AN ABSTRACT OF THE THESIS OF

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In the late 1970s, approximately 400 miles of streams were inventoried by the Prineville District of the Bureau of Land Management for in-stream and riparian condition. During the summer of 1994, the riparian portion of the survey was repeated on 17 of the original streams miles, contained within 11 stream sections where grazing strategies had been altered. This project was a case study designed to evaluate efficiency of the original methods and identify factors involved in individual stream responses. The streams selected to be resurveyed varied in community types present, gradient, elevation, grazing system, disturbance history, influence of beaver, and restoration efforts. Community types were identified by their major components (grass-shrub, sedge-rush) and measured for length and width. Length of stream bank damage was estimated and causes noted. Stream sections were surveyed between matching points for the 1976-78 and 1994 surveys. Most streams had increases in riparian area and decreases in bank damage and lengths of cutbanks, suggesting an upward trend in condition.

The bank damage, riparian area, and community identification portions of the survey were identified as useful though composition measurements were determined to be less dependable and repeatable.

Results and Review of a Riparian Survey Method Used in Eastern Oregon

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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Christine G. Rasmussen, Author

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RESULTS AND REVIEW OF A RIPARIAN SURVEY METHOD USED IN EASTERN OREGON

I. INTRODUCTION

Riparian zones are defined by Kauffman and Krueger (1984) to be assemblages of plants and animals whose presence are directly or indirectly related to factors that are stream induced or related. A more restricted definition provided by Kovalchik et al. (1991) stated that riparian zones are those plant communities that require free or unbound water or more moisture than normal. Riparian and wetland delineation can be both broad and narrow depending on the ecosystem studied, the investigators involved, and purpose for the definition. Riparian areas may occur at the edge of a lake, a stream, surround a spring, or appear in places where ground water collects near the surface of the soil. In the West, these areas are often strips of green surrounded by miles of arid or semi-arid uplands. Regardless of the definition for "riparian zones", the diversity of animals and plants that live in or use these habitats accentuate their value to an ecosystem (Kauffman and Krueger 1984).

HISTORY OF THE RIPARIAN SURVEY

In the late 1970s and early 1980s, Wayne Elmore (currently BLM's National Riparian Specialist) and others under his direction conducted a qualitative and quantitative survey of the in-stream habitat, riparian vegetation, bank conditions, water quality, macro-invertebrates and animals present (via pellet counts) along over 400 miles of stream. All streams are contained within and managed by the Prineville District of the Bureau of Land Management. In 1994, a resurvey of the riparian and bank damage portions of the original survey were conducted on 17 of the original 400 miles. The streams resurveyed were: four sections of Bear Creek, and one section each on Camp, Paulina, Indian, Roba, Bronco, Beaverdam and Heisler Creeks. In 1993, Ellie Sippel of the Prineville BLM conducted a repeat survey of the channel dimension and in-stream habitat on Bear Creek sections 1, 3, and 4 as well as Camp, Beaver, Bronco and Heisler creeks.

Several of these streams were in poor condition in 1978, with little riparian vegetation, incised channels, and large amounts of sediment movement. After the initial surveys, some streams were excluded from grazing, or the type and season of use were modified. In several reaches, juniper trees were removed from the floodplains and placed against actively eroding banks for armoring and sediment trapping (juniper rip-rap). Shrubs and trees were also planted in some reaches and juniper trees were thinned in parts of the uplands.

In all sections but Camp Creek, bank damage surveys were completed in 1976, while riparian surveys were completed in 1978. For Camp Creek, riparian vegetation was surveyed in 1978, but the bank damage survey was not completed until 1988.

In this report, different types of riparian vegetation are referred to as communities, as in the original survey. True communities are much more specific than those discussed in this survey, and are usually identified to genus and species. Communities discussed here are more similar to plant associations as they are identified by general plant types.

Total precipitation patterns for the years before the 1976-78 surveys near Prineville, Oregon, show a general upward trend from 1966 to 1983, with lower precipitation beginning in 1985 and continuing to 1994. Total annual precipitation for streams near Paulina, Oregon, show a similar pattern, slightly more distinct in the low totals for the last 9 years, and on a general upward trend (Appendix Table 8).

OBJECTIVES

The three main objectives of this study were: 1) To evaluate riparian responses to changes in management on previously surveyed streams in eastern Oregon, 2) To evaluate the original survey methods for strengths and weaknesses, and 3) To outline an efficient and accurate method of continued resurveying.

SCOPE OF RESURVEY

Since the resurvey and analysis of nearly 400 miles of stream is a large undertaking, this project was designed to re-evaluate only a few streams and determine the best strategy for re-evaluating the remaining miles. While the 1994 selection of stream reaches and the original methods of the survey make statistical validation difficult, the information gained is still valuable as a guide in setting up subsequent projects and providing insight into how to capitalize on and use information collected during the original survey.

The variety of stream types, surrounding ecosystems, and management strategies inventoried in the 1994 resurvey will help both to evaluate our expectations for stream response and to estimate the intensity of time and effort involved in conducting resurveys.

NULL HYPOTHESES

1. There have been no changes in total riparian area.
2. There have been no changes in community number or structure
3. There have been no changes in the amount or type of bank damage.
4. Bank stabilization structures have not been effective.

LITERATURE REVIEW

History

The virtual elimination of beaver by trappers represents, perhaps, the earliest riparian land use cited in the literature (Naiman et al. 1988, Elmore and Kauffman 1994). Beaver play a vital role in the natural functioning of many riparian ecosystems. Their activities alter stream temperatures, sediment and water residence times, nutrient cycles, and most interactions between a stream and its floodplain. Increased surface area of water provides quality habitat for aquatic as well as terrestrial organisms. Riparian zone extent, dynamics and functions are altered by beaver activities. With elimination of this species from its native habitat, water tables drop, vegetation communities change, and diversity is lost (Munther et al. 1982, Parker et al. 1985, Naiman et al. 1986, Naiman et al. 1988, Kay 1992, Elmore and Kauffman 1994).

The second historical land use, livestock grazing, has probably been the most influential as it covers a vast portion of the West, and has occurred for over a century. In 1901, Griffiths and Morris toured a section of the Great Basin from Winnemucca, Nevada to Ontario, Oregon. Griffiths (1902) described the damage being done to both the uplands and the riparian zones. The lowland valleys produced 2 or 3 cuttings of hay and were then used as winter forage for steers and dry cows. Water from springs and streams rarely met the rivers as they were diverted into hay meadows. Even in 1901, he reported seeing haying operations that had been abandoned due to downcutting and failing productivity in these meadows. Upland and mountain pastures were being used to support vast numbers of cattle as well as sheep for as long as the weather permitted them to stay (Griffiths 1902). These types of season- and year-long grazing have been proven to be devastating to riparian habitats (Skovlin 1984, Kovalchik et al. 1991, Platts 1991).

Control of cattle numbers on 160 million acres of public land came more than 30 years later with the Taylor Grazing Act (1934) and the Grazing Service - now the Bureau of Land Management (Elmore and Kauffman 1994). The regulation of livestock numbers has gradually improved the condition of the uplands, but riparian management has been slow to follow (Behnke et al. 1978, Kovalchik et al. 1991, Platts 1991).

In the late 1940s and 50s, riparian and stream management included dredging, straightening, diking, and other methods designed to confine streams into designated channels. In and attempt to "control" flood waters and maximize utilization of water, streams and rivers were channelized and phreatophytes removed (Elmore and Kauffman 1994). Channelization was frequently done in conjunction with irrigation projects and agriculture development projects. The agricultural industry has been key in these activities as floods in unhealthy floodplains can erode acres of productive land and deposit it downstream. However, the relationship between good stream condition, riparian condition and valley productivity was not recognized nor was it considered important (Elmore and Kauffman 1994).

At higher elevations, logging alters riparian conditions in portions of the Great Basin as it has in the forested Cascade and Coast Ranges. Removal of trees from the floodplain, logging debris, upland harvest, extensive roading and splash damming can all serve to impact healthy riparian systems. Large woody debris in the stream channel can capture smaller pieces and form debris jams. These debris jams become semi-permanent sediment traps that expand riparian areas and build floodplains (Beschta and Platts 1986). Large trees in the floodplain function in bank integrity, shading, and immobilizing debris flows. The process of removing these trees can cause direct physical disturbance of the floodplain by logging operations. If slash piles are adjacent to or in the stream, erosional processes can be accelerated by deflection of water into opposing banks. In steep terrain, upland tree harvest and logging operations with the accompanying road networks can significantly alter flow regimes and sedimentation rates (Lyons and Beschta 1983, Grant et al. 1987).

Upland Relations

Upland changes in vegetation composition and condition can also affect riparian conditions. For example, Eddleman et al. (1991) addressed the effects of increasing western juniper populations on the hydrologic cycle in central Oregon. Potential impacts include increases in runoff and evaporation due to reduced ground cover. Canopy and litter interception and transpirational processes, dominated by juniper, are proposed as other direct impacts. They cited changes in timing, quantity, and quality of water supplied to streams as probable indirect effects that would be detrimental to recovery of degraded riparian zones.

DeBano et al. (1989) addressed the interrelatedness of watershed condition and riparian health in arid systems of the southwestern USA. They outlined symptoms of degraded systems and offered strategies for treatments of stream channels, uplands, or both. Gregory et al. (1991) expressed the need to view streams and uplands as parts of a whole rather than as separate systems, focusing on the links between them.

Lateral vs. Vertical Instability

The most obvious indicator of poor condition of a channel is vertical instability or down-cutting. This process widens the gap between the surface of the soil and the water table, and in severe cases, drains large, underground reservoirs of water. Areas that once supported wet meadows and mesic vegetation now support only xeric communities (Skovlin 1984, Swanson and Abell 1988, Elmore and Kauffman 1994,). Lateral instability, or widening, is more commonly seen in areas where the stream bed is less erodible and energy is focused on stream banks. The result is a wide, shallow, open channel. In the typical evolution of a gully, the stream passes through progressive stages of down-cutting, vertical stabilization, gully widening, lateral stabilization and finally the development of a new floodplain (Swanson and Abell 1988, Kovalchik et al. 1991). According to Swanson and Abell (1988), only in the final stage, with development of a new floodplain, are any restoration methods likely to succeed.

In moderate to high gradient stream reaches where the channel has less opportunity to change its position due to substrate sizes and geomorphic constraints, riparian degradation can take the form of limited sediment storage and simplified plant communities (Beschta and Platts 1986). Sediment in moderate and high gradient stream reaches is typically limited and can move downstream quickly in the absence of elements that can capture it (beavers, large woody debris). In high gradient streams where beaver complexes are unlikely, large woody debris and large substrate elements will be more significant. Recovery of the herbaceous and shrub communities in moderate and high gradient streams is considerably easier, in terms of time required, than encouraging natural sources of large woody debris.

Methods of Riparian Improvement

Fencing of riparian areas is reported to be the quickest means of restoring habitats degraded by livestock grazing (Storch and Cope 1979, Skovlin 1984, Elmore and Beschta 1988, Smith and Abell 1988, Swanson and Abell 1988, Platts et al. 1989, Schulz and

Leininger 1990, Kovalchik et al. 1991, Platts 1991, Elmore and Kauffman 1994). Either by the removal of all cattle grazing or by the creation of riparian corridors or pastures, fencing is reported as the most effective way to restore riparian vegetation as it allows management separate from the uplands.

Elmore and Kauffman (1994) and Platts (1991) summarized various grazing strategies in terms of their impacts on herbaceous communities, shrub communities, and bank stability. No grazing, winter or dormant season and early growing season grazing are reported to increase riparian health. Exclusion of grazing allows plants to thrive encouraging root strength and sediment capture. Winter or dormant season grazing removes herbage only during plant dormancy while streambanks are frozen. In valleys with cold drainage patterns and/or alternate watering systems, cattle use can be light in the bottoms and recovery can be dramatic. In more moderate temperatures, animals may remain concentrated in the valley bottoms and damage dormant woody species by browsing and trampling. Knowledge of livestock use patterns with respect to riparian vegetation is vital for this grazing system.

Early-season grazing, while benefiting shrubs and herbs, can be damaging to the banks of steep, low sediment systems. Vegetation regrowth is allowed by the absence of grazing during the summer. Since herbaceous vegetation is lush and palatable, utilization of woody vegetation is typically low. This strategy can be very effective in restoring shrub populations if timing of grazing avoids willow reproduction and regrowth time is adequate. Early-season grazing may result in higher soil compaction and erosion in steep streams or those with finely textured soils (Elmore and Kauffman 1994).

Late-season rotation systems allow herbaceous components and banks to heal, but may be detrimental to shrub communities. Herbaceous vegetation and bank stability can be maintained or improved only if sufficient residual is left or regrowth occurs to capture sediments during high flow events. Over-utilization of woody vegetation is more likely in summer months and must be monitored closely. In rotation systems, one year of heavy utilization can remove several years' growth in woody vegetation (Elmore and Kauffman 1994).

Season-long, spring-summer, and fall grazing systems can lead to declining shrub and herbaceous communities and are typically damaging to bank stability. Season-long and spring-summer grazing allow no time for regrowth, reproduction, or litter accumulation in the herbaceous vegetation and are notorious for damaging woody vegetation. There is typically little vegetation cover remaining to capture sediments and protect banks during high flow events. Fall grazing can be detrimental for all of the reasons mentioned above, but can allow recovery if used after fall green-up and utilization is closely monitored (Elmore and Kauffman 1994). The authors caution against using any grazing strategy as a cookbook approach to management and ignoring watershed needs in development of a recovery plan.

Recovery of the herbaceous component within riparian communities is vital to capturing sediments for aggrading floodplains, building banks, and providing surface resistance the channel's erosive forces (Skovlin 1984, Beschta and Platts 1986, Elmore and Beschta 1988, Swanson and Abell 1988, Platts et al. 1989, Platts 1991, and Abt et al. 1993). Kleinfelder et al. (1992) concluded that herbaceous roots appear to supply most of the compressive strength and soil binding properties in meadow reaches for streams within the Toiyabe National Forest; communities of Nebraska sedge leading all other species sampled.

Shrub and tree components of riparian communities are important for providing root strength to banks, shade to water surfaces, and roughness elements for dissipating stream energy (Rickard and Cushing 1982, Skovlin 1984, Groeneveld and Griepentrog 1985, Beschta and Platts 1986, Elmore and Beschta 1988, Swanson and Abell 1988, Platts 1991, Kovalchik et al. 1991)

The recovery of depleted riparian species, typically willows, has received intense attention in recent years. According to Smith and Prichard (1992), vegetation treatments are most important in the recovery of degraded sites. They suggested direct methods of planting to establish the desired species or communities. Shaw et al. (1991), discussed the recruitment and growth of two species of willow in different seasons and intensities of cattle grazing. The study was conducted from 1987 to 1990 in a degraded eastern Oregon stream in the sagebrush-steppe zone. There was no difference in the increases of willow seedling densities in the spring grazing, fall grazing, and cattle exclosure pastures. The control pasture had continued season-long, heavy grazing and showed declining seedling densities over time. Fall and spring grazing treatments consisted of four cow-calf pairs per pasture for ten days. In this experiment, there were no mature willows on-site for any of the treatments. The number of seedlings that emerged suggested that off-site seed sources were adequate for revegetation with spring, fall and exclusion of cattle grazing. In this study, the numerous willow seedlings were prevented from growing out of the reach of domestic animals by heavy deer browsing. This type of wildlife use, as well as the presence of weedy species, can profoundly impact revegetation efforts (Shaw et al. 1991).

In many areas, planting may be unnecessary since natural recruitment will restore communities after changes in grazing strategies or protection from wildlife browsing occur (Rickard and Cushing 1982, Smith and Abell 1988, Shultz and Leininger 1990, Beschta et al. 1994)

Instream structures ranging from channel spanning gabions and weirs to addition of boulders and bank stabilizers have been used for decades as a means to slow or stop gully formation and create fish habitat. As more information has been gathered on the success of these structures and their impacts, scientists are learning that streams function, recover, and maintain themselves best without mechanical interference. Management that allows natural processes and disturbance regimes generally promotes recovery and maintenance of riparian and aquatic ecosystems (Elmore and Beschta 1988, Beschta et al. 1994, Elmore and Kauffman 1994).

Juniper rip-rap has been used as a means to stabilize banks by decreasing local water velocities, encouraging aggradation, and providing microsites for re-establishing vegetation. Sheeter et al. (1988) outlined a method for low gradient streams that involves cutting juniper trees and anchoring the trunks to upper cutbanks and placing the crown of the tree parallel to the channel. Trees are overlapped to provide good coverage. The authors suggested that juniper rip-rap is less permanent and offensive than hard engineering bank stabilization structures such as rock rip-rap and gabions, and that it works very well when combined with appropriate management.

II. THE RIPARIAN RESURVEY

INVENTORY AND MONITORING LITERATURE REVIEW

Baseline inventory and long-term riparian monitoring is vital to understanding the processes that govern channel morphology and vegetation condition as well as management strategies that promote recovery and maintenance of riparian systems. The Bureau of Land Management has developed and published several technical reports regarding inventory and monitoring of riparian areas. Surveys range from intensive to extensive, quantitative to qualitative, and structure to function based. Some of the more recent methods presented by BLM include Technical Reference (TR) 1737-3 by Meyers (1989), TR 1737-7 by Leonard et al. (1992), TR 1737-8 by Cagney (1993), and TR 1737-10 by Clemmer (1994). These documents represent different levels of riparian inventories.

In BLM Technical Reference 1737-3, Meyers (1989) described methods of extensive and intensive inventories developed for gathering baseline information on riparian habitats. Extensive inventories, typically done with maps and aerial photographs, are designed to locate, quantify, and classify riparian habitats based on their geographic characteristics and soils. Intensive surveys require much more time and effort and include measurements of in-channel dimensions, soil properties and vegetation. Meyers (1989) discussed using stream inventories to select sites for monitoring based on the value and condition of the resources in question. Level I monitoring involves a photographic record and written descriptions of riparian sites and is typically used on streams that are not deteriorated or produce few resource benefits. Sites with high potential for improvement and support multiple uses are evaluated at the more intense Level II, involving measurements of changes in canopy, species composition, structure and woody species density. The author is careful to point out that no monitoring program should be implemented without addressing goals and objectives within a formal plan. Descriptions of the possible measurements are provided, stating that the original classification process can be repeated entirely or in part, depending on the goals of the investigators.

The methods for conducting an Ecological Site Inventory in riparian and wetland sites are described in a BLM Technical Reference (1737-7) by Leonard et al. (1992b). Ecological Site Inventories on upland habitats have typically been completed by the Natural Resource Conservation Service (formerly the Soil Conservation Service). Sites are intensively inventoried for classification based on vegetation composition and percentage of the potential natural community as well as landscape features, physiography, soil factors, groundwater, climate factors, and stream type. Procedures for classification are much the same as Meyers (1989) for inventory and monitoring, but more emphasis is placed on upland and riparian interactions of soils, climate, hydrology and vegetation. Leonard et al. (1992a) published a viewpoint in the Journal of Range Management that illustrated the utility of using range site (ecological site) information for describing riparian areas with appropriate modifications. The cost for this method is very high, ranging from $600 to $800 per mile (Elmore, personal communication). Monitoring is discussed briefly with the warning that ecological classification can change in aggrading and degrading habitats and permanent cross sections are useful for documenting channel movements.

A Process for Determining Proper Functioning Condition (Pritchard et al. 1993) serves as a guide for an interdisciplinary group of professionals to visually classify a stream reach as to Proper Functioning Condition (PFC), Functioning at-risk, or Not Functioning as a means to identify stream sections in need of changes in management. The inventory group completes a list of Yes/No questions that focus on processes of vegetation structure and condition, hydrology, and erosion/deposition. The group of individuals (three to five) are ideally from several different disciplines including: botany, ecology, hydrology, wildlife, fisheries, soils, and range. The price of this method varies from \$100 to \$500 per mile depending on the diversity of the streams, the complexity of the condition, and the members of the inventory group (Elmore, personal communication). The PFC survey is purely subjective, requiring no field measurements. Streams identified as being in proper functioning condition are judged to have all or most hydrologic, vegetation and deposition/erosion processes and components intact and appear to be stable or in a upward trend. Stream sections that have one or more process or component missing are classified as functioning at-risk. These may be stream sections where sediment is overwhelming vegetation or species present are not of the type and vigor to protect banks. Another example of a section functioning at-risk would be a meadow system with an active head cut. Stream sections classified as not functioning have few if any of the natural processes intact and are not likely to respond to management changes. A stream that is actively down-cutting or devoid of vegetation is typically placed in this category. As this method has no actual measurements involved, its value for monitoring is limited, but is useful for detecting ecological changes.

Cagney (1993) presented an intensive but quick method of monitoring streamside vegetation within the stream inventory hierarchy outlined in Meyers (1989) and Leonard (1992b). The greenline method is a monitoring strategy strictly designed to quantitatively determine the cover composition of the greenline (the line of relatively continuous plant cover adjacent to the channel), the composition of the riparian cross-section, and the density of woody species present. The data is in the form of a single line intercept transect that is most effective in relatively stable communities. The sites for the permanent transects are carefully selected to represent the typical condition and potential of the stream reach. The purposes of this information are measurable objectives for plant communities, indications of trend, and evaluations of the impacts of management actions. The cost is quite low with $100 to $150 per mile for a relatively fast assessment (Elmore, personal communication).

Clemmer (1994) described the uses of aerial photography in managing riparian and wetland areas. Aerial photographs are useful for determining geological features and conditions, identifying channel and valley characteristics, and giving a preliminary assessment of bank conditions and sedimentation (Cuplin 1985, Cuplin et al. 1985, Bateson et al. 1987). With the proper resolution and scale, vegetation associations can be determined for use in the monitoring methods described by Meyers (1989) and Cagney (1993). Remote sensing also lends itself well to classifying riparian areas to ecological sites (Leonard et al. 1992b) and assessing functionality (Pritchard et al. 1993).

The value of each of the methods described above can only be determined by the overall objectives of the inventory or monitoring plan. When detailed baseline information is needed for management decisions and indications of trend, intensive surveys are vital. Extensive surveys are most valuable for classification of riparian habitats and location of sites for long term monitoring and intensive surveys. Aerial photography is useful for all of the surveys discussed above either in the early classification and planning stages or in direct measurements.

The stream and riparian survey conducted in the late 1970s by Elmore et al. contained many of the same principles for intensive surveys of Meyers (1989) and Leonard et al. (1992b) with surveys of in-stream habitat, riparian vegetation, bank conditions, water quality, macroinvertebrates, pellet counts (animals present), and a photographic record. However, there was no extensive survey conducted of geomorphic features beyond those included in the in-stream habitat survey.

METHODS OF THE 1994 SURVEY

In the 1994 survey, the methods of the previous survey were followed as closely as possible. Mike Henderson, BLM - Natural Resources Specialist in Lake Havasu, Arizona, was an original crew member on all of the streams resurveyed. Before the start of the 1994 survey, he spent two days in Prineville reviewing the methods of the survey with the crew members. Also, Wayne Elmore, BLM - National Riparian Biologist, in charge of the original survey, was available for answering questions regarding the methods.

In the original survey, photographs were taken every quarter-mile of the stream and riparian vegetation, as well as present representative community types, and typical features. In the 1994 survey, quarter-mile photographs were retaken when original photopoints could be located. Photographs were also taken of representative community types and defining features.

The riparian survey identifies different types of stream vegetation in broad categories (e.g. sedge-grass, willow-sedge, grass-forb). Old and secondary channels, and springs and seeps were identified as separate communities, as were communities above large, stable beaver dams and gabions. Actively eroding banks (cutbanks) were also recorded, but only as estimated lengths. Although cutbanks typically have no vegetation, and widths are very near zero, they are a factor in determining riparian stability.

Lengths and widths of the communities were measured by means of a pacing stick and some visual estimates. For measuring by means of a pacing stick, a staff marked to tenths of a meter is laid on the ground parallel to the surveyor and is used to calibrate the length of the surveyors pace. When the comfortable distance is determined (for instance 1.4 yards), the surveyor stands at the side of the staff at that distance and bends over to retrieve the staff without removing the end marked with zero from the ground. When the surveyor is standing upright, and the arm is held where it will be for pacing, the measurement on the staff where the surveyor's hand is should be noted and marked (for instance, 1.85 yards). With this calibration, the surveyor "taps" the ground in front and steps to that point, knowing that he or she has just traveled 1.4 yards. By counting the number of "taps" and multiplying by the length of calibration (1.4 yards), a surveyor can maintain a consistent pace length regardless of the ground surface or vegetation cover.

Widths were measured periodically, with a pacing stick, at points of the stream that represented the average width, typically, several per quarter-mile. The lengths of the communities are not related to the total length of the stream, as communities often appeared parallel to each other or as isolated spots within another community. In the original survey, recorded widths represented one half of the community width and lengths were doubled. In the 1994 survey, the recorded width represents the total width and lengths are not doubled. The area by either method is the same. Stream length, for identifying quarter-miles, was recorded separately, but measured simultaneously.

Community locations in relation to the stream were recorded only by quarter-miles. In the repeated survey, although the starting and ending points are the same, the number of quarter-miles within a section often differed from the number of quarter-miles in the original survey. While this was predictable for the low gradient streams where sinuosity may have increased or decreased, it is less explainable in the sections of moderate gradient.

In each community (except cutbanks), a step-toe composition measurement was conducted. For at least 220 points in each community (approximately 330 yards), the object under a point marked on the left toe of the surveyor's boot (a hit) was identified as either a grass, sedge-rush, forb, bare ground, litter, wood, rock, or shrub-tree. In the original survey, composition hits were identified as grass-rush-sedge, forb, bare ground, shrubs, and litter (including wood). If the hit was a plant, the mark on the boot had to be over the point where the plant emerged from the ground. If a tipped over grass leaf was stepped on, the hit was identified by what was under the grass leaf. The same is true for the shrub-tree communities. Although a full canopy may have existed, only the hits where stems were encountered were recorded as shrubs or trees. Woody species were identified to common name and heights were estimated in both surveys.

If the community was too small to obtain 220 hits, the crews identified as many as possible. After 220 hits, the remainder of the community was simply paced for length. If the community extended for more than a quarter-mile after the 220 hits, or the community had changed slightly, another 100 hits were taken to insure representation of the true composition.

The step-toe path was designed to follow the center of one side of the riparian zone, if the whole riparian width was a single community. If more than one community existed within the riparian width, the step-toe path followed the center of each community. If the community was wider than 12 feet (4 yards), the step-toe path followed a zig-zag pattern across the community so that the wetter and drier portions were included.

In sections of Bear Creek and Camp Creek, a community situation occurred within the sedge-grass-forb community that the previous surveyors did not encounter. In the original survey, the riparian zones were dominated by a community of grasses and forbs with considerable bare ground. In the 1994 survey, the community occurring in the same stream reach was composed of sedges and rushes on the closest margin of the riparian zone, wetter grasses and forbs within the middle zone, with drier grasses and forbs on the outer margin. During composition measurements, the step toe-path missed the sedge-rush band almost entirely. In order to compensate for this, community widths were recorded as sedge-rush and grass-forb bands. When the final composition hits were added up, the widths of the sedge-rush band were averaged and taken as a percentage of the total riparian width. That percentage of the total composition hits was added to the sedge-rush hits. For example; total composition hits = 400, sedge-rush band is 10% of the riparian width, 40 sedge-rush hits are added to the composition hits, new total = 440. This compensation is based upon the assumption that the sedge-rush band was 100% sedges and rushes, which it typically was.

As in the original survey, bank damage was interpreted as bare soil at the water's edge. Lengths were visually estimated and classified by their source as natural (erosion), trampling (trails, hoof-sheared collapsed banks, etc.), and other (beaver, road fords, logging, etc.). If the stream was dry at the time of the survey, the channel edge was used. In the sediment rich sections, juniper rip-rap was visually estimated for length and classified as effective or ineffective based on the criteria of burial in sediment and the presence of enduring plants. If the rip-rap was outside the active channel, it was labeled ineffective. In the higher energy sections (Roba Creek), burial is unlikely and effectiveness was determined by evidence of physical protection from scouring (e. g. little barren soil behind a mass of limbs and litter).

The 1994 crews judiciously attempted to follow the protocol of the 1978 surveyors. Though there were some written records of the original surveys, most of the protocol was verbal, coming from Mike Henderson and Wayne Elmore. Some of the finer points of the survey may have been lost during the last 16 years. For instance, the community compositions indicate some dramatic changes in some of the categories, while the photographs show little change, or change in the opposite direction. These variations may be due to the step-toe path occurring in a different place in 1994 (due to changes in width and area), the community occurring in a different place, or the crews identifying hits differently (is a dead grass leaf still attached to the plant considered to be a hit of litter, or the bare ground beneath it?). This type of disparity illustrates the need for thoroughly written methods, and methods that can be repeated consistently by different individuals through time.

STREAM HISTORIES, RESULTS AND CONCLUSIONS OF THE RESURVEY

Bear Creek

Bear Creek is a tributary of the Crooked River feeding into Prineville Reservoir. Grazing in the area has occurred since the mid 1800s and was typically summer-season-long use until the late 1970s. Willow-birch and sedge-rush-grass communities probably dominated the riparian vegetation prior to intensive summer-season-long livestock use (Elmore, personal communication). Juniper rip-rap were placed against selected actively eroding banks in 1982 to stimulate bank healing and aggradation. Upland juniper trees were cut from parts of the Bear Creek Watershed in 1985.

In all of the Bear Creek sections resurveyed, old channels comprised a significant portion of the riparian area. In 1978, old channels were reported only in the small section of Bear Creek Section 3.

Section 1 River mile 4.25 - 7.75 Elevation, 3380 - 3500 feet.

History

This section of stream was in poor condition at the time of the original survey, with very little riparian vegetation, extensive bank cutting and damage, channel incision, and high sediment loads. The stream was rested for six years followed by the implementation of a winter/spring three pasture system in 1985.

In June of 1987, a small, intense thunder storm occurred in this stretch of stream. Two tributaries on the west, and Salt Creek on the east contributed considerable amounts of sediment to Bear Creek between river mile 4.5 and 5.5. The high waters affected only the bottom six miles of the stream. Juniper rip-rap is extensive in this section, and has been very successful at stabilizing banks during normal spring runoff and during heavy runoff flows like in 1987.

A grass, forb, sedge-rush community presently dominates the riparian zone. Sedges and rushes occur at the innermost margin of the riparian width, and grasses and forbs ranging from reed canary grass and yellow lotus flowers close to the water, to yellow and white clover and equisetum at the driest edge. Appearing in stretches of stream with larger substrate or more disturbance (e.g. downstream from tributary junctions), the second most common community, grass-forb, has sedges and rushes either in very small patches, or missing altogether.

Results

The riparian area in this section increased from 7.8 acres in 1978 to 15.9 acres in 1994. The total bank damage dropped 94 percent, from 4120 yards in 1976 to 260 yards in 1994. The largest drop was in natural bank damage (3990 yards to 220 yards) with a large decrease in trampling damage (120 yards to 40 yards).

The sedge-grass-forb community comprises 11.2 acres of the new total. The grass-forb-bare ground community comprises 4.2 acres of the new total, and is located throughout the reach, but most commonly below river mile 6.0.

The forb component of the vegetation composition dropped over 15 percent, and the litter component rose over 10 percent. Of the 1320 yards of juniper rip-rap that were placed within this section, only 60 yards were judged not effective (95 percent success rate).

Conclusions

The data and photographs indicate that this stretch has recovered dramatically. The increase in riparian area is very positive, as are the decreases in bank damage and length of cutbanks. The new riparian area is likely a conservative estimate. Deep rooted clover plants with cheat grass at their bases could be construed as riparian vegetation by some, but were excluded from the area in the 1994 survey. The increase of litter on the ground suggests a grazing schedule that provides an opportunity for re-growth of herbaceous vegetation. The slight increase in the percentage of bare ground may be misleading. In large portions of this section, clover was well over the heads of the surveyors and excluded plant growth at the surface of the soil. Therefore, though foliar cover may be 100 percent, bare ground hits were common.

Nearly all of the juniper rip-rap has been buried to some extent, some almost entirely, making a statement about the sediment capture occurring in this stretch of stream, as well as the sediment loads coming from upstream.

Section 2 River mile 10.0 - 12.5 Elevation, 3580 - 3680 feet.

History

Being constrained by hill slopes for a large portion of the length, this section has a steeper gradient and coarser substrate than the other sections surveyed on Bear Creek. A corridor exclosure fence was built around this section of stream in 1978 and has had very good compliance. Beaver activity is common throughout the reach, with several small dams and many beaver cut juniper trees. Juniper rip-rap was placed on selected cutbanks in 1982.

Results

The riparian area increased from 5.4 acres in 1978 to 9.0 acres in 1994. Bank damage is only 9 percent of what it was in 1976, a drop from 2930 yards to 270 yards. The 30 yards of bank damage due to livestock in the present survey occurred immediately downstream of the exclosure in a water gap. Of the 170 yards of juniper rip-rap placed, 40 yards were exposed and dry at the time of the 1994 survey (success rate of 73 percent).

The most dramatic change in plant composition was the 17 percent increase in the litter component. Forbs dropped from 40 percent of the total in 1978 to 25 percent in 1994. A stand of large willows was present in this section at the time of the previous survey, and were mere skeletons in 1994. An infestation of caterpillars has decimated the willow population in all of Bear Creek for several years (Wayne Elmore, Personal communication).

Conclusions

The topography of this stretch and the land uses upstream are probably the dominant factors controlling the recovery of this stream. The sedges and rushes that are so desirable in the lower section of Bear Creek, may not be sustainable in the coarser substrates of this section. The propensity for this stream to dry-up in late summer may also preclude growth of hydrophitic plants. Immediately upstream of the exclosure (on private property) is a wide meadow-like section that is difficult to distinguish from the exclosure itself. Beavers are common both within and above this reach, often catching sediments before they arrive in the exclosure. For several miles upstream, the land management is such that there is little active erosion occurring, curtailing aggradation and riparian expansion.

Section 3 River mile 13.25 - 13.5 Elevation, 3710 - 3715 feet.

History

This unconstrained, meadow-like section was in good condition in the 1978 survey and has changed little in 16 years. The grazing schedule has been one of deferred rotation in winter/spring since approximately 1978.

Results

The total riparian area increased in this section from 4.2 acres in 1978 to 5.2 acres in 1994, an increase of 20 percent. Bank damage decreased from 102 yards in 1976 to 80 yards in 1994. The biggest decrease was in the natural bank damage, as it fell from 100 yards to 20 yards in 16 years. While there was no trampling damage in 1976, 50 yards are recorded for 1994 due to the collapse of well-vegetated overhanging banks. No cutbanks were recorded in 1978, but 90 yards were reported in 1994. Part of this length was at the upper end of the section where cattle cross frequently. Another portion of the cutbank length, toward the bottom of the section, was at the toe of the hill slope, and may be due to natural stream movement.

The forb component of the vegetation composition dropped 25 percent and the grass-sedge-rush component increased 26 percent. The other components showed only minor variation.

Conclusions

As was mentioned above, this section of stream has changed very little. Bank damage was low at the time of the original survey. Bank erosion occurring in the lower portion may be due to natural lateral movement.

The changes in plant composition (yellow lotus and clover existing beneath a canopy of sagebrush) are indicative of an expanding riparian zone. The change from forbs to grass-sedge-rush occurring in the old channel community type, where equisetum is being replaced by grasses and drier rushes, indicates a heightened water table.

Section 4 River mile 15.0 - 16.25 Elevation, 3760 - 3820 feet.

History

In the original survey, this reach of stream was in good condition. Winter/spring grazing had been in place for years previous to 1978, and damage to vegetation and banks was minimal. No beaver activity was noted in 1978.

Results

The riparian acres in this reach increased from 6.1 in 1978 to 11.0 in 1994. Bank damage was 670 yards in 1976, and is down to 50 yards in 1994. Only 7 yards of juniper rip-rap were observed on this stretch of stream. The grass-sedge-rush component of the vegetation increased by 18 percent, and the forb component dropped 14 percent.

In the 1994 survey, the riparian area was much greater. Beavers have moved into the area, cutting juniper trees, flooding juniper and sage plants, and impounding water and sediment. One beaver dam at river mile 15.75 reaches nearly from hill slope to hill slope (50 yards), and has been maintained for several years. No cutbanks were recorded in 1978, but 70 yards were recorded in 1994.

Conclusions

The activities of beaver have greatly altered this section of stream. In several locations, the floodplain was ringed with dead juniper either drowned-out or chewed by beaver. Several headcuts observed in this stretch may also be due to beavers. After a dam is abandoned and washes out, the stream headcuts through accumulated sediments, and continues to cut upstream. While downcutting is responsible for the some cutbank lengths recorded in 1994, this stretch of Bear Creek continues to be in good condition.

Camp Creek River mile 5.1 - 6.1 Elevation, 3670 - 3720 feet.

History

Four gabions and riparian fences were installed in Camp Creek in the fall of 1985-86, with two gabions contained in the section resurveyed in 1994. In February of 1986, a large event washed out all four gabions with repairs made two years later on only one. Eroding banks downstream of the gabions were rip-rapped with juniper.

Beaver activity occurs in the upper portion with small unstable dams built of sage and juniper. Livestock have grazed in the spring of the year since 1987. Prior to 1987, grazing occurred during the late summer for 8 years, preceded by 5 years of spring grazing.

The bank damage portion of the Camp Creek survey was not completed until 1988, after the 1986 storm event, and was done by a different crew than the rest of the surveys.

Results

The total riparian area of Camp Creek increased from 1.4 acres in 1978 to 7.0 acres in 1994. A large portion of the area increase is due to sediments captured by the gabions. The communities upstream and immediately downstream of the gabions comprised 3.2 acres of the total riparian area for the mile-long reach. The total bank damage decreased from 1360 yards to 280 yards. In the 1988 survey, bank damage was not broken into natural, trampling and other causes. Approximately 190 yards of juniper rip-rap were placed in this section of stream (not all of it below gabions), 9 yards of which were labeled ineffective. This rip-rap was probably placed the same year as the fencing and gabions. The length of cutbank community dropped from 510 yards in 1978 to 340 yards in 1994, a 33 percent decrease.

The gabion communities are still catching large amounts of sediment, and in some places, bank vegetation is being inundated. For the 1994 survey, this was considered to be natural bank damage. This section of stream had the tallest eroding banks of any of the others surveyed in 1994. The vegetation composition showed a 15 percent increase in the grass-sedge-rush component, a 9 percent increase in the litter component, and a 19 percent decrease in bare ground. As with most of the other sections surveyed, a secondary/old channel community was recorded in 1994 where none were recorded in 1978.

Conclusions

While this section of stream seems to be recovering, recovery may require a long time. Assessing the degree and causes of improvement in this section is difficult. Lack of a report of type of bank damage during the 1988 survey, the extreme damage caused by the 1986 storm, and the gabion construction, subsequent wash-out with only a single gabion repaired are all confounded with a change in grazing management from summer to spring use. However, the changes in vegetation composition, the diversity of community types and the presence of secondary channels are encouraging.

Indian Creek River mile 0.25 - 1.25 Elevation, 3850 - 4070 feet.

History

Indian Creek is a higher elevation section surrounded by Ponderosa pine and juniper, and flows into upper Paulina Creek, north of Paulina, Oregon. The BLM fenced two large springs in 1977 and one mile of the riparian corridor in 1981-82. Cattle have not legally grazed the riparian zone since the riparian fence was built, but trespass may have occurred (Wayne Elmore, personal communication).

In 1978, beavers resided around river mile 1.0, and were damaging aspen clones and an old cottonwood stand. After the survey in 1978, the cottonwood grove was fenced, and individual trees were wrapped with chicken wire. Now there are no beavers in this section of stream though there are willows to support them. Apparently all beaver were trapped out a number of years ago (Wayne Elmore, Personal communication).

The riparian community of Indian Creek is dominated by willow, alder, and grass, with isolated groves of aspen and cottonwood. Cobble and boulders dominate the substrate for the length of the stream. The canopy of ponderosa pine, willow and alder provides considerable shade.

Results

The total riparian area for Indian Creek has increased from 4.9 acres in 1978 to 8.0 acres in 1994. Bank damage is much less now than it was in the previous survey, only 5 percent of the original (from 3960 yards to 210 yards), and cutbank lengths dropped by 83 percent (from 960 yards to 160 yards). Composition of the riparian zone changed considerably since the original survey. The grass-sedge-rush component increased 17 percent, the litter component increased 11 percent, percentage of bare ground dropped 11 percent, and percentage of the riparian zone composed of shrubs and trees dropped 22 percent. Flow is intermittent, as it was in the original survey. Secondary and old channels make up significant portions of the new riparian area, and were not recorded at all in the old survey.

Conclusions

Several species of willows are thriving, as well as other species of woody plants, grasses and forbs. Sedges and rushes are rare in the stream, but dominate the seeps and springs. After reviewing the photographs from 1978 and comparing them with 1994 photographs, the 22 percent drop in shrub composition is suspected to be incorrect. Differing methods of identifying communities and determining the step-toe paths are likely reasons for the decrease. Ground cover is much better now with increases in the herbaceous and litter components.

Despite an exclosure fence, neither the cottonwood grove nor the adjacent aspen stand is doing well. There are no young cottonwood trees to replace the 20 decadent trees, and the aspen stand is reduced to downed wood and one or two live trees. Above and below the exclosure and in water gaps, shrubs are hedged and herbaceous cover is very closely cropped. Cattle were present in the allotment (outside the exclosure) in August at the time of the 1994 survey, but were being removed by the rancher.

Roba Creek River mile 2.0 - 3.6 Elevation, 3890 - 4200 feet.

History

Roba Creek also flows into upper Paulina Creek, neighboring Indian Creek on the East. While ponderosa pine and juniper surround both streams, the riparian communities are vastly different. The coniferous canopy surrounding Roba is much more complete than on Indian Creek. Willows, alders and cottonwoods are rare to non-existent in this part of Roba Creek, possibly due to the high amount of shade and differences in substrate types. Large portions of this stream are in poor condition with extensive cutbanks and active erosion.

Two large springs at approximately river mile 3.0 were fenced in 1978. The riparian corridor was fenced in 1983. No grazing has been permitted since that time, but at least one instance of significant trespass was recorded in October of 1991. Between 1975 and 1978, the area was thinned and slash burned with debris cleaned out of the channel. Instream drop structures and juniper rip-rap were installed in 1979 above the road ford at river mile 3.16 to 3.25. In 1982, structures were modified and strengthened, and rip-rap placed on cutbanks up to the forest boundary. One structure washed out in the winter of 1982-83 and was repaired the following year. Another washed out in 1983-84, and had not been repaired by the following summer. In the 1994 survey, the only portions of the stream that support sedge-rush communities are immediately upstream of drop structures.

Results

The total riparian area of Roba Creek increased from 2.4 to 4.1 acres since the original survey. While this stream has the highest amount of bank damage reported in 1994 (860 yards), this number is less than one-fifth of the 1976 reported damage (4490 yards). In the original survey, a significant portion of the bank damage was due to logging activities. Cutbank lengths have decreased approximately 25 percent over the years, from 1030 yards in 1978 to 770 yards in 1994.

The channel of Roba Creek consists predominantly of cobble and boulders, even though in large sections it has cut several feet into softer sediments. In significant portions of the stream length, then and now, the channel is made up of sand and gravel. The area of the two springs fenced in 1978 changed little over the 16 years, but the total area of springs and seeps expanded.

The composition of the riparian zone has decreased in bare ground (12%) and forbs (11%), and increased in litter (10%) and the grass-rush-sedge component (13%).

Conclusions

Despite livestock exclosure, except for 1991, portions of this section are still in poor shape. Sediment loads are still quite high, partly due to the extensive cutbanks, and stream bank vegetation is not of the type effective for maintaining banks. The shade provided by the ponderosa pine canopy in Roba Creek is considerably higher than in Indian Creek. While Indian Creek is in the adjacent drainage, the soils are much different.

The cobble layer that makes up most of Indian Creek is also present in Roba Creek, but it is buried under several feet of much lighter soil.

Paulina Creek River mile 0.0 - 0.25 Elevation, 3710 - 3715 feet.

History

This reach of Paulina Creek is low to moderate gradient and feeds directly into North Fork Beaver Creek, just northeast of Paulina, Oregon. The substrate is predominantly cobble, with some gravel and sand. This small stretch of stream has a wide active floodplain (approximately 20 yards), and a considerable community of willows in the upper portion.

When surveyed in July of 1994, cattle were present, and shrubs were damaged. As this section is in a rest-rotation system with several other pastures, and has no riparian fencing, heavy summer use occurs occasionally. From 1988 to 1992, cattle grazed in the spring, and were taken out by mid-June. In 1993 the pasture was rested. In 1994, cattle grazed from mid-June to mid-October. Prior to 1987, the stream had been grazed summer, fall, or spring, in consecutive years.

Results

The total riparian area in this quarter-mile has increased from 1.9 acres to 2.7 acres in 16 years. No cutbanks were recorded for either survey.

Bank damage in 1994 (70 yards) was higher than in the previous survey (60 yards). In the old survey, all of the bank damage was reported as being natural (cutbanks). In the 1994 survey, bank damage was predominantly due to cattle. The natural bank damage recorded was associated with a headcut moving up from the mouth of the stream.

Composition of the vegetation dropped 19 percent in the grass-sedge-rush component and increased 27 percent in the litter component. The willow community increased from 0.1 to 1.6 acres.

Conclusions

Except for the very heavily hedged willow stand, this section is in reasonably good condition. The change in vegetation composition was due to reporting differences such as calling a terminated sedge plant a hit of litter in 1994, as opposed to calling it a hit of sedge in 1978. The remaining composition percentages were nearly identical to the original survey. The willow community would suffer if continually subjected to summer grazing pressure like 1994.

Bronco, Beaverdam and Heisler Creeks - History

These streams are located northeast of Paulina, Oregon, near the Rager Ranger Station. They are higher in elevation than any other streams resurveyed, and are surrounded by ponderosa pine, fir, and juniper forests. All three of these streams are contained within the Bronco pasture of the Humphrey allotment and have the same grazing management. Included with other pastures in a rest-rotation pattern, spring grazing has been the management plan for a number of years. Several years of summer-season-long trespass use was informally reported for this pasture in 1991. Since the trespass was never officially recorded, verification of length and intensity is impossible. The area had been rested for several years just prior to the 1978 survey.

All three streams have similar topography. Starting from the mouth they are moderate to high gradient with boulder and bedrock substrate. The valleys are narrow and, consequently, so are the riparian zones. Vegetation is quite thick in these areas and is composed of an assortment of dogwood, alder, willow, currant, rose, mock-orange, snowberry and occasional aspen and cottonwood. Some of the surrounding ponderosa pine and fir trees, sometimes within the riparian zone, are very large. Roughly a quarter of a mile into each of the streams, the gradient is lower and the valleys wider. Portions of Bronco and Heisler valleys are quite wide and were called willow-grass meadows in the 1994 survey.

Cutbanks occurred in all three streams in 1994, where they were not recorded at all in the old survey. All of the cutbanks were at the upper, lower gradient ends of the surveyed length, and on Heisler and Beaverdam, became more severe nearing the forest boundary.

Beaver activity had been recorded for all three streams in the old survey, but by 1994 remained only on Bronco Creek. Evidence of old dams, lodges and side channels occurred in the upper portions of Heisler and Beaverdam.

Evidence of previous logging (stumps and cut woody debris) occurred only in the uppermost portions, adjacent to the forest boundary. Over 100 yards of bank damage due to logging was reported on both Beaverdam and Heisler in the 1976 survey.

At the time of the survey in August 1994, herbaceous vegetation in all but the steepest and narrowest portions of the streams were closely cropped. According to the grazing plan, cattle were removed in spring, but dry conditions persisting all summer may have prevented re-growth. The grass-rush-forb component may be under-represented due to this fact. Springs and seeps in all three streams were damaged by trampling. Occasionally, the crews observed small areas of hedged willows, but wildlife use is suspected rather than cattle.

At the time of the original survey, light utilization was recorded for all three streams. In several of the old photographs, a vigorous herbaceous cover is apparent. Then, as in 1994, the streams were intermittent or dry at the time of the survey.

Bronco Creek River mile 0.0 - 1.25 Elevation, 4060 - 4220 feet.

Results

The survey of Bronco Creek extends from the mouth to a quarter of a mile past a major tributary to the north. Above this tributary, the stream is dry during the summer, and a cobble-silver sage-grass community dominates the riparian zone. Bronco Creek has numerous willows as well as alders and a wide variety of other deciduous shrubs and trees. The spring-seep community was smaller in the 1994 survey, but second/old channel communities were recorded where they were not before. Several small, active beaver dams were located above river mile 0.5.

The riparian area of Bronco Creek increased from 3.8 acres in 1978 to 5.1 acres in 1994. Total bank damage decreased from 600 yards to 50 yards. In the original survey, no cutbank community was recorded, but in the 1994 survey, 50 yards were recorded.

The grass-sedge-rush component of the riparian vegetation increased by 10 percent, bare ground increased by 7 percent, and forbs dropped by 12 percent.

Conclusions

Although the pasture containing all three streams was apparently trespass summer grazed for an unknown number of years, this stream seems to have held up the best of the three. The maintenance of the beaver population may have played a part, as well as a lack of bank damage due to logging noted in the 1976 survey.

<u>Beaverdam Creek River mile 0.0 - 1.5 Elevation, 3990 - 4185 feet.</u>

Results

There are fewer communities found in Beaverdam Creek than either Bronco or Heisler Creeks. Willow, alder and dogwood are common, and a considerable length of secondary/old channel community was found. The total riparian area in 1994, 5.2 acres, is less than it was in 1978, 6.4 acres. The spring-seep community area expanded dramatically, from 0.03 acres in 1978 to 1.5 acres in 1994.

Composition of the riparian vegetation changed significantly. The grass-sedge-rush component increased 9 percent, the forbs 21 percent, and litter 8 percent. The bare ground component dropped 17 percent, and shrubs 21 percent.

Cutbanks in this stream were the most severe of the three, with almost 220 yards in 1994, and none recorded before. Bank damage has decreased from 1550 yards to 240 yards. Bank damage due to logging activities (140 yards) was reported in the original survey.

Conclusions

The riparian area of this section has not changed dramatically since 1978, however, other factors such as the increase in cutbanks, the loss of beaver, and the variations in the riparian community suggest that this stream may be at a higher risk of degradation. At the time of the survey (early August 1994), the shrubs were in good condition, but the herbaceous cover was cropped very closely. The forb component of the composition may have been overestimated due to this situation. Short, spread out forbs are much easier to see during composition measurements than closely cropped grasses and rushes.

Heisler Creek River mile 0.0 - 1.25 Elevation, 3990 - 4165 feet.

Results

The total riparian area of Heisler Creek dropped from 13.3 acres in 1978 to 4.7 acres in 1994. In the old surveys, groves of choke-cherry and cottonwood were recorded. In the new survey, the groves were located, but they are no longer part of the riparian zone.

Bank damage dropped from 540 yards in 1976 to 60 yards in 1994, while the length of cutbank community increased from zero to 70 yards. Over 110 yards of the original bank damage was due to logging activity.

The loss of shrub community types found in 1994 compared to 1978 may be attributed to an increase in the number of willows which serves to merge community types. The spring-seep and secondary/old channel communities are significant portions of the total riparian area, and were not recorded in the old survey. While alders were common in Bronco and Beaverdam, there were none in this section of Heisler Creek.

Conclusions

The drastic drop in total riparian area may be related to the loss of beaver, channel incision into portions of the floodplain, and a very dry summer. Several wide portions of the valley bottom were high and dry, with recent cutbanks at the stream's edge. The 40 percent drop in shrub composition is suspect after reviewing the old photographs.

Depending on where the composition hits were taken with respect to the stream length, and the location of the step-toe path with respect to the riparian width, compositions can be quite variable. Unquestionably, some event or series of events has caused the decline of this stream.

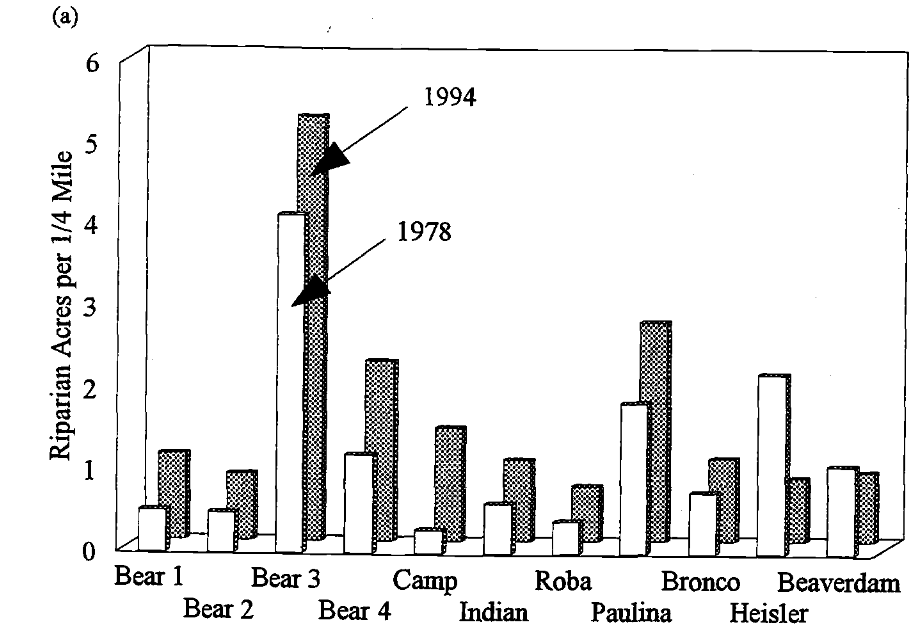
DISCUSSION

Summary of Results

Even with the wide array of grazing strategies, topography and communities, most of these streams appear to be in better condition now than they were in the late 1970s. The lengths of cutbanks, the composition of riparian vegetation, and the total riparian areas show mixed responses (Figure 1).

In the years since the surveys and alterations, the response in the previously degraded low gradient streams has been dramatic. Grazing has typically been in winter or spring with little trespass. Photographs and data reveal changes in type and vigor of vegetation, expanding riparian zones, and recovering banks. In these sections, the channel is aggrading and functioning within a floodplain.

In the moderate gradient streams, the response has been mixed. The grazing schedule has been varied from total exclosure, exclosure with trespass, winter/spring grazing with trespass, and a rotation pattern with occasional heavy summer use. In all but two of the streams, the total riparian area increased (Figure 1a). Percentages of grass-sedge-rush and litter components have generally increased. Composition percentages for



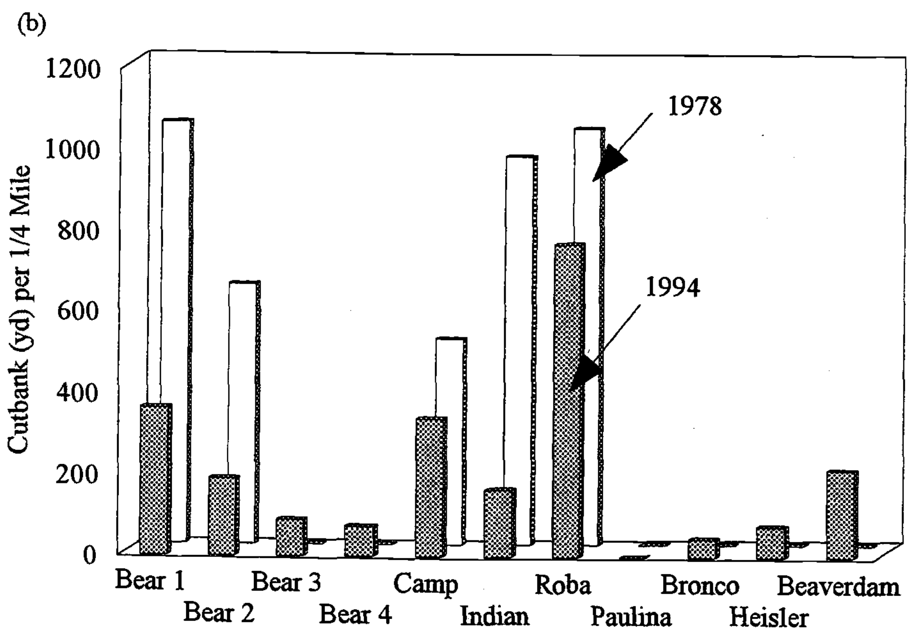


Figure 1. Summaries of (a) total riparian acres per 1/4 mile and (b) total cutbank lengths per 1/4 mile in the 1978 and 1994 surveys.

forbs and shrubs varied. In locations where forbs and shrubs were noted in the original survey, percent composition decreased in the new survey. The drop in forb composition may reflect an increase in seral stage with a shift from weedy forbs to native grasses, sedges and rushes. However, in new or expanded meadows, in old and second channels, and in cobble areas, forbs and shrubs were typically identified in the new survey where they had not existed in the old survey. Bare ground typically decreased. The apparent loss of shrubs (decrease in composition percentage) may be a function of aggrading stream beds which is reflected in the expanded riparian areas, an artifact of sampling methodology, or a combination of the two.

Actively eroding cutbanks also showed a mixed response. In the streams with originally extensive cutbanks, lengths are considerably reduced. In five streams, however, there were low to moderate lengths of cutbanks in 1994 where none were recorded in 1978 (Figure 1b). Secondary channels were recorded on ten of the eleven sections in the 1994 survey, and only on two sections in the earlier surveys. This appearance of secondary channels and old channels within the riparian area suggests that channels are aggrading and the streams are reconnecting with their historic floodplains.

In Heisler and Beaverdam, suspected non-compliance to the grazing plan may have worked in conjunction with logging activity and loss of beaver to cause a decline in total riparian area and increase cutbank lengths (Figure 1a and Figure 1b). Upstream and upland land use histories are not known.

Although the total riparian area of Roba Creek increased, recovery seems to be less than in the other streams surveyed. The considerable lengths of cutbanks and bank damage are still contributing more sediment than the stream is capable of capturing. Also, like Bronco, Beaverdam and Heisler, upstream land uses within Forest Service management are not known.

Significant portions of the total bank damage in 1976 were recorded as due to logging for Roba, Beaverdam and Heisler. Old logging evidence was present in all three streams in the 1994 survey, but was most obvious in Roba with very large, burned stumps immediately adjacent to the stream.

In all of the sections except Paulina Creek and Bear Creek section 3, bank damage in 1994 is a small fraction of what it was in the original survey (Figure 2a). Paulina Creek and Bear Creek section 3 are both small sections (a quarter-mile) and had minimal bank damage in the original survey.

The number of vegetative communities surveyed in each section is interpreted as positive though not all increased (Figure 2b). Increases from very few communities to several (Bear 1, Bear 4, and Camp) suggest that diversification is occurring with the establishment of more stable community types (i.e. sedge-rush and beaver communities where only grass-forb was originally surveyed). The decline of community types in moderate gradient, shrub dominated sections (Heisler Creek) may be due to increasing willow populations homogenizing otherwise small and discrete stands of other shrubs.

The diversity of responses to various grazing practices and the exclosure of grazing serves to illustrate the point that all of these streams are functioning in ways that are unique. Factors such as beaver, climate, topography, soils, land use history,

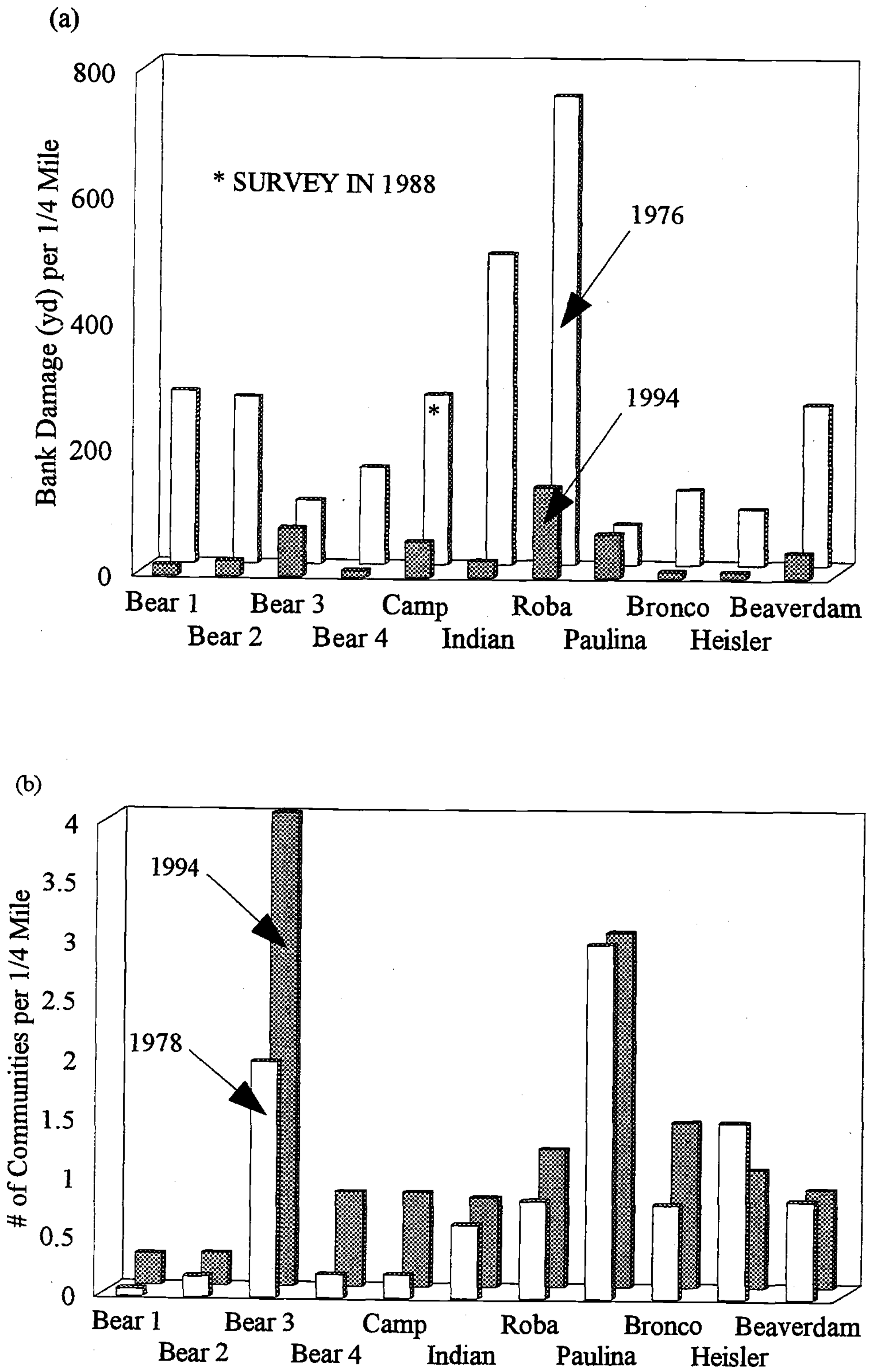


Figure 2. Summaries of (a) the total length of bank damage and (b) the number of vegetative communities identified in the 1976-78 and 1994 surveys.

compliance with grazing plans, and community changes make specific interpretation of the results difficult.

The importance of biological and topographical factors could be determined more definitively with a larger number of resurveyed streams with comparable characteristics. With the pool of quality data provided by the old surveys, we could gain a better understanding of the effects of changes in grazing management, changes in beaver populations, logging, road building, adding drop structures, etc., as well as the importance of abiotic factors such as gradient, soil, climate, and valley width. Once these factors are examined, management strategies can be more accurately determined and applied with more effective results.

Statistical Analysis

Nonparametric rank sum tests (Wilcoxon) were performed on the categorical variables of gradient (moderate or low), change in beaver status (gained beaver, lost beaver or no change), and grazing (grazed or exclosed) in order to test the importance of those variables in affecting measured quantities of riparian area per quarter-mile, bank damage per quarter-mile, number of communities per section, and length of cutbank per quarter-mile. For instance, the ranks of total riparian areas per quarter-mile in moderate gradient sections were compared to the ranks of total riparian areas per quarter-mile in low gradient sections. The resulting two-tailed probability of $Z=0.02$ ($n=11$) suggests that gradient is an important factor in determining riparian area per quarter mile. Results of the remaining tests are summarized in Table 1.

Table 1. Results of rank sum tests (two-tailed probability Z-value) with sample sizes in parenthesis

Measured variables	Gradient (7 moderate, 4 low)	Beaver (4 gained, 3 lost)	Grazing (8 grazed, 3 exclosed)
Riparian area per quarter-mile	0.02 (n=11)	0.11 (n=7)	0.61 (n=11)
Bank damage per quarter-mile	0.78 (n=11)	1.00 (n=7)	0.03 (n=11)
Number of communities	0.03 (n=11)	0.05 (n=7)	0.11 (n=11)
Cutbank lengths per quarter-mile	0.64 (n=11)	0.86 (n=7)	0.05 (n=11)

Another analysis was performed on the measured variables in an attempt to answer the question: Have these streams recovered? The non-parametric t-test ranks the differences between the old and new measurements and averages the ranks for positive and negative differences. The ranks of positive differences are used to calculate a Z-statistic that is interpreted on the number of degrees of freedom, much the same as a t-statistic, to give a probability of exceeding the Z-statistic (equivalent to the p-value). Bank damage per quarter-mile showed the strongest results with a two-tailed probability Z-value of 0.00 (10 positive differences, 1 negative with no tied pairs ignored). Differences in riparian area per quarter-mile resulted in a two-tailed probability Z-value of 0.06 (2 positive differences, 9 negative with no tied pairs ignored). Differences in cutbank length per quarter-mile resulted in a two-tailed probability Z-value of 0.42 (5 positive differences, 5 negative differences, 1 tied pair ignored). Differences in community number per section resulted in a two-tailed probability Z-value of 0.34 (2 positive differences, 7 negative differences with 2 tied pairs ignored).

The results from all of these tests are weak at best due to violations of independence (4 sections on Bear Creek; Bronco, Beaverdam and Heisler all within the same pasture), non-random selection of streams, and small sample size (n=11). Problems with non-normal distributions and significant outliers are accounted for within the nonparametric testing (Hollander and Wolfe 1973). In all of the measured variables there were questionable observations that should have been excluded from analysis but were not due to the already limited number of samples. Results from the rank-sum tests and supporting literature (Crouse and Kindschy 1984, Peterson et al. 1991) suggest that stratification by gradient, changes in beaver status and grazing strategy, at the minimum, are necessary before interpreting results from the measured variables. Separation of streams into the appropriate categories before analysis was not possible in this project due to the limited number of streams resurveyed. A discussion of stream selection and proper statistical design is provided in Chapter 2.

Discussion Of Variables

The total riparian area of a given stream reach depends on the width of the riparian area as well as the length between two given points. The length of riparian zone of a given section must remain as an independent measurement from channel length since both can change significantly with dramatic changes in riparian condition. For instance, if a stream reclaims a historic floodplain and riparian vegetation occupies the entire valley bottom, the length of the riparian zone will be the length of the valley rather than the stream winding within it.

The difficulty in using riparian area as a monitoring tool is the lack of a single definition for the edge of the riparian area. Petersen et al. (1991) used a definition that includes information on the height and duration of the water table in conjunction with vegetation occurring on a site. A typical definition of riparian zone is from the emergent vegetation at the margin of water extending to a point where vegetation cannot be discerned from upland communities (Cowardin et al. 1979). Does this include remnant vegetation that has access to deeper groundwater? What about transition zones? These questions must be addressed and criteria developed if a monitoring strategy based on changes in riparian extent is to produce scientifically meaningful results.

Gradient (moderate or low) appeared to have the closest correlation to changes in riparian area. This is consistent with the literature in that low gradient systems are less likely to be sediment limited and will have more opportunity to aggrade and recover. Low gradient systems are also more likely to show drastic changes in total riparian area as gullies form and channels are separated from groundwater supplies (Crouse and Kindschy 1984, Beschta and Platts 1986, Elmore and Kauffman 1994,). Peterson et al. (1991) indicated that stream gradient is in the fourth level of hierarchy for classifying streams in Utah, with the physiographic region, temperature regime, and water chemistry (fresh or saline) as more defining than the geologic zone (includes gradient, valley shape, and bank materials). Comparing stream reaches with different gradients in conjunction with different treatments could be misleading.

Changes in the status of beaver occupation in the study reaches were placed into three categories: had beaver in the original survey and lost them, had none and gained them, or no change (either had them and still have them or had none and still have none). Beavers have tremendous potential to alter riparian vegetation, community structure and channel morphology. Conversions are interpreted as beneficial to a stream ecosystem that is functioning well (Naiman et al. 1988). Beaver expanding into an area where the vegetation component or channel structure is not sufficient to support them can be detrimental to recovering systems, especially in areas where land use is incompatible (Munther et al. 1982, Kay 1992). In this study, interpretation of changes in beaver occupation were confounded by the placement of structures (Camp Creek) and non-compliance with grazing plans (Bronco, Beaverdam and Heisler Creeks).

Bank damage, as defined for this study, can provide insight into the direct impacts of land uses such as trampling and road fords. Less definable process-based impacts of land uses such as bank cutting and sediment deposition can also be monitored. In this resurvey effort, the extensive reductions in the amount of bank damage of all kinds suggests improvements in management. Interpretation of smaller scale changes are less reliable due to the process of estimating, variation among surveyors, and the level of damage that may be present in streams that are functioning well.

Cutbank lengths are a more specific measure of erosional processes than bank damage and can provide information about gully formation and healing. As with bank damage, the estimation process, variation among surveyors and natural levels of cutbanks make small changes more difficult to interpret. However, the level of changes observed in most of these stream sections suggests recovery.

The number of riparian communities within a given section is information that needs to be interpreted on a stream-by-stream basis. The amount of variation in community identification between surveyors can potentially confound the results. In addition, while increases in community numbers are considered to be ecologically positive, decreases may be positive or negative. For instance, the decrease of communities identified on Heisler Creek is suspected to be from the expansion of willows into small communities that were dominated by other shrubby species in the previous survey. More stringent definitions of what constitutes a community would be helpful for reducing the variability between crews.

III. RESURVEY METHODS

INTRODUCTION

This project was designed to not only resurvey and analyze stream responses, but to evaluate the original methods for strengths and weaknesses and make recommendations for resurveying the remaining miles. Presented in this chapter is a strategy for making the most effective use of time and resources in resurveying the remaining miles, as well as recommendations for stratifying stream sections and evaluating results.

CRITIQUE OF THE ORIGINAL METHODS

The most time consuming and least enlightening information from the survey came in the form of the step-toe composition measurements. This information may be useful as descriptors for the individual communities, however, it is very difficult to infer any composition differences between survey years. Problems arise in the location of the step-toe path from one year to the next, the inconsistency of categories and community types, and the biases produced in the step-toe method.

The location of the step-toe path changes by the surveyor's choice, the width of the community, and the occurrence of a community in relation to the surveyed length. In areas where communities are expanding, the surveyor may identify a willow community 300 yards downstream from the area originally identified, or identify a community 20 yards wide where it may have been 5 yards wide in the original survey. In shrub communities it is very difficult to choose a step-toe path that doesn't aim for shrub clumps, or avoid them.

Comparisons between individual community types is difficult at best due to the possible variation in identification. For instance, one surveyor may identify a willow-grass community based on 10-15 percent willow, where another may require 20-30 percent willow.

There are questions as to how certain "hits" were identified in the original survey versus the recent survey. For instance, a senescent sedge leaf lying on the ground could be called a hit of litter, sedge, or bare ground depending on its attachment to the parent plant and the surveyor's level of understanding of the methods. Reasonably accurate replication of methods is difficult at best because a description of the methods used in the original survey were not specific enough.

In the original survey, all grass, sedge and rush hits were recorded in the same category. We now know that sedges and rushes function differently than grasses in riparian communities (Kleinfelder et al. 1992, Abt et al. 1993,) and should be considered separately.

Another concern involves bare ground measurements. On the lower section of Bear Creek, composition results showed only a slight change in bare ground where photographs showed that riparian vegetation had improved dramatically. A majority of the bare ground hits recorded were encountered under a dense canopy of clover more than five feet tall.

The step toe method used in the riparian survey is a modified version of the step-point method (Evans and Love 1957) designed to evaluate upland and cultivated vegetation. The original step-point method (Evans and Love 1957) introduced single pin sampling in place of multiple pins in a frame. The surveyor had a notch cut into his or her boot, and a very sharp, tapered pin was lowered through the notch at a 30 degree angle until the pin touched either a herbaceous plant or bare ground. If the "hit" was bare ground, the nearest plant in a forward arc (180 degrees) was recorded. The method incorporates a class system for determining total ground cover, as relying on point hits would require much more effort in areas with low percent cover. For instance, in an area with 20 percent ground cover, 500 point hits would be required to obtain the 100 vegetation hits needed for botanical composition. In the step-point method, sampling points are equally spaced within transects that are also equally spaced across a given area. Where communities are essentially homogeneous, 300 to 500 points are recommended. In areas with woody vegetation, variety in slope, aspect or other environmental factor (such as availability of water), smaller homogeneous areas are sampled with 100 to 200 points suggested. Evans and Love (1957) recommended random point placement in areas of dense woody vegetation or where straight transects are not feasible. Results of the step-point method were compared among nine two-man teams in the same area grouping by species, three different samplers grouping by plant type, and between point-frame and step-point methods. The step-point method was found to be a consistent measure of plant composition.

Some of the discrepancies between the step-point method described above and the step-toe method used in the riparian survey include the lack of the pin for sampling, selection of the transect (step-toe path) and identification of vegetation types.

Owensby (1973) described a single-point sampling device (frame) that was designed to eliminate subconscious bias and make sampling easier. No mention was made of the device's usefulness in heavy or woody vegetation.

One of the major concerns with using the step-toe method of basal cover measurement is the amount of bias that is incorporated into the data. The diameter of the area identified as a "hit" (a notch in a hiking boot or wader) is much larger than the theoretical "pin-point" used for determining if a plot is full or empty. The area in question is more likely to be identified as full rather than empty even if the object occupying it is only a small fraction of the total plot (Sharrow 1995, personal communication). Direct contact of the boot with the point being sampled makes identification difficult and probably causes bias as taller vegetation is laid flat in a forward direction with the surveyor's step. The original riparian survey methods specify that a "hit" is a plant only if it falls where the plant emerges from the ground. Obtaining that information often requires digging through obscuring layers of vegetation under the boot and often disturbs the point in question. The selection of the step-toe path through the center of the riparian zone is somewhat arbitrary compared to the specific designation of evenly spaced transects across a given area and may misrepresent the variability of community compositions. Surveyor selection of the path as well as subconscious selection of the point make repeatability and bias serious concerns. The number of points recorded for each community type is typically far lower than that needed to produce an accurate estimate of the vegetation cover (Evans and Love 1957). For example, on Bear Creek Section 2, 4.8 acres of rush-grass-forb community was sampled with 153 "hits" in the original survey and 6.4 acres of the same community type was sampled with 423 "hits" in the 1994 survey.

The pacing stick method of measuring lengths used in both the original and the 1994 survey, in conjunction with known starting and ending points, should ensure repeatable measurements. However, old and new lengths were considerably different in several of the resurveyed sections and consistency with the pacing stick method in the original surveys is unknown. In moderate gradient sections with narrow valley bottoms, large changes in riparian length are difficult to explain. In the 1994 survey, there were 14.85 total miles surveyed. In the 1978 survey, there were 17.75 miles surveyed. Graphs and tables displaying data per quarter-mile is based on the number of quarter miles in the 1994 survey.

In the original survey there was no defined spacing for determining riparian widths, or a means of recording their location on the stream. More frequent width measurements, recorded per quarter-mile, make repetition and verification a much simpler process. Riparian area (length of community multiplied by average community width) per quarter-mile is possible in this scenario, as well.

PROPOSED METHODS FOR SURVEYING THE REMAINING MILES.

Obtain color copies of the old quarter-mile photos to take in the field. Use them to identify the original quarter-mile sections when possible, while keeping track of new quarter-mile lengths (with a pacing stick) as well. Permanently mark the new and old quarter-miles, possibly with a Global Positioning System and/or marker posts, and record them on field maps. Take repeat photographs of the original quarter-mile sites, representative community types, as well as other features that will assist in data interpretation (i.e. new gullies, typical bank damage, instream habitat structures, large stable beaver dams). Gather as much information as possible about the stream including all land uses of the stream, its riparian area, and associated uplands.

When beginning a new stream section, walk a significant portion of it to determine the riparian plants and communities that are likely to be encountered. Plant community identification is typically based upon the types of plants present. For instance, a community with Nebraska sedge, rushes, clover, mint, and Kentucky bluegrass, all in relative abundance, would probably be called a sedge-grass-forb community. If sedges and rushes were present only occasionally, the community type would more likely be grass-forb. In shrub dominated sections, communities are identified by the shrub type and accompanying vegetation (i.e. willow-grass, alder-chokecherry, willow-sedge). Sedges and rushes need not be distinguished from each other as they appear to function similarly in the riparian zone. Miscellaneous and non-vegetative "communities" can be identified by defining structures such as beaver dams, gabions, cutbanks, springs, and secondary/old channels. For example, cutbank communities are identified by vertical banks that show recent scouring. Only lengths are recorded since widths are very near zero and vegetation is scarce, if present at all.

The inner edge of the riparian zone is defined for this purpose as the first vegetation encountered that is not obligate emergent. The outer edge of the riparian zone is defined where the transition occurs from obligate riparian to non-obligate (facultative or xeric) species. Some upland species can appear within the riparian width, just as some riparian species (typically mature woody plants) can persist outside the riparian edge. The functional definition used in the 1994 and original survey was those plant communities requiring free and unbound water (Kovalchik et al. 1991). Knowledge of plant taxonomy and familiarity with upland vegetation can be very useful as plants that are obligate riparian in lower elevation streams may be facultative riparian or upland species at higher elevations.

Community lengths are determined by means of a pacing stick and are measurements of riparian lengths, not stream lengths. Representative community widths should be taken as often as reasonable (at least four per quarter-mile), and their locations noted by quarter-mile. Communities can appear adjacent to and within other communities which makes multiple measurements of length necessary; one to determine the length of the riparian area, and others to determine lengths of each community.

Step-toe composition measurements are more useful in describing communities than in determining changes in communities. For that reason, visual estimates of vegetative cover taken at frequent intervals (at the same time as widths) and averaged per community may be more efficient for time and effort than the 220 hits taken for the 1994 survey. Visual estimates are no more quantifiable or useful in determining vegetation composition changes than the step-toe method, however, they are much easier to obtain, requiring considerably less time and training. If more detail is needed for baseline information on a stream section, the step-point method outlined above may be adequate. A calibration would be required to see if variability encountered within riparian zones could be captured since methods outlined above are designed for homogeneous uplands and pastures. The greenline monitoring method discussed in chapter 1 may also be appropriate (Cagney 1993).

Bank damage is bare soil at the water's edge or at the edge of the channel if the stream is dry. In this survey, the length of bank damage is estimated as well as the cause. Types of bank damage include natural (due to erosion and deposition), cattle/herbivore (trampling, trails, hoof sheared banks), and other (beaver, logging, road fords, etc.). Lengths are estimated for each bank separately. For instance, if the entire length of a 20 meter stretch of stream were damaged on both sides, 40 yards of bank damage would be recorded. Bank damage and cutbank conditions can and do occur separately.

RECOMMENDATIONS FOR STREAM SELECTION AND STATISTICAL ANALYSIS

Stream gradient must be determined on all sections to be surveyed. This information is easy to obtain with topographic maps, known starting and ending points, and a map wheel or section length. Sections should be categorized into low (<2%), moderate (2-4%) and high gradient (>4%). Grazing history, present grazing strategy and actual use should be discernible from BLM records as should any history of in-channel additions including gabions, juniper rip-rap and drop structures.

Upland use and condition can be very important in interpreting stream results. Obtain records of logging, juniper control, fire, or any other land uses that can potentially impact stream functions. Valley form (narrow valley or broad) and beaver presence/absence will require a field visit to each section. The presence or absence of large and/or stable beaver dams should be noted in those sections with beaver, as small trash dams are unlikely to affect stream functions to any great degree. Grazing systems (used for at least the last 5 years) should be categorized into one of four groups based on the generalized responses of riparian vegetation (Elmore and Kauffman 1994). The first group is exclusion. The second group includes grazing during winter or dormant season and early growing season. The third group includes rotation, three-pasture rest rotation, deferred or late season, and deferred rotation grazing. The last group includes spring and fall, spring and summer, and season-long grazing. Grazing strategies not mentioned above should be examined for their timing and impact on riparian vegetation and placed in the proper category.

Streams with the same categories (e. g. moderate gradient, gained beaver, group two grazing) can be analyzed with a signed ranks test for changes in riparian area, length of cutbank, length of bank damage and number of vegetative communities. Streams with human influences such as in-stream structures and significant trespass grazing or those with recent natural disturbances should be analyzed separately. Nonparametric tests are recommended for analysis.

IV. SUMMARY

The three main objectives of this study were to evaluate stream responses, evaluate the original methods, and outline an efficient resurvey method. Stream responses show a general upward trend in terms of riparian area, number of communities, lengths of cutbanks, and lengths of bank damage. Of the original methods total area, bank damage and cutbank lengths appear to be the most reliable, with community compositions the least reliable. Chapter 2 discusses changes to the original methods that simplify the resurvey process.

The data available from the original surveys and those of 1994 offer the possibility of gaining insight into stream responses to over 16 years of management. This project was designed to explore the various factors that can influence stream responses and streamline resurvey efforts. Most of the streams resurveyed appear to be in an upward trend in regards to total riparian area, bank damage, and the number of communities encountered. Lengths of cutbanks pose a more varied response and should be looked at stream-by-stream.

The bank damage, cutbank length, and riparian area measurements are probably the most stable and would be more so with minor changes in recording of widths and lengths. The number of riparian communities, with the help of photographs and thorough written descriptions, appears to be a reliable measure of diversification if left in large functional groups. Community composition measurements were the most time consuming portion of the survey and produced the least reliable information. For future resurvey efforts, visual estimates of cover compositions taken relatively frequently should produce the same level of information as the step-toe method. Neither the step-toe nor visual estimates will give the precision of information needed to evaluate changes in vegetative cover within a community and should only be used for describing communities.

Juniper rip-rap placed on actively eroding banks in the mid 1980s seems to have stabilized banks and provided habitat and protection for riparian plants. It is unknown how much of the bank stabilization and aggradation was due to the juniper rip-rap and how much was due to changes in management and recovery of herbaceous vegetation.

BIBLIOGRAPHY

Abt, S. R., W. P. Clary, and C. I. Thornton. 1993. Sediment entrapment in vegetated streambeds. International Erosion Control Association: "Preserving Our Environment - the Race is on". Indianapolis, IN. Feb. 23, 1993. Pp. 73-91.

Bateson, F. T., P. E. Culpin and W. A. Crisco. 1987. Riparian Area Management: The use of aerial photography to inventory and monitor riparian areas. USDI, BLM/YA/PT-87/021+1737, Denver, CO. 16 pp.

Behnke, R. J., R. F. Raleigh, R. R. Johnson, and J. F. McCormick. 1978. Grazing and the riparian zone: Impact and management perspectives. Proceedings of the Symposium: Strategies for Protection and Management of Floodplain Wetlands and Other Riparian Ecosystems. Callaway Gardens, GE. Dec. 11, 1978. USDA Forest Service. Pp. 263-267.

Beschta, R. L. and W. S. Platts. 1986. Morphological features of small streams: Significance and function. Water Resources Bulletin 22(3):369-379.

Beschta, R. L., W. S. Platts, J. B. Kauffman, and M. T. Hill. 1994. Artificial Stream Restoration--Money well spent or an expensive failure? Environmental Restoration and UCOWR 1994 Annual Meeting. Big Sky, MT. Aug. 2, 1994. The Universities Council on Water Resources. 16 pp. Draft.

Cagney, J. 1993. Riparian Area Management: Greenline riparian-wetland monitoring. USDI, BLM/SC/ST-93/001+1737, Denver, CO. 45 pp.

Clemmer, P. 1994. Riparian Area Management: the use of aerial photography to manage riparian-wetland area. USDI, BLM/SC/ST-94/005+1737, Denver, CO. 55 pp.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U. S. Dept. of Interior. Fish and Wildlife Service. Biol. Serv. Program. FWS/OBS-70-31. Washington D. C. 103 pp.

Crouse, M. R. and R. R. Kindschy. 1984. A method for predicting riparian vegetation potential of semiarid rangelands. Proceedings 1984 Pacific Northwest Range Management Short Course Range Watersheds, Riparian Zones and Economics: Interrelationships in Management and Use. Oregon State Univ. Pp. 18-30.

Cuplin, P. 1985. Riparian Area Inventory and Monitoring Using Large Scale Color Infrared Photography. In: Riparian Ecosystems and Their Management: Reconciling Conflicting Uses. First North American Riparian Conference, Tucson, AZ. USDA-FS, General Technical Report RM-102. Pp. 69-71.

Cuplin, P., W. S. Platts, O. Casey, and R. Masinson. 1985. A Comparison of Riparian Area Ground Data with Large Scale Airphoto Interpretation. In: Riparian Ecosystems and Their Management: Reconciling Conflicting Uses. First North American Riparian Conference, Tucson, AZ. USDA-FS, General Technical Report RM-102. Pp. 67-68.

DeBano, L. F., L. J. Schmidt, R. E. Gresswell, B. A. Barton, and J. L. Kershner. 1989. Interrelationship between watershed condition and health of riparian areas in southwestern United States. Practical Approaches to Riparian Resource Management. An Educational Workshop. Billings, MT. May 8, 1989. Montana BLM. Pp. 45-52.

Eddleman, L. E., P. M. Miller, W. P. Clary, E. D. McArthur, D. Bedunah, and C. L. Wambolt. 1991. Potential impacts of western juniper on the hydrologic cycle. Proceedings--Symposium on Ecology and Management of Riparian Shrub Communities. Sun Valley, ID. May 29, 1991. Intermountain Research Station. Pp. 176-180.

Elmore, W. 1994. Bureau of Land Management National Riparian Specialist. Prineville, Oregon. Personal Communication.

Elmore, W. and B. Kauffman. 1994. Riparian and watershed systems: Degradation and restoration. In: Ecological Implications of Livestock Herbivory in the West. Soc. for Range Manage. Denver, CO. Pp. 213-231.

Elmore, W. and R. L. Beschta. 1988. The fallacy of structures and fortitude of vegetation. Proceedings of the California Riparian Systems Conference: Protection, Management, and Restoration for the 1990s. Davis, CA. Sept. 22, 1988. USDA Forest Service. Pp. 116-119.

Evans, A. E. and R. M. Love. 1957. The step-point method of sampling--A practical tool in range research. J. Range Manage. 10:208-212.

Grant, G., R. I. Callahan, and J. J. Devries. 1987. Assessing effects of peak flow increases on stream channels: a rational approach. Proceedings of the California Water Management Conference, Sacramento CA. Nov. 18-20, 1986. Pp. 142-149.

Gregory, S. V., F. J. Swanson, W. A. McKee, and K. W. Cummins. 1991. An ecosystem perspective of riparian zones: Focus on links between land and water. Bioscience 41(8):540-551.

Griffiths, D. 1902. Forage conditions in the northern border of the Great Basin. USDA Bureau of Plant Industry. Bulletin 15.

Groeneveld, D. P. and T. E. Griepentrog. 1985. Interdependence of groundwater, riparian vegetation, and streambank stability: A case study. Riparian Ecosystems and Their Management: Reconciling Conflicting Uses. First North Am. Riparian Conference. Tucson, AZ. Apr. 16, 1985. USDA Forest Service. Pp. 35-38.

Hollander, M. and D. A. Wolfe. 1973. *Nonparametric Statistical Methods*. John Wiley and Sons, New York.

Kauffman, J. B. and W. C. Krueger. 1984. Livestock impacts on riparian ecosystems and streamside management implications...a review. Journal of Range Management. 37(5): 430-438.

Kay, C. E. 1992. The impact of native ungulates and beaver on riparian communities in the intermountain west. Natural Resources and Environmental Issues. Vol. I: 23-44.

Kleinfelder, D., S. Swanson, G. Norris, and W. Clary. 1992. Unconfined compressive strength of some streambank soils with herbaceous roots. Soil Sci. Soc. Am. J. 56:1920-1925.

Kovalchik, B. L., W. Elmore, W. P. Clary, E. D. McArthur, D. Bedunah, and C. L. Wambolt. 1991. Effects of cattle grazing systems on willow-dominated plant associations in central Oregon. Proceedings--Symposium on Ecology and Management of Riparian Shrub Communities. Sun Valley, ID. May 29, 1991. Intermountain Research Station. Pp. 111-119.

Leonard, S. G., G. J. Staidl, K. A. Gebhardt, and D. E. Pritchard. Viewpoint: 1992a. Range site/ecological site information requirements for classification of riverine riparian ecosystems. J. Range Manage 45:431-435.

Leonard, S., G. Staidl, J. Fogg, K. Gebhardt, W. Hagenbuck, and D. Pritchard. 1992b. Riparian Area Management: Procedures for Ecological Site Inventory-- With Special

Reference to Riparian-Wetland Sites. USDI, BLM/SC/PT-92/004+1737, Denver, CO. 136 pp.

Lyons, J. K. and R. L. Beschta. 1983. Land use, floods, and channel changes: Upper Middle Fork Willamette River, Oregon (1936-1980). Water Resources Research, 19(2): 463-471.

Meyers, L. H. 1989. Riparian Area Management: Inventory and Monitoring Riparian Areas. USDI, BLM/YA/PT-87/022+1737, Denver, CO. 89 pp.

Munther, G. L., J. M. Peek, and P. D. Dalke. 1982. Beaver management in grazed riparian ecosystems. Wildlife-Livestock Relationships Symposium. University of Idaho. Pp. 234-241.

Naiman, R. J., C. A. Johnston and J. C. Kelley. 1988. Alteration of North American streams by beaver: the structure and dynamics of streams are changing as beaver recolonize their historic habitat. Bioscience. 38(11):753-762.

Naiman, R. J., J. M. Melillo and J. E. Hobbie. 1986. Ecosystem alteration of boreal forest streams by beaver *(castor canadensis)*. Ecology. 67(5)1254-1269.

Ownesby, C. E. 1973. Modified step-point system for botanical composition and basal cover estimates. J. Range Manage. 26(4): 302-303.

Parker, M., F. J. Wood Jr., B. H. Smith, R. G. Elder, R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott, and R. H. Hamre. 1985. Erosional downcutting in lower order riparian ecosystems: Have historical changes been caused by removal of beaver? Riparian Ecosystems and Their Management: Reconciling Conflicting Uses. First North Am. Riparian Conference. Tucson, AZ. Apr. 16, 1985. USDA Forest Service. Pp. 35-38.

Petersen, M. M., D. J. Somerville, R. F. Sennett, W. P. Clary, E. D. McArthur, D. Bedunah, and C. L. Wambolt. 1991. Preliminary riparian classification system for private and state-owned lands in Utah. Proceedings--Symposium on Ecology and Management of Riparian Shrub Communities. Sun Valley, ID. May 29, 1991. Intermountain Research Station. Pp. 79-82.

Platts, W. S. 1991. Livestock Grazing. In: Influences of Forest and Rangeland Management in Salmonid Fishes and Their Habitats. American Fisheries Soc. Special Publication 19:389-423.

Platts, W. S., R. L. Nelson, R. E. Gresswell, B. A. Barton, and J. L. Kershner. 1989. Characteristics of riparian plant communities and streambanks with respect to grazing in northeastern Utah. Practical Approaches to Riparian Resource Management. An Educational Workshop. Billings, MT. May 8, 1989. Montana BLM. Pp. 73-81.

Pritchard, D., H. Barrett, J. Cagney, R. Clark, J. Fogg, K. Gebhardt, P. L. Hanson, B. Mitchell, and D. Tippy. 1993. Riparian Area Management: Process for Assessing Proper Functioning Condition. USDI, BLM/SC/ST-93/003+1737, Denver, CO. 60 pp.

Rickard, W. H., and C. E. Cushing. 1982. Recovery of streamside woody vegetation after exclusion of livestock grazing. Journal of Range Management. 35(3): 360-361.

Schulz, T. T., and W. C. Leininger. 1990. Differences in riparian vegetation structure between grazed areas and exclosures. Journal of Range Management. 43(4): 295-299.

Sharrow, S. 1995. Department of Rangeland Resources, Oregon State University. Personal Communication.

Shaw, N. L., W. P. Clary, E. D. McArthur, D. Bedunah, and C. L. Wambolt. 1991. Recruitment and growth of Pacific willow and Sandbar willow seedlings in response to season and intensity of cattle grazing. Proceedings--Symposium on Ecology and Management of Riparian Shrub Communities. Sun Valley, ID. May 29, 1991. Intermountain Research Station. Pp. 130-137.

Sheeter, G. R., E. W. Claire, and D. L. Abell. 1988. Juniper for streambank stabilization in eastern Oregon. Proceedings of the California Riparian Systems Conference: Protection, Management, and Restoration for the 1990s. Davis, CA. Sept. 22, 1988. USDA Forest Service. Pp. 420-423.

Skovlin, J. M. 1984. Impacts of grazing on wetlands and riparian habitat: A review of our knowledge. In: Developing Strategies for Rangeland Management. Boulder, CO: National Research Council/National Academy of Sciences. Westview Press. Pp 1001-1103.

Smith, B., and D. Pritchard. 1992. Riparian area management: management techniques in riparian areas. TR 1737-6. BLM/SC/PT-92/003+1737. Service Center, CO. 44 pp.

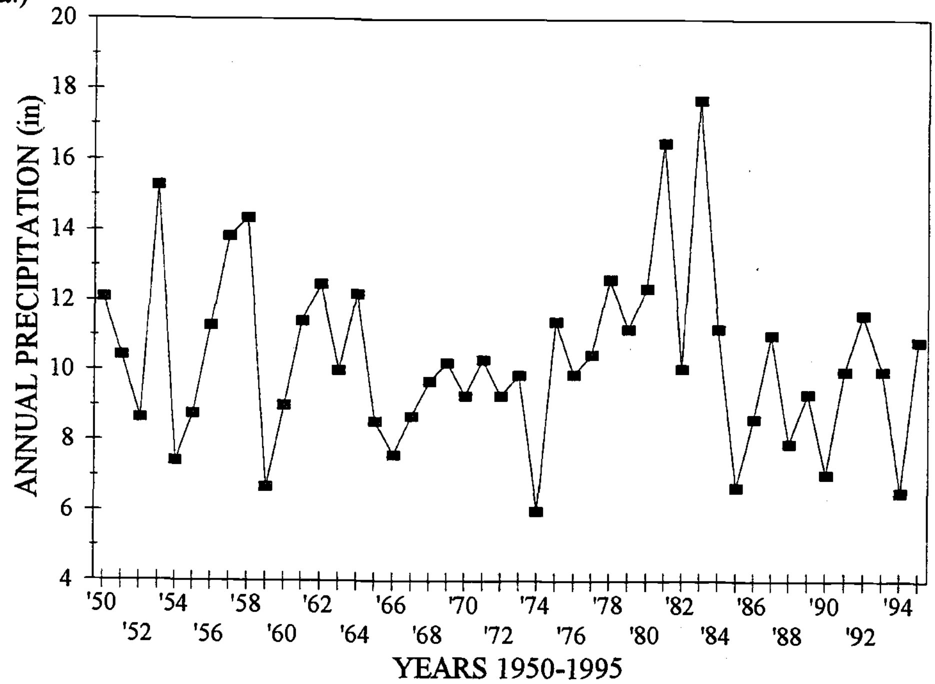
Smith, J. J., and D. L. Abell. 1988. Recovery of riparian vegetation on an intermittent stream following removal of cattle. Proceedings of the California Riparian Systems Conference: Protection, Management, and Restoration for the 1990s. Davis, CA. Sept. 22, 1988. USDA Forest Service. Pp. 217-221.

Storch, R. L., and O. B. Cope. 1979. Livestock/streamside management programs in eastern Oregon. Proceedings of the Forum--Grazing and Riparian/Stream Ecosystems. Trout Unlimited, Inc. Pp. 56-59.

Swanson, S., and D. L. Abell. 1988. Using stream classification to prioritize riparian rehabilitation after extreme events. Proceedings of the California Riparian Systems Conference: Protection, Management, and Restoration for the 1990s. Davis, CA. Sept. 22, 1988. USDA Forest Service. Pp. 96-101.

APPENDICES

a.)



b.)

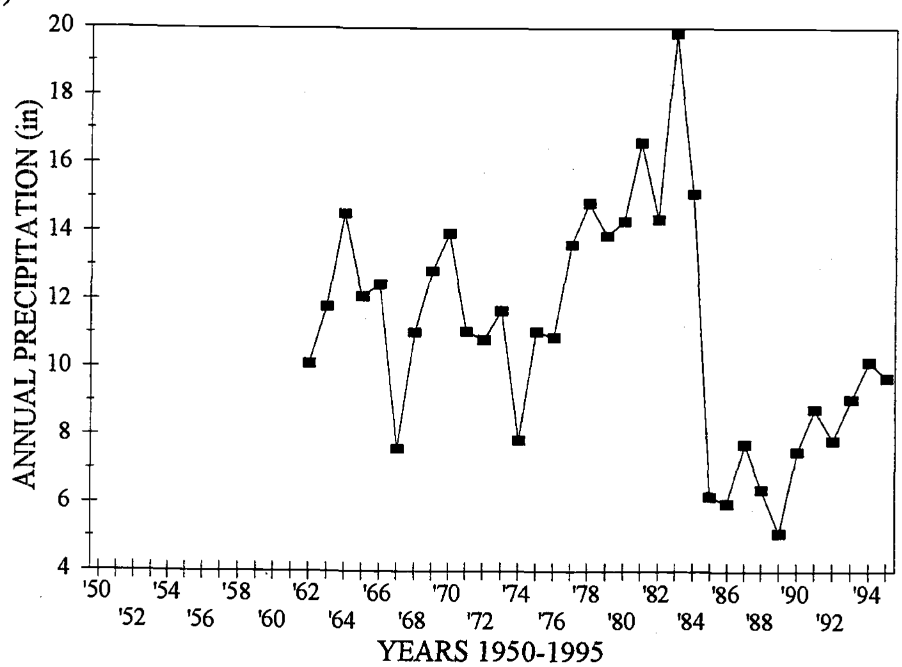


Figure 3. Annual precipitation from 1950 to 1995 for a.) Prineville, and b.) Paulina, Or.

Table 2. A summary of the total riparian acres within each section, 1978 and 1994, and the average number of riparian acres per quarter-mile.

Stream	Quarter-miles	Gradient	Grazed	1978 Area	1994 Area	1978 area per 1/4 mile	1994 area per 1/4 mile
Bear 1	15	low	yes	7.8	15.9	0.5	1.1
Bear 2	11	mod	no	5.4	9.0	0.5	0.8
Bear 3	1	low	yes	4.2	5.2	4.2	5.2
Bear 4	5	low	yes	6.1	11.0	1.2	2.2
Camp	5	low	yes	1.4	7.0	0.3	1.4
Indian	8	mod	no	4.9	8.0	0.6	1.0
Roba	6	mod	no	2.4	4.1	0.4	0.7
Paulina	1	low	yes	1.9	2.7	1.9	2.7
Bronco	5	mod	yes	3.8	5.1	0.8	1.0
Heisler	6	mod	yes	13.3	4.7	2.2	0.8
Beaverdam	6	mod	yes	6.4	5.2	1.1	0.9

Table 3. A summary of the yards of bank damage per section, by category and total.

Stream	Quarter-miles	Grazed	Time	Damage Natural	Damage Trampling	Damage Other	Damage Total	Damage per 1/4 mile
Bear 1	15	yes	1994	218	44	3	265	18
			1976	3995	117	13	4125	275
Bear 2	11	no	1994	248	33	16	268	24
			1976	2808	79	42	2929	266
Bear 3	1	yes	1994	23	54	0	77	77
			1976	102	0	0	102	102
Bear 4	5	yes	1994	42	9	0	50	10
			1976	774	0	2	776	155
Camp	5	yes	1994	285	0	0	285	57
			1988	0	0	0	1360	272
Indian	8	no	1994	157	39	12	209	26
			1976	669	3201	94	3964	496
Roba	6	no	1994	797	60	8	865	144
			1976	1386	2594	507	4487	748
Paulina	1	yes	1994	28	42	0	70	70
			1976	65	0	0	65	65
Bronco	5	yes	1994	38	12	2	52	10
			1976	467	114	22	603	121
Heisler	6	yes	1994	44	13	0	57	9
			1976	261	102	177	540	90
Beaverdam	6	yes	1994	232	8	0	240	40
			1976	738	609	200	1547	258

Table 4. Community composition of the total riparian area broken into the classes of grass-sedge-rush, forb, shrub-tree, bare ground and litter. Also shown is the difference between the 1976-78 and 1994 percentages.

			Percent of total riparian area									
Stream	Acres	Time	G-S-R	Diff. G-S-R	Forb	Diff. Forb	Shrub	Diff. Shrub	Bare Ground	Diff. Bare ground	Litter	Diff. Litter
Bear 1	15.9	1994	54		20		1		13		12	
	7.8	1978	53	1	36	-16	2	-1	7	6	2	10
Bear 2	9.0	1994	49		25		0		6		20	
	5.4	1978	54	-5	40	-15	1	-1	3	3	2	17
Bear 3	5.2	1994	71		18		0		6		5	
	4.2	1978	45	26	43	-25	2	-2	7	-2	3	2
Bear 4	11.0	1994	65		30		0		3		3	
	6.1	1978	47	18	44	-14	0	-0	7	-4	2	1
Camp	7.0	1994	62		15		1		12		10	
	1.4	1978	47	15	18	-3	3	-3	30	-19	1	9
Indian	8.0	1994	32		29		9		12		19	
	4.9	1978	15	17	24	5	31	-22	23	-11	8	11
Roba	4.1	1994	36		26		0		20		18	
	2.4	1978	24	13	37	-11	0	0	32	-12	8	10
Paulina	2.7	1994	61		3		4		5		27	
	1.9	1978	81	-19	8	-6	1	3	10	-5	0	27
Bronco	5.1	1994	46		15		9		21		9	
	3.8	1978	36	10	27	-12	16	-6	14	7	7	2
Heisler	4.7	1994	41		24		8		17		9	
	13.3	1978	27	14	6	18	49	-41	13	4	5	5
Beaverdam	5.2	1994	26		28		11		17		18	
	6.4	1978	17	9	7	21	33	-21	34	-17	10	8

Table 5. Lengths of cutbanks (yards) for each section of stream, 1978 and 1994.

Stream	Quarter miles	1994 lengths	1978 lengths
Bear 1	15	365	1039
Bear 2	11	190	639
Bear 3	1	90	0
Bear 4	5	74	0
Camp	5	341	506
Indian	8	165	958
Roba	6	772	1028
Paulina	1	0	0
Bronco	5	46	0
Heisler	6	75	0
Beaverda	6	214	0

Table 6. Summary of juniper rip-rap surveyed lengths (in yards).

Stream	Effective	Not effective
Bear 1	1263	62
Bear 2	124	43
Bear 4	7	0
Camp	180	9
Roba	162	49

Table 7. A summary of section characteristics and measured variables (area - acres, bank damage and cutbanks - yards).

					Differences per 1/4 Mile			
Stream	Quarter-miles	Gradient	Grazed	Beaver Status	Area	Bank Damage	Cutbank Length	Community Number
Bear 1	15	low	yes	gained	0.5	-257	-45	0.2
Bear 2	11	mod	no	gained	0.3	-242	-41	0.1
Bear 3	1	low	yes	no change	1.1	-25	90	2.0
Bear 4	5	low	yes	gained	1.0	-145	15	0.6
Camp	5	low	yes	gained	1.1	-215	-33	0.6
Indian	8	mod	no	lost	0.4	-469	-99	0.1
Roba	6	mod	no	no change	0.3	-604	-43	0.3
Paulina	1	low	yes	no change	0.8	5	0	0.0
Bronco	5	mod	yes	no change	0.3	-110	9	0.6
Heisler	6	mod	yes	lost	-1.4	-81	13	-0.5
Beaverdam	6	mod	yes	lost	-0.2	-218	36	0.0

Table 8. A list of common and scientific names of plants cited in the text.

Common Name	**Scientific Name**
Canarygrass	*Phalaris spp.*
Kentucky Bluegrass	*Poa Pratensis*
Equisetum	*Equisetum spp.*
Clover	*Trifolium*
Yellow Lotus	*Astragalus spp.*
Sedges	*Carex spp.*
Rushes	*Juncus spp.*
Cheatgrass	*Bromus tectorum*
Willow	*Salix spp.*
Sagebrush	*Artimesia tridentata*
Cottonwood	*Populus trichocarpa*
Alder	*Alnus spp.*
Juniper	*Juniperus occidentalis*
Aspen	*Populus tremuloides*
Ponderosa Pine	*Pinus ponderosa*
Fir	*Pseudosuga spp.* or *Abies spp.*
Red-osier Dogwood	*Cornus stolonifera*
Choke-cherry	*Prunus virginiana*
Mock-orange	*Philadelphis lewisii*
Snowberry	*Symphiocarpus spp.*
Wild Rose	*Rosa spp.*
Mint	Family Labiate