the stream bank. Utilization is compared to a similar plant, or a portion of the same plant, that has not been browsed. Lower utilization rates for lower resiliency/similarity segments are not particularly based on plant physiology, or the ability of plants to withstand grazing pressures, but rather on emphasizing plant regeneration and/or reestablishment.

Table 3. Greenline - Stubble Height (Inches).

Stream Group	Properly Functioning	Functioning at Risk (High to Moderate)	Functioning at Risk (Low) to Non Functioning	Non Functioning (states C & D)
0,1,2,3,4, 12,16	2/3/5	3/4/5	4/5/6	3/4/5
5,6,9,10 13,14,15	3/4/5	4/5/6	5/6/8	4/5/6
7,8,11,17	4/6/6	5/6/8	6/8/8	5/6/8

Stubble Height:

This is the height of standing **greenline** herbaceous vegetation at the time of measurement. These values take into consideration any anticipated regrowth. Measurement can be in one of two ways. It can be an average of all the forage within the bankfull zone, or it can focus on one or several Key species within the bankfull zone. The bankfull zone is normally associated with the so-called "greenline", which is the first perennial vegetation from the water's edge. It is realized that some species may not naturally grow to a desired length, or natural conditions such as a drought may stagnate growth. If this occurs, percent utilization may be a better parameter than stubble height.

Table 4. Riparian Zone Soils Disturbance (Percent)*

*These parameters are appropriate where ground cover (a combination of vegetation, litter and rock fragments (larger than ¾ inch in diameter) protect, and are in contact with the soil. If total ground cover within the riparian emphasis area is less than **80%,** use the next lower resiliency or similarity parameter.

Stream Group	Properly Functioning	Functioning at Risk (High to Moderate)	Functioning at Risk (Low) to Non Functioning	Non Functioning (states C & D)
0,4,6,10	15%	15%	10%	15%
1,2,5,7, 12,16	15%	15%	10%	15%
3,8,9,11, 13,14,15, 17	10%	10%	5%	10%

Riparian Soils Disturbance:

This refers to detrimental soil disturbance within the riparian area. This differs from bank disturbance in that the entire riparian area is assessed, rather than just the stream bank. Characteristics of detrimental soil disturbance include puddling (results in hummocky soils), compaction and displacement. It can be associated with high amounts of bare soil. Soil disturbance will not necessarily be measured exclusively within bankfull zone, but will be measured in the larger floodplain area or sensitive low terrace, depending on the channel type. Soil is considered bare if not protected by vegetation, moss, litter or rock. Other soil factors, such as displacement, compaction, and/or puddling, in addition to burning and on-site organic matter (litter and large woody debris), may also be considered per FSH 2509.18 – Soil Management Handbook, Region 4 Supplement No. 2509.18-95-1 and other appropriate Regional standards and guidelines.

Table 5. Bank Disturbance/Alteration - One Year (Percent)

Stream Group	Properly Functioning	Functioning at Risk (High to Moderate)	Functioning at Risk (Low) to Non Functioning	Non Functioning (States C & D)
0,3,4,6,12,16	25%	20%	15%	20%
1,2,5,13	20%	15%	15%	15%
7,8,9,10,11,14,15,17	15%	10%	10%	10%

Table 5A. Bank Stability - Cumulative (Percent)

Stream Group	Properly Functioning Condition	Functioning at Risk (High to Moderate)	Functioning at Risk (Low) to Non Functioning	Non Functioning (States C & D)
0,3,4,6,12,16	85%	80%	75%	80%
1,2,5,13	80%	75%	70%	75%
7,8,9,10,11,14, 15,17	75%	70%	65%	70%

Bank Disturbance/Alteration refers to short-term (annual) physical disturbance of alteration of the bank by livestock trampling. Characteristics of bank disturbance/alteration are bare soil exposed to running water, bank erosion or sloughing. Bank disturbance is measured from the low water line to the top of the bank and as far away from the shoreline as necessary to properly assess conditions that may lead to a section of the bank eroding or falling into the stream during higher flows.

Bank Stability refers to long-term bank structure, expresses as a percentage of the streambank in one of six stability classes. It is intended for long-term trend monitoring and should be read on 3-5 year intervals. It includes damage from natural processes, such as floods, and human caused impacts, such as mining or recreation vehicle crossings, as well as from livestock.

Other socio-political requirements or constraints may supersede these parameters. For example, Total Maximum Daily Load (TMDL) requirements for a Clean Water Act, Section 303(d) stream may require 80% of the banks to be in a stable condition. This requirement would supersede the above parameters, unless they are more stringent than the TMDL requirement.

Table 6. Riparian Zone Forage Utilization and Stubble Heights *(Riparian** Vegetation).

Season of Use	Properly Functioning Condition (%/Stubble Height)	Functioning at Risk (High to Moderate) (%/Stubble Height)	Functioning at Risk (Low) to Non Functioning (%/Stubble Height)	Non Functioning (States C & D) (%/Stubble Height)
Spring	**65/2**	**55/3**	**45/4**	**55/3**
Summer	**55/3**	**45/4**	**35/5**	**45/4**
Fall	**45/4**	**35/5**	**20/6+**	**35/5**

Table 6A. Riparian Zone Forage Utilization and Stubble Heights (*Upland** Vegetation).

These parameters are appropriate where ground cover (a combination of vegetation, litter and rock fragments (larger than ¾ inch in diameter) protect, and are in contact with the soil. If total ground cover within the riparian emphasis area is less than **60 percent,** use the next lower resiliency or similarity parameter.

Properly Functioning Condition (% Utilization)	Functioning at Risk (High to Moderate) (% Utilization)	Functioning at Risk (Low) to Non Functioning (% Utilization)	Non Functioning (States C & D) (% Utilization)
50%	**40%**	**30%**	**40%**

* ***Riparian*** vegetation is considered those grasses and sedges normally associated with wet or anerobic soil conditions. ***Upland*** vegetation consists primarily of grasses normally associated with dryer soil conditions.

<u>Percent Utilization</u>:
The percent of total weight of key species within the Riparian Zone utilized by livestock while grazing the affected riparian area.

<u>Stubble Height</u>:
The height of standing herbaceous vegetation at the time of measurement. Measurement can be in one of two ways. It can be an average of all the upland forage within the Riparian zone, or it can focus on one or several Key Species within the Riparian zone. It is realized that some species may not naturally grow to a desired length, or natural conditions such as a drought may stagnate growth. If this occurs, percent utilization may be a better parameter than stubble height.

Only a percent utilization is given since residual stubble heights associated with utilization rates can be highly variable depending on the plant species and growing conditions.

Key To Determine Allowable Use Parameters Within Riparian/Wetland Areas

A managerial dilemma is deciding what monitoring parameter to apply to a particular situation. Two basic schools-of-thought polarize the issue. One school-of-thought is based on a simplistic one-size-fits-all concept that loosely reasons that if one component of the system is in satisfactory condition, the rest of the components will follow accordingly. Stubble height is one parameter that seems to have defaulted, in some areas, to this universal status; reasoning that stubble height is relatively easy to measure and it provides a somewhat accurate picture of grazing impacts. Depending on actual on-the-ground situations, the one-size-fits-all stubble height parameter, in itself, may not represent a true picture of impacts to riparian vegetation, channel stability, water quality and aquatic habitat.

The opposite school-of-thought lies in the camp of intensively monitoring a multitude of parameters, on a regular basis throughout the entire affected area. Though this methodology may reflect a more accurate picture of actual impacts and effects, the time and effort required to conduct such monitoring is prohibitive on any large-scale landscape. The answer lies somewhere in the middle.

Clary and Leininger (2000) suggest that no single management approach is best for all situations and no management tool serves all purposes. Other 'experts' assert that application of specific parameters depends on the type of landscape and intensity of impacts, but cannot offer any substantial suggestions without "looking on-the-ground" with a full interdisciplinary team. Again, this concept is well intended, but, in practice, the time and effort required for such intensive reviews on every area is impractical.

There is a need to adapt monitoring parameters to physical conditions found on the ground. Rather than instituting a universal, one-size-fits-all parameter, such a stubble height, the manager needs to be able to key in on the cause of any problems, rather than monitoring the symptom.

This concept is reinforced by Clary and Leininger (2000). They suggest that many managers tend to look at short-term impacts in the form of single monitoring parameters (such as stubble height), rather than looking at long-term management objectives such as the concepts of Potential Natural Community, Desired Future Condition or Properly Functioning Condition. They suggest that a manager should have a clear picture of the desired long-term structure and function of a riparian and channel system before setting any specific standards, such as stubble height. This is also emphasized in the University of Idaho, Stubble Height Study Report (2004)

Leonard *et al* (1997) stressed that regardless of other differences in management objectives, grazing must be compatible with achieving or maintaining "Properly Functioning Condition" (PFC) to be considered to be sustainable. PFC is achieved when adequate vegetation, landform, and/or large woody debris is present to:

- Dissipate stream energy associated with high waterflows, theregy reducing erosion and improving water quality
- Filter sediment, capture bedload, and aid floodplain development
- Improve flood-water retention and ground-water recharge
- Develop root masses that stabilize streambanks against cutting action
- Develop diverse ponding and channel characteristics to provide the habitat and water depth, duration and

temperature necessary for fish production, waterfowl breeding and other uses
- Support greater biodiversity

They go on to say that livestock grazing may not always be entirely compatable with other resource uses or values. In some of these situations, excluding livestock grazing may be the most logical and responsible course of action. The compatibility of grazing in riparian areas depends on the extent to which grazing management considers and adapts to certain basic ecological relationships. Prior to developing grazing management prescriptions, the manager should have some understanding of grazing effects on ecosystem functions such as soils, water quality and hydrologic/ geomorphic conditions and processes.

The following key is designed to help the manager focus in on the parameter or parameters that may be monitored in an effort to obtain a more efficient and accurate reflection of short-term impacts, while maintaining or moving toward desired riparian and channel conditions over the long term. Use of the key can be accomplished in a relatively short amount of time without requiring the need of large interdisciplinary teams. However, the use of ID teams is still encouraged when and where possible.

Use of the key requires a basic knowledge of the Properly Functioning Condition[39] concept. The quasidichotomous key is subdivided into three parts. The first part consists of socio-political factors. These factors attempt to address the human values placed on a certain riparian area or reach of stream. The second part addresses the resource values themselves. These values are developed using the Properly Functioning Condition assessments. Beaver change the natural conditions of a stream channel and riparian area and are addressed separately.

Again, it is emphasized that a short-term or annual monitoring parameter (i.e., five-inch greenline stubble height, etc.) is NOT the desired condition. It is merely a surrogate for achieving long-term goals and desired conditions. These desired conditions are determined by the manager. They can be Properly Functioning Condition, some seral state or stage of vegetative communities, some state or stage of channel stability, water quality, aquatic habitat and so forth. These can and should be set by an ID team prior to establishing standards.

Once a parameter, or parameters is/are established, monitoring is required to determine if the parameter(s) are sufficient to attain the desired goal or condition. If not, parameters can and should be adjusted so that long-term conditions are achieved and maintained.

Use of the key is a several-step process. First, a desired condition must be determined. Secondly, the existing condition must be known. The key is based on a desired future condition of Properly Functioning Condition. To this end, the 17 checklist questions (USDI 1998)[40] must be answered. The third step is to go through the key, answering the yes-no questions until the suggested parameter or parameters are determined.

To use the tables, channel type must be known. To determine Stream Group used in the tables, go to Table 7 in this guide. The channel type is found in the extreme left column, the associated Stream Group is found in the adjacent column to the right. Find the

[39] USDI, Bureau of Land Management, 1998. Riparian Area Management, A User Guide to Assessing Proper Functioning Condition and the Supporting Science for Lotic Areas, TR 1737-15, National Applied Resource Sciences Center, Denver, Co.

[40] Ibid

appropriate stream group along the extreme left side of the parameter table(s), locate the existing condition along the top of the table(s) and at the intersection of the Stream Group row and the existing condition column are the suggested parameter(s).

For example, using Table 3 (Greenline Stubble Height) the numbers at the intersection of Stream Group 4 and Function At Risk-High to Moderate are the numbers 3/4/5. This means key species greenline vegetation can be grazed to 3 inches in the early season, to 4 inches in the mid-season, and to 5 inches if grazed in the late season. The exact dates or times of "early", "mid" and "late" can vary between Forests or even between years, therefore are not specified. However, for the Caribou National Forest, "early" is usually defined as the beginning of the growing season to mid July, "mid" season from mid July to mid August, and "late" season from mid August to the end of the growing season (see Impact Guidelines section for more detail).

Socio-political Factors:

1) **AIZ* contains TE species and/or stronghold for Sensitive Species**
   *These parameters are appropriate where ground cover (a combination of vegetation, litter and rock fragments (larger than ¾ inch in diameter) protect, and are in contact with the soil. If total ground cover within the riparian emphasis area is less than **60 percent,** use the next lower resiliency or similarity parameter.

   YES Control grazing to protect species habitat. Increase protection at least one Resiliency or Similarity Level: e.g. area is determined to be PFC/High Similarity, use guidelines for Functional-at-Risk/Moderate Similarity; If already at Low Resiliency/Similarity, rest the area for one or more years until condition reaches Moderate Similarity; go to 2

   NO Go to 2

2) **AIZ contains a 303(d) stream**

   YES Increase protection at least one Resiliency or Similarity level(i.e. high to moderate or moderate to low); If already at Low Resiliency/Similarity, rest the area for 1 or more years until condition reaches Moderate Similarity; go to 3

   NO Go to 3

3) **A 303(d) stream or Riparian/Aquatic TES species is immediately below (within 1 mile) Forest boundary**

   YES Consider increasing protection one Resiliency or Similarity Level; If already at Low Resiliency/Similarity, rest the area for 1 or more years until condition reaches Moderate Similarity; go to 3a

   NO Go to 3a

   3a) **A 303(d) stream or Riparian/Aquatic TES species is one to ten miles below Forest boundary and within 1 stream order**

   YES Consider increasing protection one Resiliency or Similarity Level; If already at Low Resiliency/Similarity, consider resting the area for 1 or more years until condition reaches Moderate Similarity; go to 3b

NO Go to 3b

3b) **A 303(d) stream or Riparian/Aquatic TES species is greater than 10 miles below Forest boundary or is two or more stream orders greater than the stream order at the Forest boundary.**

YES Use evaluated Similarity Level; go to 4

NO Go to 4

Physical Factors:

4) AIZ is at Properly Functioning Condition (PFC)

YES Go to 5

NO Go to 4a

4a) AIZ is Functioning At Risk (FAR)

YES Go to 6

NO Go to 4b

4b) AIZ is Non Functioning (NF)

Go to 6

5) **If AIZ is at PFC, are there any rated factors within control rated "No"?**

YES Go to 6

NO Maintain current grazing scheme; great work!!

6) Are any "Hydrology" factors rated "No"?

YES Go to 7

N0 Go to 6a

6a) Are any "Vegetation" factors rated "No"?

YES Go to 10b

NO Go to 6b

6b) Are any "Erosion/Deposition" factors rated "No"?

YES Go to 8

NO Go to 7

Floodplain and Channel Characteristics

7) Is floodplain inundated in relatively frequent (1 to 3 years) events?

YES Go to 8

NO Go to 7a

7a) Is the channel Type F or G? (See page 60, Figure 2)

YES Go to 7b

NO Go to 8

7b) Is the channel in State B or E? (See page 57, Table 1)

YES Go to 8

NO Go to 7c

7c) Is the channel in State C or D? (see page 57, Table 1)

YES Use "High Similarity/High Resiliency guidelines; go to 8

NO Go to 8

8) Are the floodplain and channel characteristics adequate to dissipate energy?

YES Go to 9

NO Go to 8a

8a) Are channel characteristics changing (i.e. widening, deepening, bank cutting)?

YES Go to 8b

NO Go to 9

8b) Are Stream Type Groups 05, 07, 08, 09, 11, 13, 14, 15 or 17?

YES Go to 8c

NO Go to 9

8c) Is adequate vegetative cover present to protect banks and dissipate energy during high flows?

YES Go to 9

NO Go to 8d

8d) **Is bank soil structure, texture and cohesive strength such that extensive root and surface mass is needed to maintain bank stability (i.e. silty alluvial soils)(e.g. C3-C6, DA4-DA6 and E3-E6 Channel Types)?**

YES Go to 8e

NO Go to 9

8e) **Are livestock suppressing vegetative cover?**

YES Use stubble height guidelines (Table 3); go to 9

NO Go to 9

9) **Are channels in balance with the landscape setting?**

YES Go to 10

NO Go to 9a

9a) **Is sinuosity within acceptable parameters for the channel type?**

YES Go to 9d

NO Go to 9b

9b) **Has the channel been artificially straightened or meanders being cut off?**

YES Go to 9c

NO Go to 9d

9c) **Are livestock aggravating channel straightening?**

YES Use bank disturbance, vegetation and/ or woody/shrubby species utilization guidelines (Tables 1, 2, and/or 5/5A); go to 10

NO Go to 9d

9d) **Are overhanging banks present in good condition?**

YES Go to 9f

NO Go to 9e

9e) **Is overhanging bank sheering aggravated by livestock?**

YES Use bank disturbance guidelines (Table 5/5A); go to 10

NO Go to 9f

9f) **Is width/depth ratio greater than normal for the Channel Type?**

YES Go to 9g

NO Go to 9h

9g) **Is bank sheering/instability aggravated by livestock?**

YES Use bank disturbance, forage utilization, stubble height and/or woody/shrubby species guidelines (Tables 1, 2, and/or 5/5A); go to 10

NO Go to 9h

9h) **Is lateral movement of stream channels within natural ranges?**

YES Go to 9k

NO Go to 9i

9i) **Are stream banks eroding excessively? (Greater 30 percent)**

YES Go to 9j

NO Go to 9k

9j) **Are livestock contributing to excessive lateral migration?**

YES Use bank disturbance, vegetation utilization and/or woody/shrubby species guidelines (Tables 1, 2, and/or 5/5A); go to 10

NO Go to 9k

9k) **Is the stream channel vertically stable?**

YES Go to 10

NO Go to 9l

9l) **Is the channel downcutting or aggrading at an accelerated rate? (e.g. headcutting or excessive sediment buildup)**

YES Go to 9m

NO Go to 10

9m) **Are livestock aggravating the condition?**

YES Use stubble height, bank disturbance, soil disturbance and/or woody/shrubby species utilization guidelines (Tables 2, 3, 4, and/or 5/5A); go to 10

NO Go to 10

10) Is the flow/sediment ratio in balance (no excessive erosion or deposition)?

YES Go to 11

NO Go to 10b

Vegetation Characteristics;

10b) In B and C channel Types, are point bars being colonized and stabilized with willows and/or sedges? For other channel types go to 10c.

YES Go to 11

NO Go to 10c

10c) Are livestock retarding vegetation establishment?

YES Use vegetation utilization, stubble height and/or woody/shrubby utilization guidelines (Tables 1, 2 and/or 3); go to 11

NO Go to 11

11) Is the riparian area widening or has achieved its potential extent?

YES Go to 12

NO Go to 11a

11a) Is riparian vegetation capturing upslope sediment?

YES Go to 11b

NO Go to 11b

11b) Are livestock retarding riparian vegetation vigor and density?

YES Use riparian stubble height/utilization and/or soils disturbance guidelines (Tables 4, and/or 6/6A); go to 12

NO Go to 11c

11c) Is riparian vegetation capturing instream sediment?

YES Go to 12

NO Go to 11c

11d) Are livestock aggravating the lack of greenline vegetation?

YES Use stubble height guidelines (Table 3); go to 12

NO Go to 12

12) Are there at least two age-classes of deep-rooted riparian/wetland vegetation?

YES Go to 13

NO Go to 12a

12a) Is young age-class recruitment or replacement vegetation present?

YES Go to 13

NO Go to 12b

12b) Are livestock suppressing recruitment or replacement of vegetation?

YES Protect replacement vegetation – use vegetation utilization guidelines (Table 1) for streamside vegetation and stubble height/utilization guidelines (Table 6/6A) for area-wide guidelines. Increase protection at least one Resiliency or Similarity Level until at least two age classes are established; go to 13

NO Go to 13

13) Is there a diverse (two or more species) composition of deep-rooted (e.g. sedges/willows) riparian vegetation with high vigor?

YES Go to 15

NO Go to 13a

13a) Are livestock suppressing vigor?

YES Use vegetation utilization and/or woody/shrubby utilization guidelines (Tables 1, 2 and/or 6/6A); go to 14

NO Go to 14

14) Are plant communities an adequate source of coarse and/or large woody material?

YES Go to 15

NO Go to 14a

14a) Is coarse and/or large woody debris needed to dissipate energy and capture bedload?

YES Go to 14c

NO Go to 14b

14b) Is sufficient material available to dissipate energy and capture bedload?

YES Go to 14c

NO Use Woody/Shrubby Species guidelines (Table 2); go to 15

14c) Is sufficient material available to maintain/replace woody material?

YES Go to 15

NO Go to 14d

14d) Are livestock suppressing recruitment of adequate plant communities?

YES Use Woody/Shrubby Species guidelines (Table 2); go to 15

NO Go to 15

Beaver;

15) Are beaver dams active and stable?

YES Go to 15a

NO Go to 15a

N/A Use guidelines established above.

15a) Are willows/wood available for dams/food?

YES use guidelines established above.

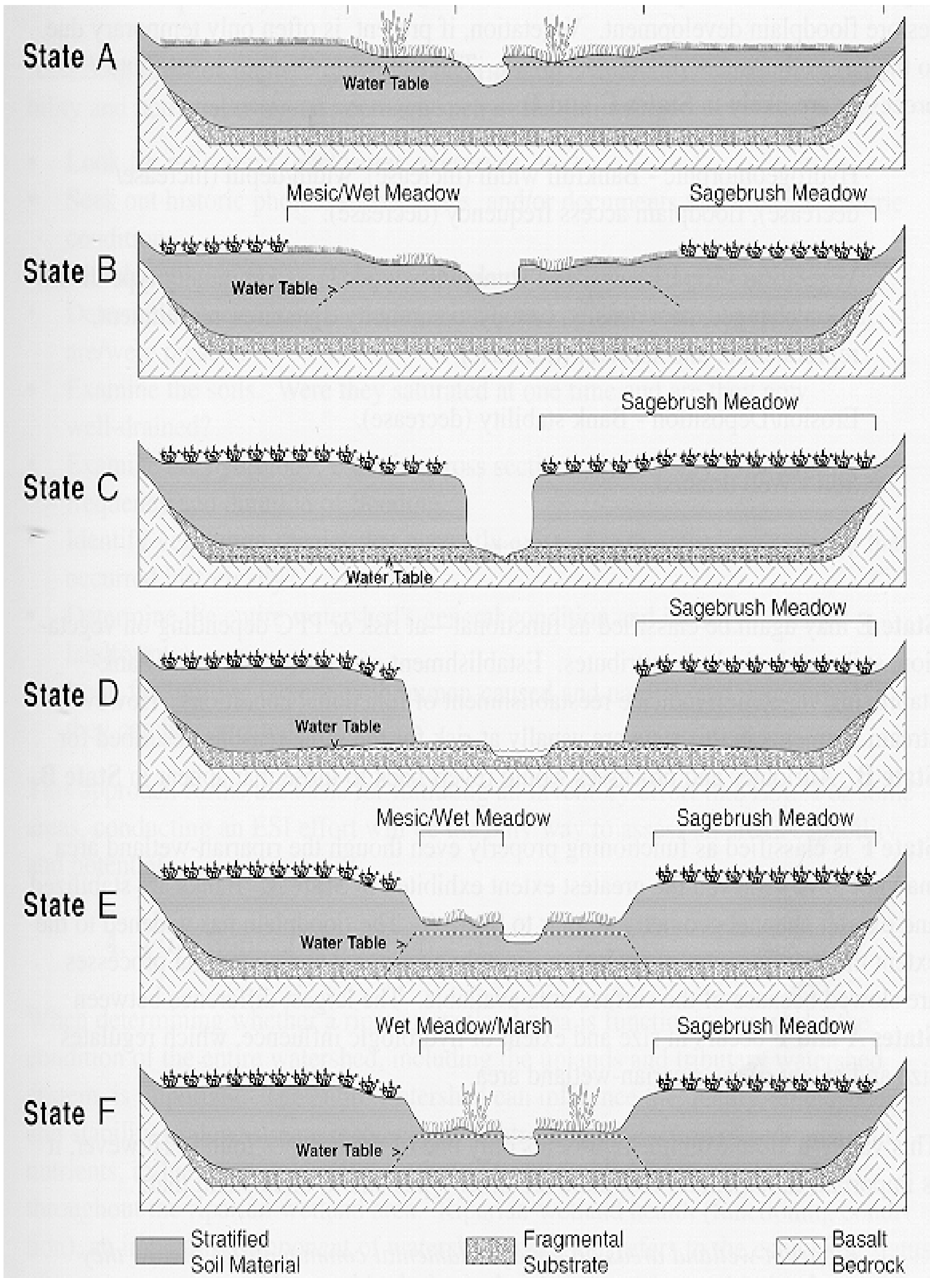
NO Consider beaver management; Go to 15b

15b) Are livestock contributing to lack of willows/wood?

YES Use Woody/Shrubby Species Utilization Guidelines (Table 2)

NO Go back to 6 if applicable; otherwise use guidelines established above.

Figure 1. Succession of States for Alluvial/Nongraded Valley Bottom Types*



* From Prichard, ISDI, 1998, p. 11-13

Ecological Status/Successional State/Similarity[41]

Since there is often limited information concerning which community types indicate unnatural disturbances and because it is extremely difficult to find examples of PNC situations in riparian areas, the following procedures may be used to broadly rate riparian areas as to their successional status.

A list has been developed of all community types known to occur on lands administered by the Intermountain Region. In this list, each community type has been assigned an "L" if they are known to occur in latter successional stages, or an "E" for types known to occur in earlier stages of succession. Percent composition of each community type from measurements can be used to determine the ecological status, thus the Similarity to the natural range of variation and desired conditions.

Ecological Status

- Arrange the community type compostiion values to either an "Early or "Late" column (found in the R-4 Integrated Riparian Evaluation Guide, Appendix 1).
- Summarize all types that occur in the "Late" column and divide by the percent of the vegetation that should be represented by late seral community types. This value will range from 75-95 percent.
- Rating of ecological status is then determined by comparing this number with those assigned to each of the five seral status values:

  1-15 = very early,
  16-40 = early,
  41-60 = mid,
  61-85 = late, and
  86+ = PNC

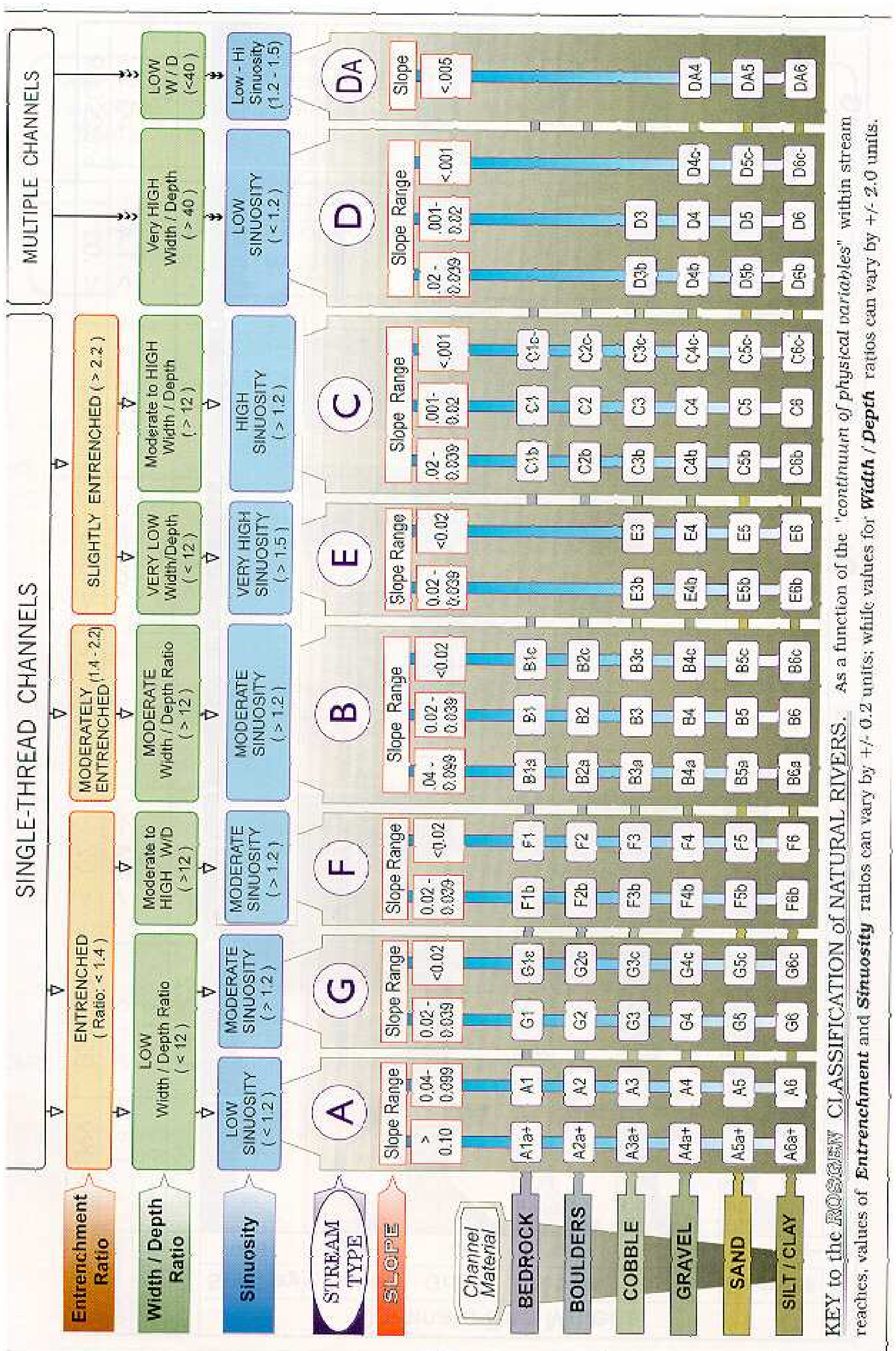
These ecological status ratings may now be evaluated against standards or desired conditions set for the area being evaluated.

[41] In USDA Forest Service, Intermountain Region. 1992. Integrated Riparian Evaluation Guide – Intermountain Region, March 1992.

Table 7. Summary of Stream Channel Characteristics and Sensitivity to Disturbance
(Source: Modified from D. L. Rosgen, Applied River Morphology, 1996 pg 8-9.)

Stream Type	Stream Group	Sensitivity to Disturbance	Recovery Potential	Sediment Supply	Stream Bank Erosion Potential	Vegetation Controlling Influence
A1, A2	SG-00	Very low	Excellent	Very low	Very low	Negligible
A3	SG-01	Very high	Very poor	Very high	Very low to very high	Negligible
A4, A5	SG-02	Extreme	Very poor	Very high	Very high	Negligible
A6	SG-03	High	Poor	High	High	Negligible
B1, B2, B3	SG-04	Very low to low	Excellent	Very low to low	Very low to low	Negligible to moderate
B4, B5, B6	SG-05	Moderate	Excellent	Moderate	Low to moderate	Moderate
C1, C2	SG-06	Low	Very good	Very low to low	Low	Moderate
C3	SG-07	Moderate	Good	moderate	Moderate	Very high
C4, C5, C6	SG-08	Very high	Fair to good	High to very high	High to very high	Very high
D3, D4, D5, D6	SG-09	High to very high	Poor	High to very high	High to very high	Moderate
DA4, DA5, DA6	SG-10	Moderate	Good	Low to very low	Low to very low	Very high
E3,. E4, E5, E6	SG-11	High to very high	Good	Low to moderate	Moderate to high	Very high
F1, F2	SG-12	Low	Fair	Low to moderate	Moderate	Low
F3	SG-13	Moderate	Poor	Very high	Very high	Moderate
F4	SG-14	Extreme	Poor	Very high	Very high	Moderate
F5, F6	SG-15	Very high	Poor to fair	High to very high	Very high	Moderate
G1, G2	SG-16	Low to moderate	Fair to good	Low to moderate	Low to moderate	Low
G3, G4, G5, G6	SG-17	Very high to extreme	Very poor to poor	High to very high	High to very high	High

Figure 2. Rosgen Channel Classification Key.



(Source: D. L. Rosgen, Applied River Morphology,1996, pg 5-6.)

Table 8. Riparian/Stream Channel Morphology Objectives.

Channel Type	Pool Frequency	Pool Type	Width/ Depth Ratio	Deep-Rooted Vegetation	Percent Bank Stability	Large Woody Debris	Stability Rating
A1	Irregular	Scour step	<12	Not important	>60	Not important	<44
A2	Irregular	Scour step	<12	Not important	>60	Not important	<44
A3	Irregular	Scour step	<12	Not important	>70	Important for pools - irregular spacing	<91
A4	Irregular	Scour step	<12	Not important	>60	Important for pools - irregular spacing	<96
A5	Irregular	Scour step	<12	Not important	>60	Important for pools - irregular spacing	<96
A6	Irregular	Scour step	<12	Not important	>60	Important for pools - irregular spacing	<81
B1	Infrequent	Scour step	>12	Not important	>60	Not important	<46
B2	Irregular	Scour step	>12 <21	Not important	>60	Not important	<46
B3	Irregular 3-5 bankfull widths	Scour step	>12 <22	Important	>60	Important for pools	<61
B4	Irregular 3-5 bankfull widths	Scour	>12 <20	Important	>65	Important for complexity	<65
B5	Irregular 3-5 bankfull widths	Scour	>12 <20	Important	>65	Important for complexity	<69
B6	Irregular 3-5 bankfull widths	Scour	>12 <20	Important	>65	Important for complexity	<61
C1	Irregular	Backwater and scour	>12	Important woody /sedge	>65	Important for pools	<51
C2	Irregular	Backwater and scour	>12	Important woody /sedge	>65	Important for pools	<51
C3	Irregular 5-7 bankfull widths	Riffle/scour pool	>12 <37	Important woody /sedge	>70	Important for complexity	<86

Channel Type	Pool Frequency	Pool Type	Width/ Depth Ratio	Deep-Rooted Vegetation	Percent Bank Stability	Large Woody Debris	Stability Rating
C4	Irregular 5-7 bankfull widths	Riffle/scour pool	>12 <29	Important woody /sedge	>70	Not important	<91
C5	Irregular 5-7 bankfull widths	Riffle/scour pool	>12 <30	Important woody /sedge	>70	Not important	<91
C6	Irregular 5-7 bankfull widths	Riffle/scour pool	>12	Important woody / sedge	>70	Not important	<86
D3-6	Irregular	Scour/ debris dams	>40	Very important woody /sedge	>65	Not important	<108
E3	Irregular	Riffle/scour pool	>6 <10	Very important sedge/ woody	>65	Not important	<64
E4	Irregular	Riffle/ scour pool	>2 <6	Very important sedge/ woody	>65	Not important	<76
E5	Irregular	Riffle/ scour pool	>2 <7	Very important sedge/ woody	>65	Not important	<76
E6	Irregular	Riffle/ scour pool	<12	Very important sedge/ woody	>65	Not important	<64
F1-6	Irregular 5-7 bankfull widths	Scour/ debris dam	>12 <40	Not important	>65	Important for pools	<116
G1-6	Irregular	Scour step	<12	Important woody /sedge	>70	Not important	<113

Column Definitions:

Channel Type: As defined by Rosgen 1996

Pool Frequency:

Infrequent - Due to physical channel conditions, pools are infrequent within any given reach. There is no set pool spacing or number of pools within any given reach.

Irregular - Due to physical channel conditions, pools are irregularly spaced within any given reach. There is no set pool spacing or number of pools within any given reach.

Bankfull widths - Channel geometry is such that pools are spaced at specified intervals based on the bankfull width of the channel. e.g. 5-7 bankfull widths - if the bankfull width is 10 ft., pools would be expected to be spaced 50 to 70 feet apart within any given reach; or within a 1,000 ft. reach, 14 to 20 pools would be expected to occur.

Pool Type:

Scour step - Due to the steepness of the channel bed, the stream "steps" down the slope. Water plunging over these "steps" scours a pool below the obstacle. "Steps" may be formed by rock or organic debris.

Scour - Channel steepness is not enough to form plunge pools, but do support sufficient velocities for water to scour pools as it works its way over and between rocks and organic debris.

Backwater - Small dams are formed within the channel by rock and organic debris. Water pools behind these barriers rather than forming scour pools below the obstacle.
Riffle/scour pool - This stream type exhibits a sequencing of steeps (riffles) and flats (pools) that are linked to meander geometry. The spacing interval is predictable depending on channel type and width.

Scour/debris dam - Pools are formed as a result of bank and bottom scouring and small dams formed by organic debris. Rocks do not play an important role in pool formation.

Width/Depth Ratio: The ratio of the bankfull (approx. 2.5 year reoccurrence flood level) surface width to the mean depth of the bankfull channel.

Deep Rooted Vegetation: Some channel types do not contain sufficient rock, large wood, etc. content in the banks to suppress bank erosion. In this situation, vegetation having deep and dense root systems is necessary to bind the soil and suppress bank erosion.

Woody/Sedge - Though sedges are important to be maintained on-site, woody plant species (willow, alder, dogwood, etc.) are more desirable to be maintained than sedges because of potential high bank heights. Woody species' roots generally extend deeper than sedges.

Sedge/Woody - Though woody species may be desired, sedges are sufficient to protect potential bank erosion.

% Bank Stability: Minimum percent of stable banks needed to maintain channel stability. This is a total of both banks within a stream reach.

Stability Rating: As developed by Pfankuch (1975) (also known as R1/R4 Stream Reach Inventory and Channel Stability Evaluation). Ratings by channel type are those reflecting channel stability of "Good" or better as defined by Rosgen (1996).

Monitoring

Monitoring objectives should be dictated by the present condition and trend of the riparian habitat in relation to management goals, the resource potential for change and the importance of other resource values. Good monitoring objectives should be achievable, measurable and worthy of the costs incurred to accomplish and monitor them (Leonard *et al* 1997).

The six monitoring parameters are intended to be the minimum requirements. Other, more comprehensive monitoring protocols may be used as necessary and are described in documents such as the R-4 Integrated Riparian Evaluation Guide (1992) and may be used as needed to properly assess and evaluate a specific situation. The Beaverhead/Dearlodge National Forest, as well as other Forests and BLM offices, have also developed bank disturbance and other monitoring guidelines.

As a minimum, monitoring will be within Key Areas. Monitoring will include:

1) Administrative monitoring of one or more of the six parameters, as appropriate, and

2) Longer term effectiveness monitoring to gauge progress toward desired conditions.

If the effectiveness monitoring confirms movement toward the desired condition, then the similarity level may move to a higher level. Poor outcomes will result in reevaluation of the current standards and possibly more restrictive or application of different measures.

Specific Key Areas should be determined through an interdisciplinary team process, conferring with the permittee. Key areas should be representative of the riparian aggregates within the grazing area. Care should be taken to avoid inclusions that are not representative of the area.
The objectives of these standards are to protect the riparian and aquatic resources. Key Area and Key Species selection should be done with this in mind.

For example: A stream flowing through an allotment has two major stream types. One falls into a category that is highly resilient, and another, smaller, portion falls into a lower resiliency category. A chain is as strong as its weakest link. Therefore, the manager may want to consider either applying the more stringent standards to the entire stream or making the less resilient reach a special management area, such as a riparian pasture, applying the more stringent standards.

Another scenario may be the identification of Key plant species. If it is known that an ungulate may key in on one plant species and leave other plant species in sufficient densities to protect the bank, then perhaps the focus should be on the remaining plants, not a single species. This is why each situation should be discussed in an interdisciplinary setting and the specific needs of the area considered.

In lieu of Monitoring

The above parameters require time and effort on the behalf of the Range Manager or permittee. Someone must be physically on-the-ground on at least a weekly, if not daily basis, especially when a parameter is close to being exceeded. In some cases, this is not possible. Therefore, an alternative to comprehensive monitoring is offered. This alternative is simply time-in-pasture. If a pasture contains a riparian area that cannot be monitored as necessary to assure and insure instituted parameters are not exceeded, or if previous monitoring has not determined time-in-pasture as it relates to allowable uses and impacts, then a **30-day** limit within the pasture is advocated as a starting point. This is supported in the literature by several authors (e.g. Myers 1989). Five to ten days may be a maximum time allowed within riparian pastures. However, this is not to be construed to be a total default to monitoring specific parameters as described above.

Monitoring is essential to ensure the health of the riparian areas, stream channels, water quality and aquatic habitat is maintained or improved as necessary. Further, this time period may have to be adjusted on an individual basis, depending on the existing climatic conditions, densities and distribution patterns of livestock within each pasture and conditions of riparian areas and stream channels. This time period may be shortened or lengthened, depending on specific monitoring of the above parameters. This time limit also means that livestock will be moved from the pasture *within* the time limit, **not** that livestock will *begin* to be moved at the time limit with residual livestock removed sometime after.

Caveat - These S&Gs are based on resource needs, structured from published literature and on-the-ground experience of resource professionals. It is conceded that socio-political or other resource conditions or constraints may require selecting one or more options that meets the needs of management to protect the resource, yet allow continued use of the resources.

For example: A stream within a pasture is in Stream Group 8. This stream group is highly sensitive to disturbance. The current vegetation and physical features of the riparian area and stream channel within the allotment have a low similarity of desired conditions. The standard for allowable bank disturbance is 10 percent or less. It may be improbable that the livestock can continue to use the riparian area at present rates with this small amount of allowable bank disturbance...a dilemma.

This leaves the manager with several options.

1) Do not allow any livestock within the allotment;

2) Fence the riparian area;

3) Keep the livestock out of the riparian area through the use of a rider, salting, alternative water and shade sources, etc;

4) Reduce the number and/or duration of livestock using the area;

5) Change or modify the grazing system;

6) Use a parameter other than bank disturbance (such as stubble height) that will provide resource protection, yet allow some bank disturbance to occur; or

If the livestock owner is dependent on the use of the allotment for maintaining his livelihood, elimination of all livestock use, or substantially reducing numbers or duration, may not be a realistic social alternative, even though it may be a reasonable environmental alternative. Fencing is expensive to install and maintain and may take several years to install and funding may be limited. Keeping the livestock out of the riparian zone with no physical barriers is difficult if not impossible in some situations. That leaves selecting other parameters that will protect the resource, yet allow grazing to continue.

Protection of the resource is a primary goal. As long as trend is in the direction of that goal, the manager has the discretion to use a single or multiple parameters, depending on the requirements of that site. It has been shown in the literature that maintaining a minimum stubble height, for example, is effective in moving a stream channel toward equilibrium in some situations, even though some physical bank damage may be still occurring. If the stream has a low fisheries or riparian value, options may be greater than if the stream has a critical value.

Keeping options open for the manager is essential. Key areas are selected by an interdisciplinary team. The team may also suggest other parameters to monitor. Based on this input, the manager can select those parameters that best meets the needs of the land and resources under management. However, the manager needs to be extremely careful when selecting a parameter. Selection has to be justified based on the situation and the resource to be managed. In the case of the Example Allotment, the standards allow minimized bank disturbance. This value is based on the characteristics of the resource. Simply selecting another parameter based on convenience or personal bias may foster scrutiny from a variety of sources.

FIELD GUIDE FOR THE MEASUREMENT OF IMPACTS ON RIPARIAN SYSTEMS

I. Site Selection

The goal is to sample the stream reach (or reaches) that represents and reflects management activities and resource conditions. That is it should be representative of the habitat type or stream group being impacted and reflect a typical result or consequence of the impact.

A) **Key Riparian Area** -- A key riparian area is defined as an indicator site that reflects the direct impacts of the uses over a larger area or stratum. It may represent all or part of the length of a stream/riparian zone, a critical fragile meadow or a wetland. The selection criteria for a Key Area are:

1) A key area should be representative of the stratum in which it is located. Identify a stratum first by homogeneous landtype, soil type or habitat type. Then make sure your sampling site falls within a homogeneous stream type group.

2) The site should enable the manager to measure the direct impacts the activity to be monitored on one or more of the parameters for that specific stream group. A direct impact measurement requires that the highest resource concerns are identified and sample for those parameters that involve those concerns. For example, if resource concerns in a sedge dominated wet meadow are bank stability and plant vigor, then a Key Area site inside that meadow that will produce direct measurements of bank alteration and plant utilization within the meadow would be selected. Do not use measurements on a fringe around the outside of the meadow as an indicator of what's happening inside the meadow.

If there are specific management concerns and objectives for a fringe area (such as maximizing bluegrass vigor by holding use to a certain percentage), then establish a Key Area within the bluegrass fringe and monitor the most meaningful parameters for that specific site. Extrapolating impacts between stream groups or habitat types can lead to inaccuracies and reduce the defensibility of conclusions.

3) A Key Area should be capable of, and likely to, show response to management actions. The measurements should be indicative of the impacts that are occurring in the stratum of concern. For example, do not select a microsite that is seldom used by ungulates when the riparian area of concern shows an obvious higher ungulate impact level.

4) A Key Area may be selected to represent special or unique situations such as: a wet meadow that supports a sensitive plant or animal species; a

relatively short but significant stream reach in poor condition that is being impacted, etc.

B) **Numbers of Sites** -- The number of sample sites depends on the size of a homogeneous stratum; the variability of impacts within that homogeneous stratum; the mix of strata along the length of a stream; or a mix of sensitivity levels. For example: If there are three stream type groups within a reach of the stream, you may need to place at least one transect within each of the stream groups; or select the most sensitive and monitor it.

Personnel, funding and time constraints may force taking quantitative measurements on one site and perform ocular estimates (see Section II) on the other different sites. In any situation, 1) visit as much of the riparian area as possible and 2) make sure that your samples accurately represent the impacts on a larger scale, or at least represent impacts to the most sensitive areas. The number of sample sites may vary also with the experience level of the person measuring the impacts.

II. Sampling Methodology

Monitoring Plans should include both short-term and long-term parameters. Annual (short-term) measurements are intended to measure the impacts of uses on the basic riparian parameters within the current season of use and are not intended to evaluate trend or condition. Long-term parameters are re-visited over a period of years and are used to determine condition or trend.

Adaptive Management

Since no single grazing methodology or monitoring parameter will work for every situation every time, adaptive management may be necessary to change monitoring parameters or management schemes to achieve management goals and objectives. Adaptive management requires knowledge of the current conditions, potential or capability of riparian sites, current management and effects of the management on the resources; and management changes that may be made to move the current condition toward the desired condition. Single indicators of condition or trend are usually not adequate to make good decisions about on-ground situations. Information on the condition and trend of the vegetation and streambank plus knowledge of the current management practices, help establish “cause-and-effect” relationships that are important to make appropriate management decisions. Such information allows refinement and development of more appropriate, locally-derived livestock management techniques and monitoring criteria to meet desired conditions (University of Idaho 2005, Cowley and Burton 2005).

<u>**Monitoring Flow Chart (from Herrick *et al* 2005)**</u>

Define Management and Monitoring Objectives

Select Monitoring Sites and Indicators

Establish and describe monitoring sites
and record long-term monitoring data (baseline)

Year 1:
Establish long-term
monitoring program

Record short-term monitoring data

Every Year:
Maintain Annual
Event Record

Adjust management as needed (adaptive management)

Year 3 to 5:
Repeat long-term
monitoring

Repeat long-term monitoring measurements:
Compare data with baseline and annual
measurements and interpret changes.

Refine Management Strategy (Adaptive Management)
as needed to achieve long-term goals and objectives;
and/or implement Administrative action if warranted.

Cowley and Burton (2005) suggested a "multiple indicator" monitoring protocol that monitors both long- and short-term parameters. They suggest that three indicators (*greenline, woody species regeneration, and streambank stability*) can be used for long-term effectiveness monitoring. These indicators assess the effectiveness of local livestock grazing management strategies and actions in achieving the long-term goals and objectives for stream, riparian and aquatic resources. Short-term monitoring parameters (*woody plant utilization, stubble height and streambank alteration*) provide data and information that can be used to determine if current season's livestock grazing is meeting intended standards or criteria for use in riparian areas to accomplish long-term goals and objectives.

Procedures outlined by the protocol provide information useful for making decisions in the adaptive management process. They include placement of a defined plot at paced intervals along the greenline, or first perennial vegetation on the streambank above the water line. The placed plot approach uses a Daubenmire plot which more closely focuses the observations by the user, reducing chances for variation among users and increasing repeatability. A designated monitoring area (DMA) is located in the riparian area along the streambank. DMAs are not necessarily "key areas" in the classic sense; rather they are areas that are representative of grazing within a riparian area. They do not necessarily reflect "average" use in all riparian areas, rather they reflect typical livestock use where they enter and use vegetation in riparian areas immediately adjacent to the stream. DMAs may be selected where livestock use exceeds the apparent average use of the riparian zone. The thinking is that the condition at that monitoring site would reflect the worst possible condition, such that if the DMA meets objectives at that point, then the rest of the riparian zone is also meeting the objectives. If Riparian Proper Functioning Condition (Prichard 1998) is used, PFC should be assessed within the DMA. In addition to the above criteria, DMAs should:

- Have the potential to respond to and measure changes in grazing management. Livestock trails associated with livestock use of the riparian area may be included in the DMA;
- Avoid selecting sites where vegetation is not a controlling factor, such as cobble, boulder and bedrock armored channels;
- Do not place DMAs on high-gradient streams unless they have a distinctly developed floodplain;
- Avoid water gaps and small trail areas such as along fences that do not represent livestock grazing impacts along the riparian area. These areas may be monitored, but they should not be considered for specific DMA monitoring.

Parameter Sampling

1) STREAMBANK ALTERATION and STABILITY

<u>What</u>: Bank alteration and bank stability are two different parameters used to measure short-term (alteration) and long-term (stability) effects of livestock grazing. Bank *alteration* measures the reduction in streambank integrity whereas *stability* measures changes in stream channel condition over time.

Alteration

This parameter is a tool that focuses on mechanical damage, such as ungulate hoof action, and is not a measure of stream health or long-term trends (USFS R1 2005). The definition of a measurable impact includes:

- sheering off a portion of the streambank by ungulate hooves that leaves a smooth vertical surface and an indentation of a hoof print at the bottom or along the sides;
- trampling that leaves an indentation of a hoof print and exposes roots or soil resulting in a depression at least ½ inch deep or soil displacement at least ½ inch upwards (simple impressions on heavy herbaceous ground cover do not constitute measurable impacts);
- trailing that exposes or compacts the soil, as evidenced by a very hard soil surface layer or numerous animal tracks that sink into and /or displace the soil ½" or more.
- trailing or trampling on top of terraces, above the active floodplain is NOT considered streambank alteration.

Stability

Stability is an indicator of the condition of the channel bank. It monitors the effectiveness of the grazing management program to achieve desired riparian condition goals or objectives. Banks are categorized into one of six conditions and expressed as a percentage of the linear stream bank in that condition. Natural abiotic disturbances (such as current year bank collapse from inherent soil instability) are counted and not distinguished from biotic disturbances (ungulates, etc.). The inherent stability ratings for stream groups are factored into allowable impact percentage.

Where: Measure streambank alteration/stability in the zone between the greenline and the scour line (elevation of the bottom of undercut bank or the lower limit of perennial vegetation). When greenline is away (> 3 meters or 10 ft) from the stream channel or terrace wall, streambank alteration/stability is read along the edge of the terrace wall or along the top of the streambank.

There is no need to evaluate impacts on mid-channel bars because they will either lag behind or parallel the impacts on main channel streambanks.

Crossings are generally counted, unless they are stabilized. If a crossing is not representative of a significant stream reach, then the disturbance may be highly localized and it may be prudent to select another transect location. Conversely, if a crossing or series of crossings are representative of a stream reach, the impacts should be measured.

How: Bank alteration/stability is a linear measurement, not an area measurement. Transects should be permanently marked on both sides of the stream at the beginning and end of the key area or DMA. They should extend at least 110 meters on each side of the stream, varying according to site complexity. Normally, 40 to 50 plots on either side of the stream channel (80 to 100 total) will account for site variability and provide an adequate sample size. If severely disturbed, more sites may be needed. For complete instructions, refer to "Monitoring Streambanks and Riparian vegetation – Multiple Indicators" by Cowley and Burton (2005).

a) Select a representative site. This can either be within a key area or a DMA

b) Pace off at least 110 meters or 361 feet on the left and right bank. Check your pace beforehand with a 100-foot tape. Make sure that you include all the undulations in the bank that experience contact with active channel stream flow.

c) Use a Daubenmire plot for both alteration and stability readings. For *alteration*, use the entire 42 X 50 cm plot with the center bar on the greenline. Determine the number of lines (0 to 5) that intersect streambank alteration. For *stability*, use the width of the frame (50 cm). Record the condition of the bank within that 50 cm width. Use the categories: Covered and Stable (CS); Covered and Unstable (CU); Uncovered and Stable (US); Uncovered and Unstable (UU); false bank (FB); or unclassified (UN). Record findings as a percentage of the linear distance measured.

d) When done on one side, cross the stream and repeat the measurements on the opposite bank, parallel to the transect on the previous bank.

e) Record your measurements separately for the right and left banks (state which way one is facing - upstream or downstream)

f) Allow up to a 10 percent difference between samplers as an acceptable variation.

2) **STUBBLE HEIGHT**

What: Streamside vegetation serves numerous roles in riparian settings. It serves as a forage source, an element of habitat for birds, fish and mammals, it buffers the force of water, filters out sediments, collects sediments and provides aesthetic variety. Without appropriate vegetation, riparian areas deteriorate, streambanks are more susceptible to erosion, sediment delivery to the channel may increase, in-stream sediment caught may decrease, and overall riparian condition and function can be adversely impacted.

A minimum amount of residual herbaceous vegetation is required to provide the above benefits. Cattle can affect the density and vigor of herbaceous vegetation two ways. One is by physical damage through trampling. The second is through direct consumption. Overuse can change the vegetation from protective sedges to non-protective forbs and grasses.

Cattle generally prefer green grasses and forbs to woody vegetation. Maintaining green grasses and forbs can reduce browsing on riparian shrubs. Foraging preferences change if green grasses and forbs are consumed below a certain residual height. Plant physiology can also change if the plant is damaged beyond a certain point, reducing overall plant vigor or causing the plant itself to be replaced with another species, which may not be as desirable to maintain riparian function.

Where: Measure stubble height along the "greenline". The "greenline" is the first perennial vegetation from the water's edge. Seral status of the vegetation may create different greenline characteristics and patterns. For example, a greenline of high seral status may exhibit a continuous line of vegetation, where a lower seral status or unstable channels may create discontinuous patterns or have perennial vegetation higher on the bank.

How: Like the bank disturbance parameter, this is a linear measurement. Measurements can be done by pace or by measuring with a tape or calibrated rod or stick. Measurement can also be part of Multiple Indicator sampling (Cowley and Burton 2005). Following is the minimum needed to measure this parameter. If Multiple Indicator, or other sampling method is used, follow the procedure specified in that protocol(s).

a) A total of at least 20 sample points are needed.

b) At ten foot intervals along your first 100-foot transect, measure the leaf length of the nearest graminoid to your sample point, if all vegetation types are used. If a specific species is being measured, use the same procedure, but measure the nearest key species.

c) Repeat the procedure on the opposite bank and average the results from both streambanks. If both banks have about the same use, average the two. If one bank is impacted heavier than the other, just the most impacted bank.

3) **FORAGE UTILIZATION**

What: If stubble heights are not appropriate or practicable, forage utilization can be monitored. Utilization is described as a percent and can be monitored on an area or transect basis. Two methods are available for most riparian communities. A third method may be used for bluegrass stands and mountain meadows. BLM and USFS have described these methods in separate manuals.

Where: Forage utilization can be used along the greenline, within the riparian zone or on the uplands.

How:

a) **Utilization Cages**: Use the same clip/weigh procedure established for upland sites. It is important to sack and air-dry samples from riparian sites before weighing for the most accurate calculations. This is because the grazed riparian plants tend to dry out proportionally more than the un-grazed samples. Without air-drying the samples before weighing, the un-grazed samples will have a higher proportion of water than the grazed samples and thus will distort the utilization figure significantly. Correction factor charts are available for riparian species and should be used if you do not air-dry your samples.

b) **Photographic**: Photographic Utilization Guide for Riparian Graminoids, Kinney and Clary, Intermountain Research Station General Technical Report INT-GTR-308, June, 1994. This publication employs height/weight correlation charts to determine utilization. In order to use it correctly, you must identify the graminoid species you are sampling.

c) **Grazed loop**: USFS Region 1 Handbook 2209.21 outlines a grazed loop or equivalent method for bluegrass bottoms and mountain meadows (tufted hairgrass, some sedges, timothy, bluegrass, some redtop). Regression charts are available in the handbook for these two community types. Generally, the charts are reliable up to 45 percent utilization. Above that use level, reliability decreases. It may be necessary to check this method against clipped and weighed samples.

4) **WILLOW/ SHRUB UTILIZATION**

What: Utilization is a short-term or annual indicator tool used to determine if current season's livestock grazing is meeting the planned grazing requirements. Utilization is NOT intended to define long-term goals, objectives or trends.

Willows are an important component in maintaining proper riparian function. They provide shade, cover and streambank protection. Livestock and wildlife browse these shrubs, especially when herbaceous vegetation is either limited or has become undesirable. Direct browsing of willows reduces the cover and shade they provide over the stream and within the riparian area and, if grazed excessively, could reduce vigor or prevent regeneration. If the willows are providing streambank protection, reduced vigor and or densities of willows could result in decreased stream channel stability.

Where: Along the streambank and within the riparian zone of the representative reach. The representative reach can be a key area or DMA, depending on the protocol used. Each shrub or a random sample of shrubs can be monitored, depending on the density of the shrub community, the severity of impacts and the issues involved.

How:

a) Utilization is measured on shrub species within a 6 ft. zone adjacent to the water's edge. Exclude from consideration plants that have more than 50% of the active growing stems above the normal reach (3-5 ft) of the animal grazing the site. Compare browsed and un-browsed shrubs. Scan the shrub to be measured to determine if the measurements are representative of the seasonal growth on the entire shrub. Use will be classified into one of five categories: None to Slight; Slight to Light; Moderate; Heavy to Severe; Extreme. (See Cowley and Burton 2005 for more information).

b) The number of leaders or the number of individual plants to be measured will depend on the kind and number of plants along the transect. If use by itself, try to observe at least two leaders on at least ten different plants on each bank. Average the results from the left and right banks. If one bank has obviously more use than the other, use the results from the most impacted bank. If only one bank is available to ungulates, the double the sample size on the single bank. Select only those plants that are available to grazing animals. If the measurement occurs in the spring before measurable growth commences, measure the previous year's growth. If the measurement occurs during the mid or late season, use the current year's growth. If the Multiple Indicator protocol is used, measure utilization within the DMA, per protocol instructions.

5) **WOODY SPECIES REGENERATION**

What: Regeneration is a long-term indicator of riparian condition used as a goal or objective in managing livestock. It can be used for trend analysis to determine changes over time. Information on the condition and trend of the vegetation and knowledge of current management practices can help establish “cause-and-effect” relationships that are important to make appropriate management decisions. This helps the manager to make better, more informed decisions concerning livestock grazing within the riparian area (Cowley and Burton 2005).

Where: Within a 2 meter (6 ft.) zone along the greenline or edge of the stream. The 2 meter zone is established one meter on either side of the greenline. This extends the measurement zone into the stream in many cases. This is necessary because willows and other woody vegetation may grow below the greenline or extend into the stream on a gravel bar, for example. Measurement, however, should not extend into the stream more than ½ the width of the stream. This precludes measuring woody vegetation on the opposite bank in the case of a narrow stream channel less than 3 ft. wide.

The transect length would coincides with the DMA, or if used separately, a minimum of 363 feet. This results in a sample size of about 0.1 acres.

How: Within the sample zone, record the species and age class. If the Multiple Indicator protocol is used, this will be within each sample plot. If measured separately, all, or selected woody plants within the 2 meter boundary along the transect are recorded.

Each plant will be recorded as being in an age class. Age classes are:

- Sprout – 1 stem at the ground surface
- Young – 2 to 10 stems at the ground surface
- Mature – greater than 10 stems at the ground surface
- Dead – 0 stems alive

In addition, a 5th category can be used: Decadent – greater than 10 stems but less than ½ the stems are alive.

For single-stemmed species, such as aspen, cottonwood, etc. similar age classes apply, but are defined differently. See Cowley and Burton (2005) or Winward (2000).

6) **RIPARIAN SOIL DISTURBANCE**

What: Detrimentally disturbed soil is soil that has been detrimentally displaced, compacted, puddled or severely burned as defined in the soil quality standards and guidelines found in FSH 2509.18-95-1.

Definitions of Detrimental Soil Disturbance:

Detrimental soil diplacement--the loss of either 5 centimeters or one-half of the humus-enriched topsoil (A horizon), whichever is less, from a 1 by 1 meter area or larger.

Detrimental compaction--compaction that doubles the soil strength or reduces porosity by 10 percent or more from undisturbed values. In sandy soils, a reduction of 12 percent or more from undisturbed values is detrimental.

Detrimental puddling--clearly identifiable ruts with berms or hoof prints deforming/shearing the soil surface, affecting infiltration and permeability.

Severely burned soil--the loss of either 5 centimeters or one-half of the naturally occurring litter layer, whichever is less.

Where: Within the Riparian Management Area. This area will vary according to Category.

How: Areal extent sampling is the most appropriate method for sampling soil displacement, soil puddling, and qualitative estimation of soil compaction in riparian areas. Two stategies are used to measure aerial extent of detrimentally disturbed soils.

a) Strategy 1--grid points or line transects are used to sample an entire activity area (in this case across the riparian area) and each point or line segment is simply determining whether the impact is or is not detrimental according to the guidelines.

b) Strategy 2--soil delineations within the activity area (riparian area) are stratified by management impact and sampled to determine differences between impact areas. This method is used to sample continuous variables such as bulk density and ground cover. Disturbed soil is compared to this method using the Student's t-test.

Qualitative and Quantitative Measurements:

Displacement--at each point or line segment, measure depth of topsoil loss comparing with surrounding undisturbed areas using a meter stick. If the site has lost less than 5 cm or one-half the A horizon in 1 by 1 meter area, consider it within guidelines.

Compaction--at each point or line segment, qualitatively compare soil strength and structure by using a tile spade to penetrate and break the soil apart. Compare with surrounding undisturbed areas. Cone penetrometer may also be used.

Strong platy structure indicates detrimental compaction.

Puddling--at each point or line segment, qualitatively note any deformation of the soil by rutting or hoof action. Clay content plays a significant role.

Severely burned soil--measure depth of litter layer or crust at soil surface.

Percent disturbance is then calculated from the point grid or transect.

GLOSSARY

BANKFULL and BANKFULL WIDTH: The point on the streambank and the width of the channel at a stage typically defined by the annual high flow.

CLIMAX: The highest ecological development of a plant community capable of perpetuation under prevailing climate and soil conditions.

COMMUNITY: Any assemblage of populations of plants and/or animals in a common special arrangement.

COMMUNITY TYPE: An aggregation of all plant communities distinguished by floristic and structural similarities in both overstory and undergrowth layers. A unit of vegetation within classification system.

COMPOSITION: Relative percentage of a biotic (eg. plant species) or abiotic (eg. gravel substrate feature present for a given area.

COVER, PERCENT: The area covered by the combined aerial parts of plants and vegetative ground covering expressed as a percent of the total area.

ENTRENCHMENT: The degree to which the stream channel is cut into the surrounding floodplain.

FLOODPLAIN: The area adjacent to the active stream channel which is inundated during flows which exceed bankfull level.

GREENLINE VEGETATION: The first perennial vegetation from the water's edge.

HABITAT TYPE: An aggregation of all land areas capable of producing similar plant communitites at climax.

KEY AREA: See Section I (Site Selection)

KEY SPECIES: A species that is an indicator of change. It may or may not be a forage species.

LANDTYPE: A portion of a landtype association having unique geomorphic processes, soils, landforms and habitat types. Usually mapped at scales of 1:30,000 to 1:60,000 and encompassing from less than ten acres to hundreds of acres.

LANDTYPE ASSOCIATION: A grouping of landtypes based on similar landforms, soils and habitat types. Usually mapped at scales from 1:60,000 to 1:125,000 and encompassing hundreds to thousands of acres.

NON-SUITABLE (RIPARIAN) RANGE: Does not produce grazing or browsing forage on a sustained yield basis and is not accessible by domestic livestock.

POINT BAR: A deposit formed on the inside or convex side of a stream bend by lateral accretion. The top level of the point bar is generally at the height of the floodplain and the elevation of the bankfull stage.

RIPARIAN MANAGEMENT AREA: An area in which management for riparian attributes are emphasized. Riparian Management Areas (RMAs) fall within 4 Categories

STREAM TYPE: A characterization of stream channels based on entrenchment, width/depth, sinuosity, slope and substrate.

STRATUM: A portion of a riparian system that is relatively homogeneous based on land type, soil type, habitat type or the stream channel features of geomorphology, stream flow, geology and sinuosity.

SUITABLE (RIPARIAN) RANGE: Any area with the inherent capability to produce grazing or browsing forage on a sustained yield basis and is accessible to domestic livestock. Suitable upland range requires that water also be reasonably available.

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Version 1-1 updates table of contents page numbers and several Table/page number cross references.

Version 1-2 adds several more recent citations and modifies bank disturbance/stability criteria and monitoring techniques.