Vegetation changes associated with livestock exclusion from riparian areas on the Dead Indian Plateau of southwest Oregon.

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ABSTRACT

Livestock exclusion (> 10 years) resulted in the colonization of bare soil by grasses and sedges, in turn replaced by riparian shrubs and trees. Similar patterns of change were observed in nearby paired grazed areas, though magnitudes of change were lower. The collection of repeat photos across the monument indicate that observations from photos of grazed areas paired to exclosures are representative of the larger monument landscape. The increase in woody vegetation across the landscape is likely a response to time since the last disturbance (fire and floods), a decline in spatial extent of livestock influence, and improved livestock management practices. In areas that have not experienced fire for many decades, and are not prone to scouring floods, livestock management factors are the most plausible explanation for increased riparian woody species abundance. The rapid recovery of riparian shrubs in areas with a cobbly substrate relative to areas with deeper alluvial soils may be due in part to the protection from grazing and hoof impact afforded by boulders. Improved management practices have allowed the development of riparian herbaceous vegetation and increased vegetative reproduction by aspen close to point sources of water for livestock. Grazed seeps, springs, and small sag ponds show less improvement of vegetation composition and structure over time than lotic riparian systems, a reflection of intense localized disturbance by livestock. One of the exclosures formerly a ranch under private ownership showed a replacement of yellow starthistle (*Centaurea solistitalis*) by annual grasses, perennial grasses, and riparian vegetation. Photos in grazed areas showed increased yellow starthistle in the vicinity of stockponds, and Canada thistle (*Cirsium arvense*) in higher elevation highly utilized riparian areas. Observation indicates beaver activity is associated with the escape of riparian vegetation from the confines of cutbanks. Increased extent of riparian habitat, the girdling of conifer, and vegetative reproduction of hardwoods (willow, white alder, and aspen) emphasize the influence of beaver play on riparian composition and structure.

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INTRODUCTION

Riparian zones are one of the most spatially limited, (Elmore 1987, Thomas et al. 1979b, Behnke 1979) and most sensitive (Kauffman and Krueger 1984) habitats in the western landscape.   Riparian zones are also the most productive and diverse habitats in much of the west (Thomas et al. 1979a,b, Knopf 1985, Cross 1985, Kovalchik and Elmore 1992) and frequently produce 10 times the forage of adjacent upland forested sites (Elmore 1987). Allen (1989) stated that riparian stringer meadows in the Sierra Nevada Mountains of California were small but produced up to half the summer forage for livestock. Riparian zones may act as refugia for upland species when fires or other disturbances occur in the uplands (Wales 2001). The link between riparian vegetation diversity, especially in the shrub and overstory layers, and riparian wildlife diversity is well documented (Thomas et al. 1979b, Kauffman and Krueger 1984, Finch 1985, Szaro et al. 1985 Taylor 1986,).

Riparian habitats are important because they facilitate the persistence of a disproportionate number of wildlife compare to other ecological sites (Case and Kaufman (1997), Thomas 1979b, Gains 1977, Kelley et al. 1975, and Kirby 1975). Vegetation parameters are almost always the habitat factors of primary importance in determining the suitability of a piece of habitat for a specific species or group of species (Wray and Whitmore 1979, Stauffer and Best 1980, Meents et al. 1981, Collins 1981, Maser et al. 1984, Taylor and Littlefield 1986, Sedgwick and Knopf 1992, Behnke 1979). The disproportionate number of species utilizing riparian areas implies that livestock impacts to riparian vegetation composition, structure and ecological processes is likely to result in a disproportional impact on landscape biodiversity (Case and Kaufman 1997). Beaver are known to increase the size of many wetlands (Johnson and Naiman 1990, Munther 1981), and plant species richness at the landscape scale by increasing habitat diversity (Wright et al. 2002).

Vegetation Changes Consequent to Livestock Removal from Riparian Areas

<u>Community attributes:</u> Livestock have been shown to influence riparian herbaceous composition (Platts and Nelson 1989, Fusco et al. 1995, Popolizio et al.1994, 1990, Allen

1989, Kaufmann et al. 2002, Krueger and Winward 1974, Schulz and Leininger 1991), and species richness (Holder et al. 1980, Winegar 1977). Several authors observe that grazing facilitates species adapted to herbivory or drought (Kauffman et al. (2002), Green and Kauffman 1995, Green 1991). Common patterns of change in the herbaceous community following reduced influence by livestock include the colonization of bare soil (Allen 1989, Kauffman et al. 2002, Platts and nelson 1989), a replacement of grasses by sedge (Green and Kauffman 1995, Allen 1989, Gunderson 1968, Clary 1995), sedges adapted to dry areas are replaced by sedges representative of higher moisture (Platts and Nelson 1989). Green (1991) notes a replacement of ruderal by longer lived more competitive plant species.

<u>Woody vegetation:</u> Livestock have been shown to influence abundance of obligate riparian woody vegetation (Knopf and Cannon 1982, Ammon and Stacey 1997, Clary 1999, Schulz and Leininger 1991, Case and Kauffman, Kaufman et al. 2002, Maschinski 2001, Platts and Nelson 1989, Shaw 1992), and the architecture (volume, height, vertical diversity, or branching pattern) (Knopf and Cannon 1982, Ammon and Stacey 1997, Clary 1999, Kaufman et al. 2002, Taylor 1986, Gunderson 1968, Shaw1992) of woody vegetation. Age of transects/exclosures can be best indicator of riparian shrub characteristics (Kauffman et al. 2002, Taylor 1986), evidence that livestock are able to exert a strong influence on riparian communities. Others report the loss of the lower shrub strata (Gunderson 1968, Szaro et al. 1985).

Studies have shown that the influence by native and non-native ungulates is additive (Krueger and Winward 1974, Case and Kauffman 1997, Maschinski 2001). Riparian vegetation has been shown to be resilient and able to recover from livestock influence because of favorable growing conditions in the presence of water, and their adaption to disturbance (Kauffman et al. 1995). Slower change measured by Skovlin (1984) indicates that elevation may play a role in the rate of riparian recovery. An important mechanism influencing riparian vegetation dynamics is the reduced ability of riparian plants to reproduce under livestock grazing (Davis 1977, Case and Kauffman 1997, Kaufmann 1987, Kovalchek and Elmore 1992, Shaw 1992, Pickford and Reid 1942).

Livestock use of riparian shrubs is often described to increase in the late summer as upland herbaceous forage dries and becomes less palatable, or declines in abundance as a consequence of grazing (Kovalchik and Elmore 1992, Schulz and Leininger 1991, Case and Kauffman 1997, Green and Kauffman 1995, Kauffman et al. 1983, and Thilenius 1990).

Other hardwoods are similarly affected by livestock (Green and Kauffman 1995). The decline of aspen is a particular concern in Oregon (Shirley and Erickson 2001), and within the CSNM as evidenced by the construction of exclosures for its protection from livestock and beaver. Several interacting factors (fire, herbivory, and or timber harvest) influence the persistence of aspen (Bartos and Campbell 1998, Shirley and Erickson 2001, Romme et al. 2001). Livestock have actually been used as a tool to eradicate aspen in areas where forage production is emphasized as a management objective (Jones 1983, Fitzgerald and Bailey 1984). Others identify elk browsing as a factor influencing aspen regeneration at locations in the Rocky Mountain National Park (Bartos et al. 1994, Suzuki et al. 1999, Kilpatrick et al. 2003). Where aspen occur as a seral stage in conifer communities, increased seedling establishment occurs on mineral soil (Seidel et al. 1990).

Munther (1981) describes occupied beaver habitats including aspen within wide valley bottoms as resistant to incursion by livestock. Aspen in narrower valleys tend to be away from water where regeneration following the harvest of mature aspen by beaver becomes susceptible to browsing by cattle. Several authors record the use of aspen, and particularly the younger aspen sprouts by beaver (Masslich et al. 1988, Basey et al. 1987). Masslich et al. (1988) found that aspen resprout density was higher in areas with active beaver.

Tools for aspen restoration include commercial harvest, prescribed fire, mechanical root stimulation, removal of competing vegetation, protection from herbivory, and regeneration from seed as treatments to regenerate aspen (Sheppard 2001, Shirley and Erickson 2001, Bartos and Mueggler 1981). Beaver mediated riparian habitat (Johnson and Naiman 1990, Munther 1981) and stimulation of aspen suckers implies that beaver may play an important role in the maintenance of aspen.

Soil impacts: Livestock have been shown to increase the abundance of bare soil (Platts and Nelson 1989), increase stream width/depth ratios (Platts and Rinne 1985), and decrease bank stability (Platts and Rinne 1985, McInnis and McIver 2001). Clary (1995) tried to separate the effects of defoliation and soil compaction by examining the effects of simulated grazing and compaction on a variety of riparian sites in Idaho and Oregon. Results show that the effects of soil compaction were more consistent across study areas than vegetation response to defoliation. The latter was found to be variable by plant species, plant community, and grazing intensity. The most consistent vegetation response to grazing was a reduction in height and biomass following compaction treatments. The increased height in control quadrats indicated that soils were still recovering from compaction prior to experimental compaction. Exclosures in Sheep Creek, Colorado had nearly twice the litter build up, and willow canopy coverage was 8.5 times greater than in the grazed areas (Schulz and Leininger 1990), a mechanism likely affecting habitat and soil organic matter in riparian areas. Szaro et al. (1985) also noted the ability of shrubs to filter out debris, a mechanism likely contributing to the accumulation of organic matter.

Excessive trampling and herbivory by livestock can lead to destabilized and compacted soil, leaving banks vulnerable to shearing by hooves and accelerated erosion (Platts 1991, Meehan et al. 1977, Kauffman et al. 1983). This in turn can lead to wider, shallower streams (Gunderson 1968) and increased sedimentation of streambeds and degradation of fish spawning habitat (Kauffman & Krueger 1984, Meehan et al. 1977).

Management of Riparian Areas

Early range researchers recognized that season-long use, early use, and allowing the concentration of livestock were damaging to riparian areas (Pickford and Reid 1942). Several authors (Pickford and Reid (1942) Kovalchic and Elmore (1992), Thomas et al. (1979b) recognize the need to manage riparian meadows differently from upland range. Kovalchik and Elmore (1992) imply that standard grazing systems (continuous, rest rotation, and deferred rotation) do not consider streambank integrity or the physiology of shrubs and trees.

Protection of the vegetation in riparian systems, including seasonally wet meadows, through the reduction or elimination of livestock grazing is a common recommendation (Martin and Ward 1973, Davis 1977, Kindschy 1978, Behnke 1979, Thomas et al. 1979a,b, Holder et al. 1980, Dealy et al. 1981, Kauffman and Krueger 1984, Apple 1985, Taylor 1986, Kovalchik and Elmore 1992, Sharp 1992, Bock et al. 1993, Ames 1977, Thomas et al. (1979b), Pickford and Reid (1942)). Thomas et al. (1979b) go further to suggest that livestock grazing may be incompatible with protection and maintenance of wet meadows and riparian woody vegetation.

McInnis and McIver (2001) studied the effects of “moderate” livestock use in riparian pastures over a two-year period and found that streambank vegetative cover and bank stability was significantly reduced by livestock grazing relative to ungrazed areas. Their study used a “moderate” level of grazing with a target of 50 percent utilization of forage.

Several authors advocate complete removal of livestock for 5 to 10 years to allow the recovery of riparian areas (Kovalchik and Elmore 1992, Elmore and Kauffman 1994, Fleischner 1994). Skovlin (1984) found that 10 years of protection insufficient for recovery of higher elevation willow stands.

Managers commonly define stubble height thresholds to maintain hydrological function. Clary (1995) examined the influence of stubble height criteria on biomass production. The authors found that grazing to a 5 cm stubble height during the growing season, or 10 cm in the late summer, or to a utilization rate exceeding 30 percent of the annual biomass results in a decline in biomass production the following year Clary (1995).

Physical, Historic, and Climatic Description of the Cascade-Siskiyou National Monument (CSNM)

Streams in the Monument drain two distinct watersheds: the Klamath River basin to the south and the Rogue River basin to the northwest. Natural aquatic habitats within the monument include wetlands, seeps, springs, vernal pools, intermittent and perennial streams, and fish-bearing streams. Non-natural aquatic habitats throughout the monument include irrigation ditches, reservoirs, pump chances, spring developments, and the Talent Irrigation District (TID) diversion system.

In the *Klamath Basin Habitat,* Beaver trapping, ranching, flood control, water diversion, and timber harvest are thought to have significantly altered the floodplains and stream channels along Jenny Creek in the last 150 years (USDI 1995). Beaver dams historically maintained high water tables and wide riparian zones by adding structure to the flood plains, dissipating stream energy, and capturing sediment. As beaver were trapped and removed from the area, these beneficial hydrologic functions were diminished. Floodplains were cleared to provide more pastureland as ranchers became established in the area and efforts were made to control the stream. Eventually, much of the stream through ranch lands was straightened out, berms were constructed to prevent the stream from exceeding its banks, and stream-side shrubs and trees were removed to prevent debris jams from forming or channels from migrating.

Streamside vegetation varies considerably in the Emigrant Creek Watershed depending on aspect and elevation. California black oak, Oregon white oak, and Oregon ash are common components of overstory riparian vegetation in southwest-facing drainages. Big-leaf maple, black cottonwood, ponderosa pine, Douglas-fir and incense cedar, while not common, are also present. North-facing slopes are covered with a mixture of coniferous and deciduous vegetation. Douglas-fir and white alder provide good stream shading along Emigrant Creek above the mouth of Tyler Creek. This combination gives way to a white fir-dominated plant community near the highest elevations in the watershed. Common understory plants are poison oak, manzanita, wedgeleaf ceanothus, and willow (USDI 2000).

While the influence of trapping beaver out of riparian systems has not been well described for southwest Oregon, there can be little doubt that beaver played an important role in local riparian areas during historical times. In his travels through this region, early explorer Peter Skene Ogden was disappointed to find out that beaver had been trapped out of the Rogue River Valley prior to 1827 (Davies 1961). Other trappers part of Ogden’s exploration removed 735 beaver from two tributaries of the Klamath River, likely Jenny Creek and Fall Creek which traverse the CSNM. This is a substantial number, even if tallies include beaver from Klamath River and other tributaries.

In the late 1800's and early 1900's, cattle, sheep, horses, and goats roamed the CSNM on a season-long basis at an order of magnitude greater stocking rate than current (Hosten et al. 2007b). Cattle grazing is currently managed as nine grazing allotments, two of which are currently vacant (Agate and Siskiyou Allotments). Five of the active allotments account for 97% of the authorized grazing in the Monument (Figure 1). The Soda Mountain and Keene Creek Allotments contain most of the Animal Unit Months (AUMs) in the Monument. Existing grazing leases authorize a total of 2,714 active AUMs within the CSNM boundary during the grazing season. This number includes 99% of the Soda Mountain Allotment and 44% of the Keene Creek that are within the CSNM. The average actual use for the Soda Mountain and Keene Creek Allotments between 1985 and 2006 is 58%. (63% for Soda Mountain and 49% for Keene Creek Allotments). Grazing season generally is May through October. Lower elevation sites in Camp an Agate pastures of the Soda mountain Allotment occurs in the spring. Grazing in the Skookum and Oregon Gulch pastures is intermediate to late summer and fall grazing at higher elevations (Keene and Emigrant Pastures of the Soda Mountain Allotment, and Keene Allotment).

Restatement of Objectives

This paper uses repeat photography to determine if livestock influence vegetation composition, structure and ecological processes within lentic and lotic riparian areas of the Cascade-Siskiyou National Monument. Photos at the time of livestock exclosure construction 10 to 20 years ago are paired to photos of similar vintage and ecological site outside of exclosures. Results from the paired photopoints are also compared to repeat photos retaken across the larger CSNM landscape. The repetition of riparian transects completed in the 1980s and Proper Functioning Condition surveys (USDI 1998) at the same survey sites provide further temporal and spatial context for the repeat photos.

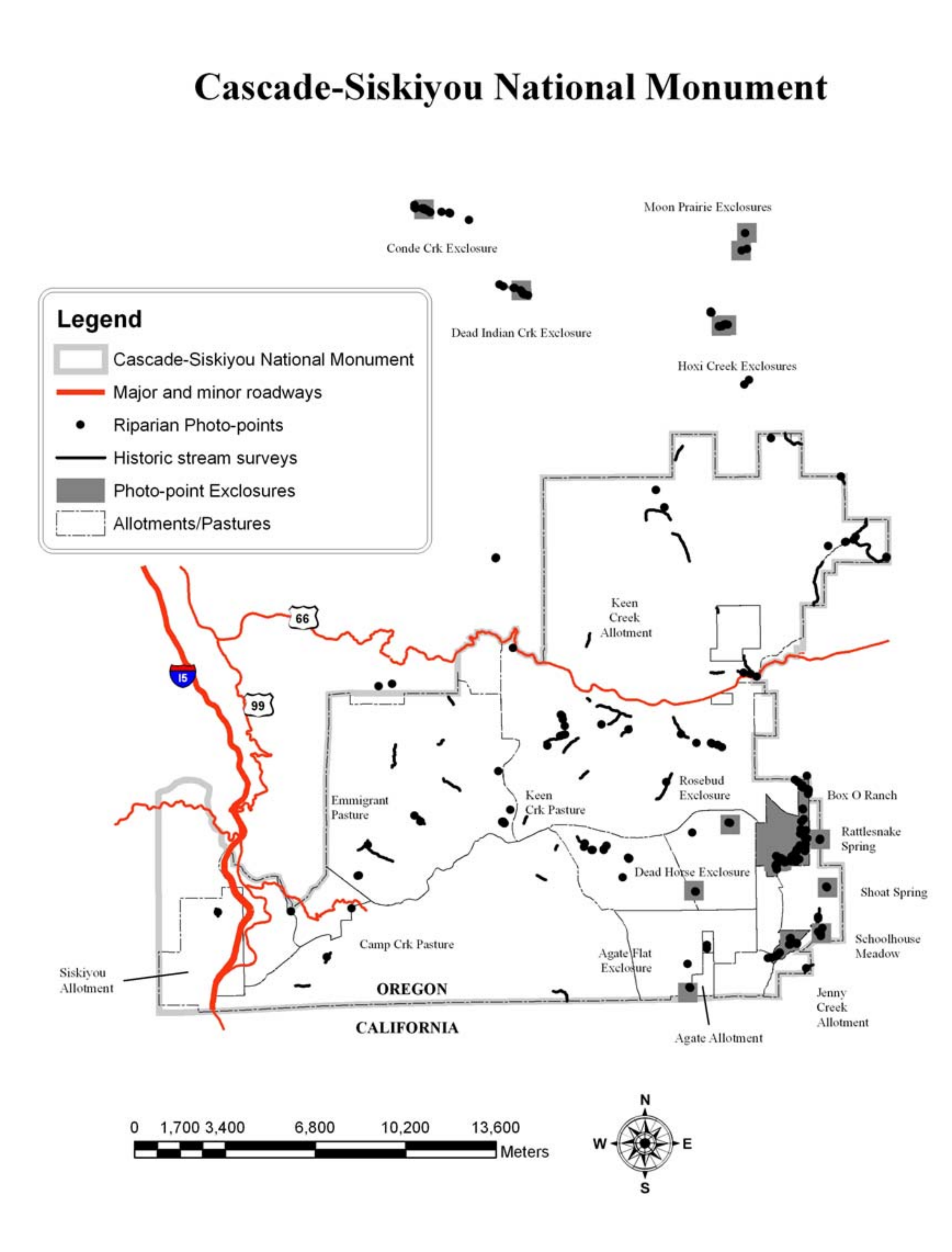

Figure 1. General location of the Cascade-Siskiyou National Monument, exclosures, and photo-point locations. Note: not all riparian photo-sites are shown on this map.

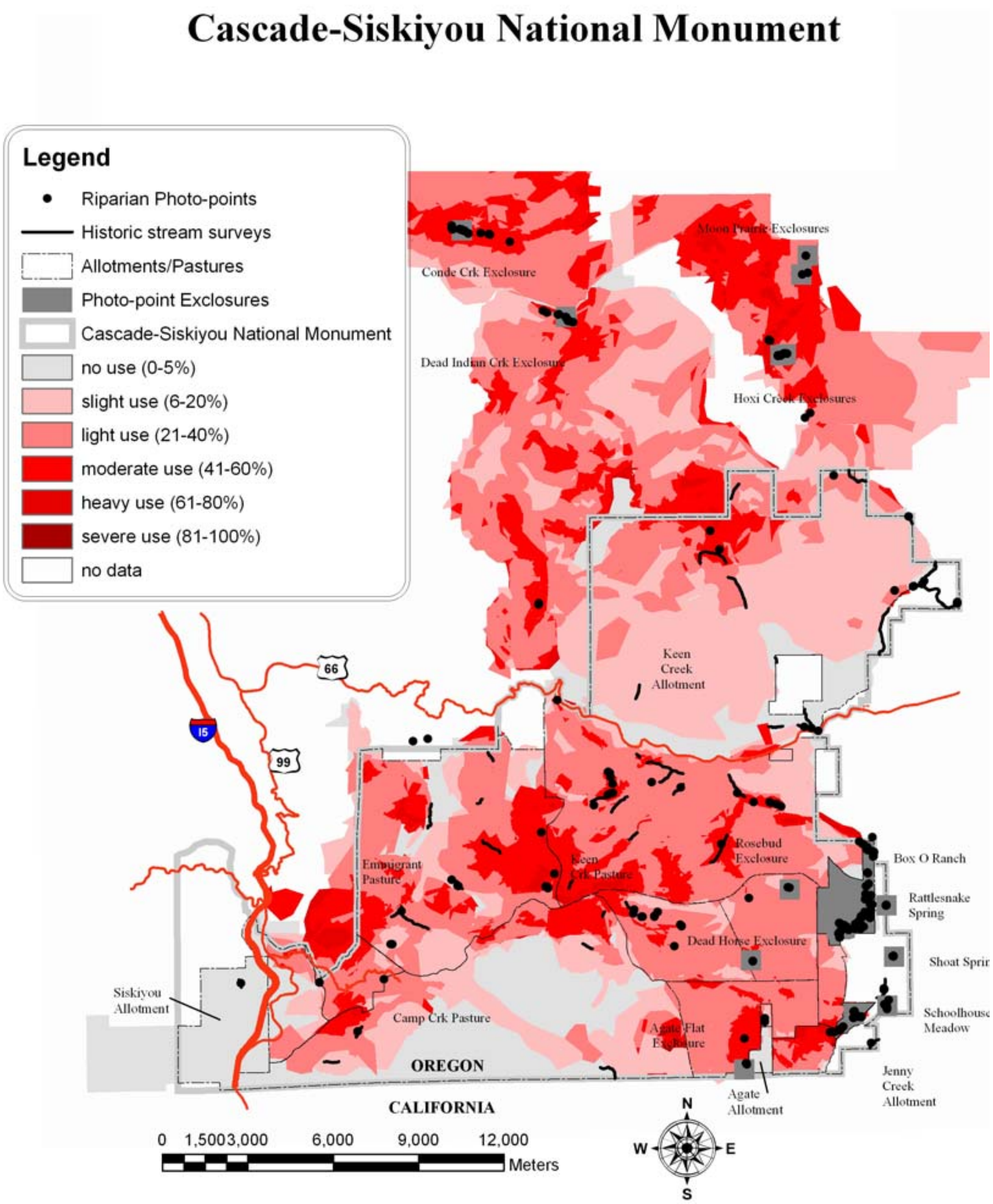

Figure 2. General location of the Cascade-Siskiyou National Monument, exclosures, and photo-point locations with forage utilization. Note: not all riparian photo-sites are shown on this map. See Hosten et al. (2007b) for description of the derivation of utilization maps.

METHODS AND MATERIALS

Description of Exclosures

Most of the exclosures were created to protect riparian resources from excessive livestock use. Conde and Moon Prairie exclosures were specifically created to protect aspen, while the Dead Indian exclosure was constructed to protect riparian vegetation as well as aspen stands. In the latter case, wire mesh was put around individual aspen to protect trees from beaver. Several exclosures experienced restoration activities including the creation of water catchments and planting of willows and other riparian plants suited to local conditions (Hoxie Creek west, Schoolhouse, Box O Ranch). The vegetation within the exclosures varies from seeps with no outflow (Deadhorse) to springs with high flow volumes (Shoat Spring), and both lentic and lotic situations (Table 1). The size of the exclosures varies from a fraction of an acre (Rattlesnake Spring) to several hundred acres (Box O Ranch). The Box O Ranch differs from other exclosures in its past management. Acquired by the BLM in 1995, it has been described as experiencing heavy season-long grazing for many years prior to the cessation of grazing under BLM management. The collection of exclosures therefore vary in the composition of their vegetation, past history, size, and continued management. For the purposes of this study, most have been paired to nearby photo sites with similar vegetation and history of land management. The proximity of paired sites implies similar use by all ungulates prior to exclosure construction, and continued use by native ungulates post construction. Of the 16 exclosures presented in Table 1, 10 have photos and remain unconfounded by multiple management actions.

Table 1: List of exclosure and fencing projects from 1995 or earlier derived from the Range Improvements (RIPS) database for protecting or providing finer control of livestock within riparian areas.

Project Name	RIPS Project Number	Year	Plant Community	Confounding Factors
Dead Horse	750146	1952**	Seep and stockpond	livestock trespass
Agate Flat	750542	1996*	Seep/stockpond, prairie	
Big Glade	750063	1975	-	
Cottonwood	750258	1981	-	
Hobart Lake	750479	1991	Sag pond	
Jenny Creek	750476	1991	Lotic riparian	Intermittent livestock use
Dead Indian	750464	1992	Lotic riparian, aspen	livestock trespass
Rattlesnake	750369	1992	Seep, sedge dominated	
Hoxie Crk east	750492	1993	Lotic riparian, open meadow	livestock trespass
Hoxie Crk west	750492	1993	Lotic riparian, conifer	livestock trespass
Schoolhouse	750506	1993	Lotic riparian, open meadow, conifer	livestock trespass
Bean Cabin	750530	1994	Lentic riparian, Open meadow	Tree harvest, livestock trespass
Conde	750535	1994	Lotic riparian, aspen	
Shoat Spring	750538	1995	Lentic/lotic, high volume spring	
Box O Ranch	n/a	1995	Lotic riparian, open meadow	livestock trespass
Elk exclosure	n/a		Mixed upland	Authorized livestock grazing
Moon Prairie	750559/60	2000*	Two aspen stands	

*may have been fenced prior to this data

** there was likely a period of grazing after initial fencing

Repeat Photography

Old photos were collected and scanned into a digital database. Repeat photos were taken at the same stage of phenology and perspective as the original photo. The photo series were viewed to assess vegetation change within the photo field of view. Change in vegetation was categorized in abundance classes by major plant taxa recognizable in photos, including yellow emergent aquatic vegetation, sedges and rushes grass, annual grass, forbs, yellow starthistle, Canada thistle, and riparian shrubs and trees.

The abundance classes include:

0	none present
1	presence only
2	25% of field of view
3	50% of field of view
4	75% of field of view
5	100% of field of view

Data were summarized for exclosures and paired sites, as well as in the context of all paired photo-retakes in riparian areas. The semi-quantitative nature of the data coupled with the sensitivity of data to perspective (landscape versus object oriented) and distance from riparian areas makes analysis difficult. Results are therefore summarized as the percentage of class change by biological object within grazed and ungrazed areas. Data are also examined in ordination space to determine patterns of change between objects of interest, relative to grazed and ungrazed areas. Changes observed from repeat photos are also summarized by topic (change within individual exclosures, noxious weeds, aspen regeneration) with reference to particular photo pairs. Select photos are provided in Hosten (2007b).

Repetition of Past Surveys and Current Proper Functioning Condition (PFC)

Historic field surveys conducted by the BLM between 1980 and 1982 were repeated in 2005 to assess livestock grazing influence on CSNM riparian zones, together with base-line hydrologic data and a proper functioning condition (PFC) assessment. Since changes to riparian plant communities can be slow and cumulative, we hoped that repeating these surveys after 25 years would provide a snapshot of longer-term dynamics and spatial patterning relative to environmental conditions to compliment shorter-term riparian exclosure studies. Repeat surveys include: the “Habitat Diversity Index” (HDI), the “Riparian Zone Condition Assessment” (RZC), and the “Observed Apparent Trend” (OAT).

<u>Habitat Diversity Index:</u> The Habitat Diversity Index was created to measure the ability of a riparian area to provide food, cover, and reproductive requirements for

wildlife. Components of the index used for comparison to current conditions include: (a)A numerical value based on presence or absence of the various plant forms (emergents/submergents, sedges/rushes, grasses, forbs, upright shrubs, hardwood trees, and conifers) [Two points were assigned if presence was greater than 2% foliar cover, while a value of one point was optional if the plant form was present at less than 2% foliar cover.]; (b) a value representing the condition of the riparian zone [excellent (6), good (4), fair (2), or poor (0).]; (c) the width of the combined sides of the riparian zone was assigned point values by width classes as follows (point values in parentheses): 0 to 20 feet (2), 20 to 40 feet (4), or 40 feet or wider (6); and (d) snags, grouped by height and DBH into two groups: less than six feet tall and less than eleven inches DBH and greater than six feet tall and eleven inches DBH. [Point values were assigned by the number of snags per acre in each size class. If both size classes were present, only the larger value was assigned. One additional point was assigned if both hardwoods and conifer snags were present.]

Observed Apparent Trend: The Observed Apparent Trend included estimates of surface litter and pedestalling (plants or rocks that appear elevated as a result of soil loss by wind or water erosion, Pellant et al. 2005). Surface litter was given a value between 0 and 20, and pedestalling was between 0 and 15.

PFC and Hydrological Survey Data: In addition to historic data, more recent protocols including Proper Functioning Condition Surveys (PFC) [USDI 1998] and hydrological baseline data were collected for assessment relative to environmental and livestock utilization patterns at the allotment and pasture levels. Classification of reaches as being in “proper functioning condition,” “functional-at-risk,” or “nonfunctional” status was summarized and analyzed on a pasture by pasture basis. The percent of reaches showing active erosion are summarized to allow comparison between allotment/pasture.

Since riparian transects were not permanently marked, results of the repeat surveys and PFC surveys were summarized by allotments and pastures within which they occurred rather than differences between individual transects. To reduce subjectivity, only data derived from direct measurements were use when repeating data across time. Photos from the original surveys were retaken to provide visual representations of changes in the 25 year interval, and are included in the examination of repeat photos.

Multivariate techniques associated with PCORD (McCune and Mefford 1999) are used to examine spatial and temporal patterns in datasets relative to environmental and management factors. Ordination is used to create two dimensional figures showing relative similarity of samples to each other. Axes define similarity space, within which samples most similar to each other are arranged most closely. Several graphics are utilized to further describe relationships between individual species or environmental data to the pattern of samples arranged in ordination space.

Joint plots can be used to represent direction and magnitude of change in individual variables correlated with ordination scores representing the plant community matrix.

Lines representing the relation between variable and ordination scores radiate from the centroid of the ordination scores within ordination diagrams. For a given variable, the line forms the hypotenuse (h) of a right triangle with the two other sides being r values between the variable and the two axes. Although the r values determine the relative scaling of the vectors, the absolute scaling is arbitrary and the “Vector Scaling” option is provided to set this scaling factor to ensure jointplots fit within ordination axes to be easily read. Weak variables from the secondary matrix included within the joint plot can be removed by stipulating a “Joint Plot Cutoff” effectively removing variables with a xr^2 less than the cutoff value.

RESULTS AND DISCUSSION

Repeat Photography

An ordination of observations from individual repeat photos (Figure 3) indicate few outliers. An exception being photos associated with the Rosebud Exclosure, likely because the site represents a stockpond. The photos associated with the Box O Ranch occupy a wide range of composition within ordination spaces signifying the range of habitats across this large exclosure.

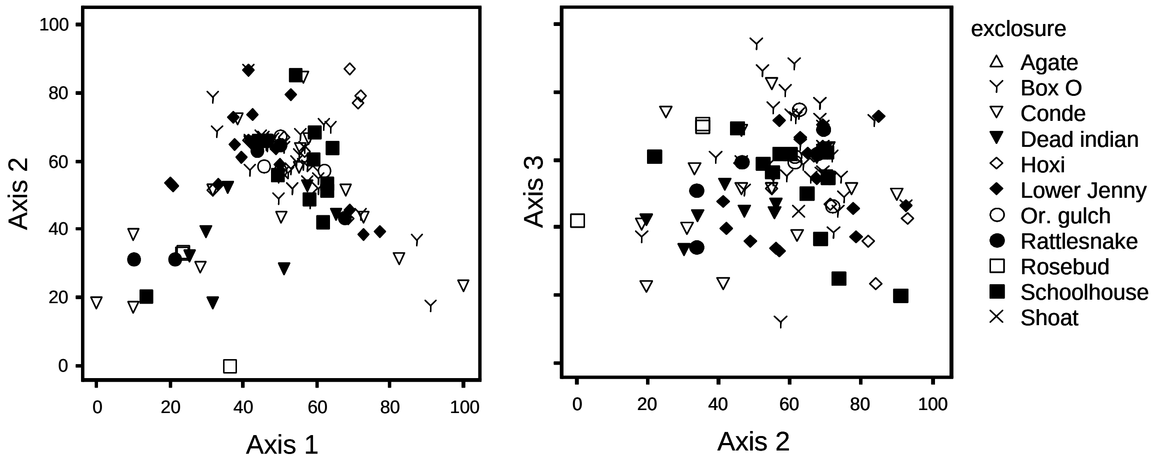

Figure 3. Ordination of individual photo-derived information classes (riparian shrubs, emergent plants, sedges and rushes, grasses, and forbs) for photos associated with livestock exclosures**.**

Figure 4 describes the percentage of plant class abundance differences (new photo derived abundance class – old photo derived abundance class). A greater percentage of photo points show increases in riparian shrubs under ungrazed conditions versus the grazed condition. The grazed condition shows a larger percentage of photopoints with no change in riparian shrub abundance. Emergent plants (bulrushes) showed tremendous increase under ungrazed conditions, but too few photos with of emergent plants occurred under grazed condition to enable comparison. Patterns of change indicated by the relative proportions change direction and magnitude of change within the stacked histogram columns representing sedge/rush, grass, and forbs are similar under grazed and ungrazed conditions. The data indicate that far fewer declines in abundance occurred for any plant classes. Some declined occurred for rushes and sedges, and grasses under both grazed and ungrazed conditions.

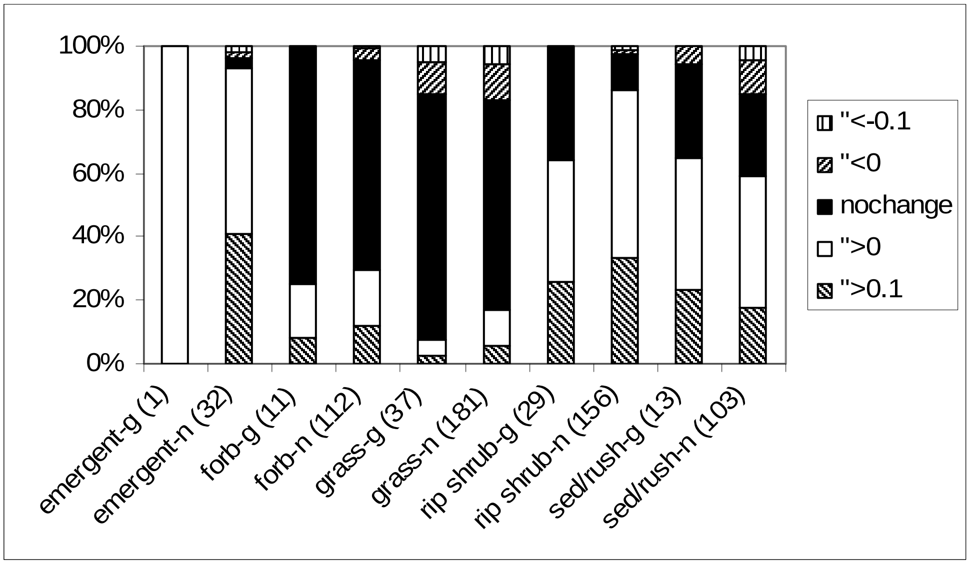

Figure 4. The count of vegetation abundance changes (new photo derived abundance class – old photo derived abundance class) within 5 magnitude classes for riparian shrubs, emergent plants, sedges and rushes, grasses, and forbs expressed as a percentage of all changes in exclosures and nearby paired grazed areas. Number of photos in parentheses, grazed indicated by “g”, ungrazed indicated by “n”.

Figure 5 indicates that declines in aspen cover have occurred on grazed and ungrazed lands. There are not enough photo observations to comment on differences between the grazed and ungrazed conditions. Patterns of change for other photo-attributes are similar to descriptions of photos paired to livestock exclosures (Figure 4).

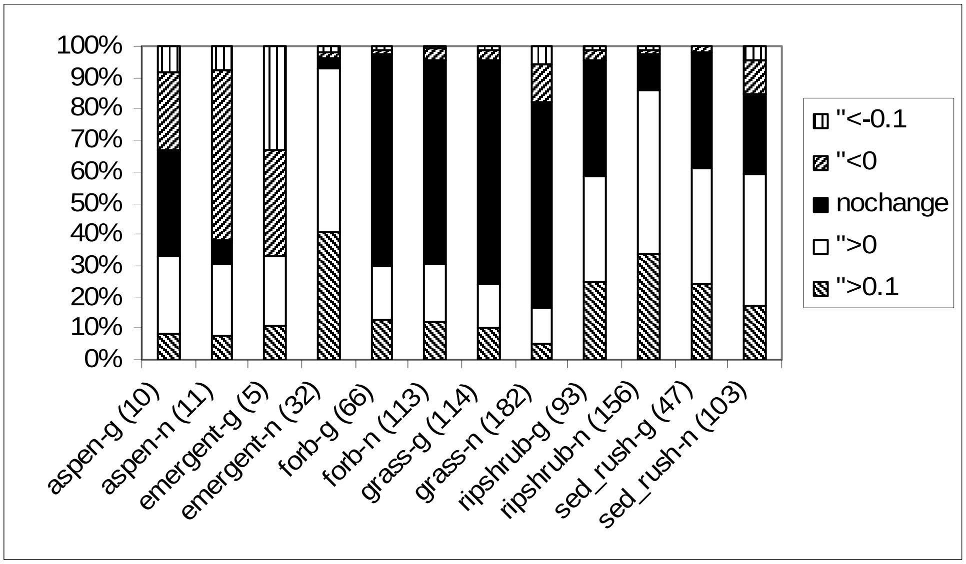

Figure 5. The count of vegetation abundance changes (new photo derived abundance class – old photo derived abundance class) within 5 magnitude classes for aspen, riparian shrubs, emergent plants, sedges and rushes, grasses, and forbs expressed as a percentage of all changes in repeat photos incorporating the CSNM. Number of photos in parentheses, grazed indicated by “g”, ungrazed indicated by “n”.

For photos taken within exclosures and paired sites, there were few increases in bare ground under grazed or ungrazed conditions, though there were a greater number of instances of decline in bare ground under ungrazed conditions than grazed areas (Figure 6). There were more instances of decline in cutbanks than increases under ungrazed conditions. While this pattern appears similar under grazed conditions, too few observations prevent a valid comparison. Both grazed and ungrazed conditions show a decline in woody debris, a result of time elapsed since the last flood, as well as recovering riparian vegetation covering debris.

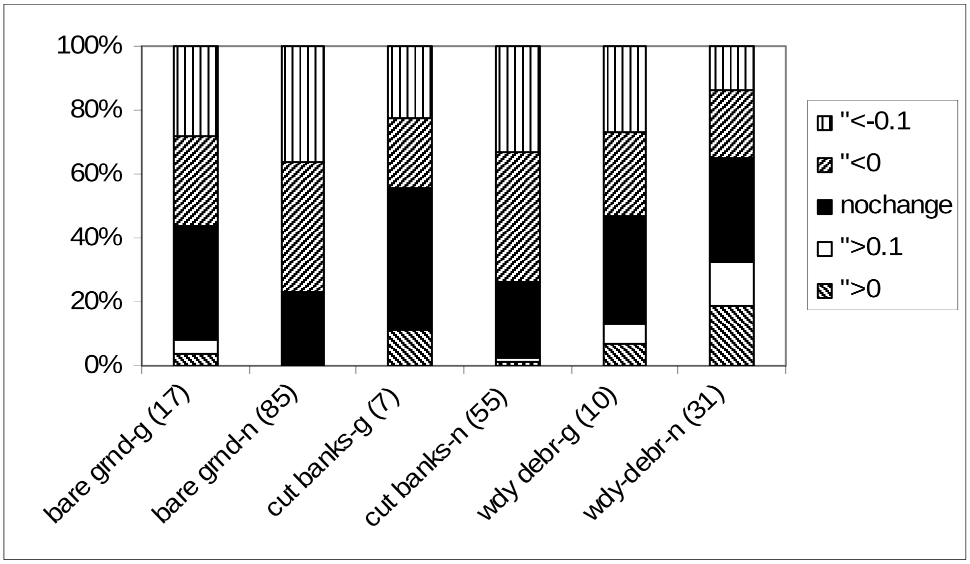

Figure 6. The count of ground and debris abundance changes (new photo derived abundance class – old photo derived abundance class) within 5 magnitude classes for bare ground, cutbanks, and woody debris expressed as a percentage of all changes in repeat photos within exclosures and paired areas outside exclosures. Number of photos in parentheses, grazed indicated by “g”, ungrazed indicated by “n”.

The pattern of declining bare ground under both grazed and ungrazed conditions remains true for all riparian photos (grazed and ungrazed) retaken across the landscape (Figure 7). While there were more instances of decline in cutbanks under both grazed and ungrazed conditions, more cutbanks remained static under grazed conditions (Figure 7). The abundance of woody debris remained little changed under grazed conditions, and showed an equitable number of increases and declines under ungrazed conditions.

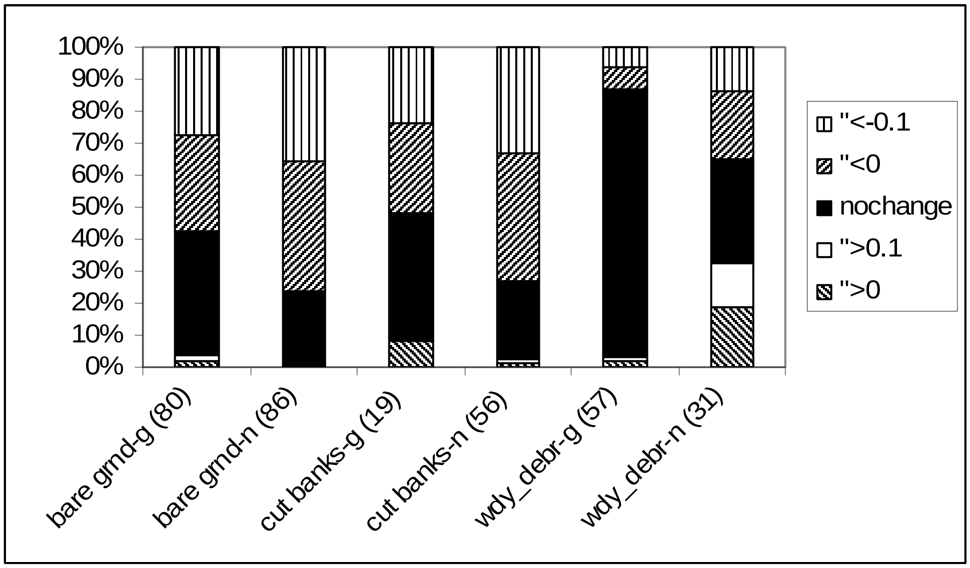

Figure 7. The count of ground and debris abundance changes (new photo derived abundance class – old photo derived abundance class) within 5 magnitude classes for bare ground, cutbanks, and woody debris expressed as a percentage of all changes in repeat photos within eorporating the CSNM. Number of photos in parentheses, grazed indicated by “g”, ungrazed indicated by “n”.

The background patterning of ordinations representing grazed and ungrazed site differences (Figure 8a and 8b) indicate that change under grazed conditions is encompassed within the change under ungrazed conditions. The magnitude of change is larger under ungrazed conditions. The largest vector of change in figure 8a (ordination axes 1 and 2) is that of yellow starthistle, almost at 180 degrees to annual grass and grass as a general vegetation class, suggesting a reciprocal relationship. Cutbanks and bare ground appear similarly related to vegetation defined as emergent, riparian shrub, forb, and sedges and rushes. The strongest relationship along Axis 3 (Figure 8b) is that of woody debris and weeds counteracted by riparian shrubs. Site inspection validated that weeds were missing, but that woody debris was often obscured by the new growth of riparian shrubs.

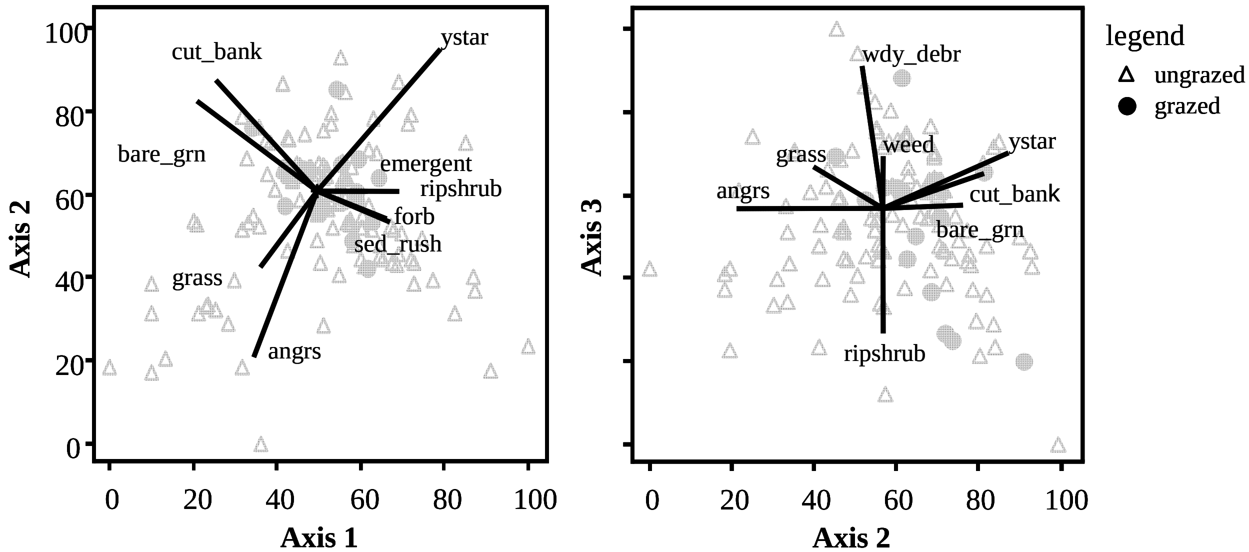

Figure 8a and 8b. Jointplot showing strength and direction of major axes of change for components of change estimated from repeat-photo pairs. Background ordination shows dispersion of grazed and ungrazed photo-retakes. Jointplot r^2 cutoff = 0.1, and vector scaling = 200%.

Observations from Individual Photo-pairs (see Hosten 2007b for photo-pairs)

Few photos of yellow starthistle were noted in riparian areas outside of the Box O, likely because the timing of photos with phenology allowing plant identification is serendipidous. Exceptions were the stockponds of the Agate Flat Pasture (photo-pairs 18 and 20). One photo-pair indicates that Canada thistle has expanded within riparian areas in the Keene Ridge area over the past 20 years.

Of 28 photo-pairs with yellow startistle on the Box O Ranch (Table 2), two photo-pairs show increases in thistle abundance, while 26 show declines in weed abundance (photo-pair 1). Most of the declines in thistle abundance are large (21) versus five smaller declines. The two sites with small declines in yellow starthistle (Table 2, millerh and southend) are in areas with shallow soils favoring the annual life-cycle. Other areas of yellow starthistle decline are associated with deeper soils (HQ and xsing), and within riparian areas (xsing, see photo-site 1). The decline in yellow starthistle at the shallower sites was observed to be variable from year to year and attributed to the development of a microphytic crust in the absence of livestock trampling. The partial replacement of yellow starthistle by annual grasses at several photosites is likely due to the ability of grasses to grow in the absence of season-long grazing.

Table 2. counts of yellow starthistle change in abundance classes for 7 photo-sites on the Box o ranch.

magnitude	HQ	MILLERH	NORTHEND	ROADSIDE	SLAPPYS	SOUTHEND	XSING
<0.1	2	1	0	4	2	4	8
<0	0	3	0	0	0	2	0
no change	13	6	13	9	23	9	8
>0	0	1	0	0	0	0	0
>0.1	0	1	0	0	0	0	0
Photos wth weeds	2	6	0	4	2	6	8
photo count	15	12	13	13	25	15	16

Observations of aspen are restricted to 10 photo-pairs falling within exclosures (Conde Creek and Dead Indian Creek exclosures), and 11 photo-pairs outside of exclosures. Additional aspen observations were made in the Moon Prairie exclosures without the benefit of photo pairs (photo-set 24). Many old photos of photo pairs show individual aspen with little vegetative regeneration (photo-pairs 7 and 4). Photo retakes frequently show a loss of canopy and decline in condition of the mature aspen (photo-pairs 7 and 4).   With one exception, all photo-pairs (inside and outside of exclosures) show substantial vegetative recruitment and denser stands in the repeat photo. The Moon Prairie exclosure (photo-set 24)shows vegetative root sprouts outside of the exclosure fence. The increase in stand density has occurred on grazed sites in historical high livestock use areas (Little Hyatt area, as well as areas currently under high use (Soda Mountain pairs). One mature aspen evident in the old photo of a photo pair in the Dead Indian Exclosure was felled by a beaver and died without vegetative regeneration. The major site within the Dead Indian Exclosure with mature aspen trees felled by beaver were in areas of water seepage and submergence as a consequence of beaver dam construction (photo-pair 7). Resprouts of aspen, willow, and white alder were all observed to be food sources for beaver.

Beaver activity was noted as several sites within and outside of livestock exclosures. Beaver activity outside of exclosures was restricted to riparian areas with alluvial soils occupied by willow dominated riparian thickets on wide valley bottoms.

The high water table of these sites appeared to be maintained by beaver dam construction, indicating a synergistic relation between beaver and extensive riparian thickets. Beaver activity within the Box O Ranch was in an area where riparian thickets are expanding beyond the cutbanks consequent to the 1974 floods (photo-pair 2). Flooding and felling by beaver were noted as reasons for conifer die-off within the Dead Indian Exclosure.

All exclosures show vegetation change over time. Paired sites usually showed similar dynamics, albeit of a lesser magnitude. Many of the Box O Ranch photo-pairs show large increases in riparian shrubs and herbaceous vegetation. The Jenny Creek Riparian Allotment shows a tremendous increase in riparian shrubs and sedges following fence construction (photo-pairs 11 and12). While the increase in willow at the paired riparian site was sometimes equal in magnitude (photo-pair 14), photo pairs indicate a more moderate development of riparian herbaceous vegetation in this high livestock use area (photo-pairs 13 and 15). The lower Hoxi Creek Exclosure showed an increase in willow and herbaceous vegetation (photo-pair 8). Increases at the paired site were more modest for both riparian shrubs and herbaceous vegetation (photo-pair 9). Several exclosures exhibiting increased riparian shrubs and/or herbaceous vegetation showed little expansion beyond pre-existing cutbanks (Hoxi Creek, Schoolhouse Meadow, most sites within the Dead Indian Exclosure, and most sites within the Box O Ranch). Several exclosures showed little or no increase in riparian shrubs (Rattlesnake, Deadhorse Spring, and Shoat Spring). Exclosures including stockponds (photo-pairs 18 and 19) showed a large increase in sedge/rush and, or riparian shrubs in comparison to unfenced stockponds (photo-pair 20).

The difficulty in pairing the Box O Ranch to other sites is a reminder of the intense management (creation of pastures, straightening of the river course and creation of berms, and season long grazing) experienced by the ranch. Similar ecological sites (alluvial meadows) are generally occupied by willow thickets and support beaver (photo-pair 3), negating their use as a control.

The different patterns of change within the exclosures is a measure of the complexity of the landscape in terms of substrate (alluvial soils versus boulders), slope, aspect, elevation, current season and intensity of livestock use, soil compaction, past history (consider the creation of pastures within the Box O), and the presence or absence of beaver.

Proper Functioning Condition (PFC) and Repetition Riparian Surveys

Examination of individual Habitat Diversity Index (HDI), and Observed Apparent Trend (OAT) repeatable survey variables reveal patterns of changed over time. Four of nine variables collected in the original surveys were retained. The excluded variables were considered too subjective to provide comparison over time. The variables examined include: HDI riparian zone width, HDI snags, OAT surface litter, and OAT pedestalling. The two surveys represented by these variables were not completed at all locations, so that OAT observations are restricted to three allotments/pastures, while HDI surveys span four allotments/pastures. The four variables examined all show more gains than declines across the allotment/pastures examined. Surface litter, pedestalling, and riparian zone width all relate to improved riparian habitat. The Keene Creek Pasture of the Soda Mountain Allotment shows the greatest number of declines in condition (loss of litter, presence of pedestalling, and decline of riparian width, indicating higher ungulate influence in ripararian areas than other allotment/pastures.

Snag production more represents plant community and logging activities surrounding riparian areas than influence by livestock. The Camp Creek Pasture of the Soda Mountain Allotment is dominated by droughty non-conifer communities sparsely populated by ponderosa pine and Douglas-fir. Recent drought has resulted in conifer die-back across the landscape, particularly in Camp Creek. Ongoing logging activities on private lands interspersed through other pastures has contributed to relatively lower snag production in conifer dominated allotment/pastures.

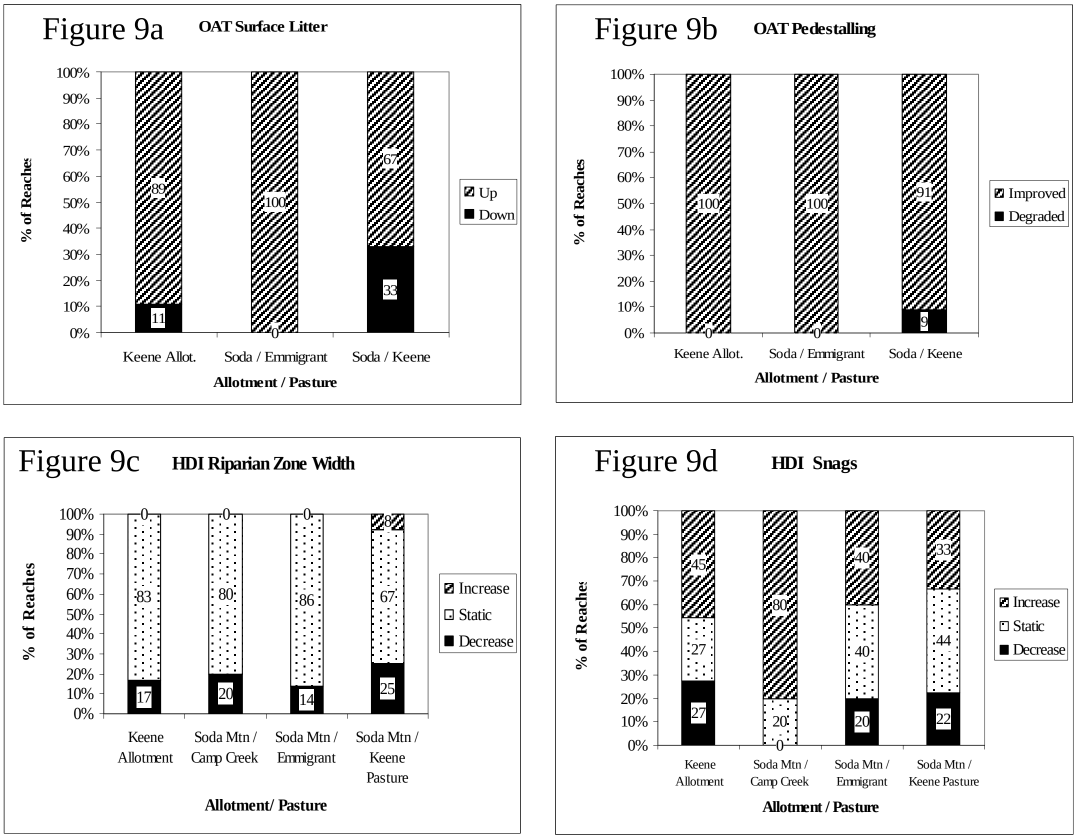

Figure 9. The percentage of transects showing gains or losses of surface litter, pedestalling, riparian zone width, and number of snags.

Change in six plant functional groups from the HDI surveys are shown in Figure 10. All the life forms examined, except hardwoods (Figure 10e), show more increases than declines [grasses (10a), forbs (10b), upright shrubs (10c), rushes and sedgets (10d)] across all allotment/pastures. Hardwoods show few increases in abundance, and most declines occur in Keene Allotment and Camp Creek Pasture of the Soda Mountain Allotment. Conifer abundance appears static across most Allotment/Pastures. Allotment/pasture wide dynamics of rushes and sedges are characterized by relatively few instances of no change and many instances of increases and declines in abundance within the same allotment/pasture. The largest decline in rushes and sedges occurred in the Camp Creek pasture of the Soda Mountain Allotment, an area experiencing relatively little use by livestock. Low use by livestock and large increase in upright shrubs within

Camp Creek (Figure 10c) suggest that riparian shrubs are displacing riparian dependent herbaceous vegetation. In more heavily grazed areas without large increases in shrubs, local declines in rushes and sedges may be due to recent disturbance, and increases in areas that have remained disturbance free for a few years.

In general, larger, longer-lived groups such as conifers remained mostly static, while smaller, rapidly growing plants like rushes, sedges, and forbs with short reproductive cycles showed the most increases and decreases. Across the CSNM as a whole, a majority of reaches surveyed showed an increase in rushes and sedges, while grasses, forbs, upright shrubs, hardwood trees, and conifers had a majority of reaches remaining static.

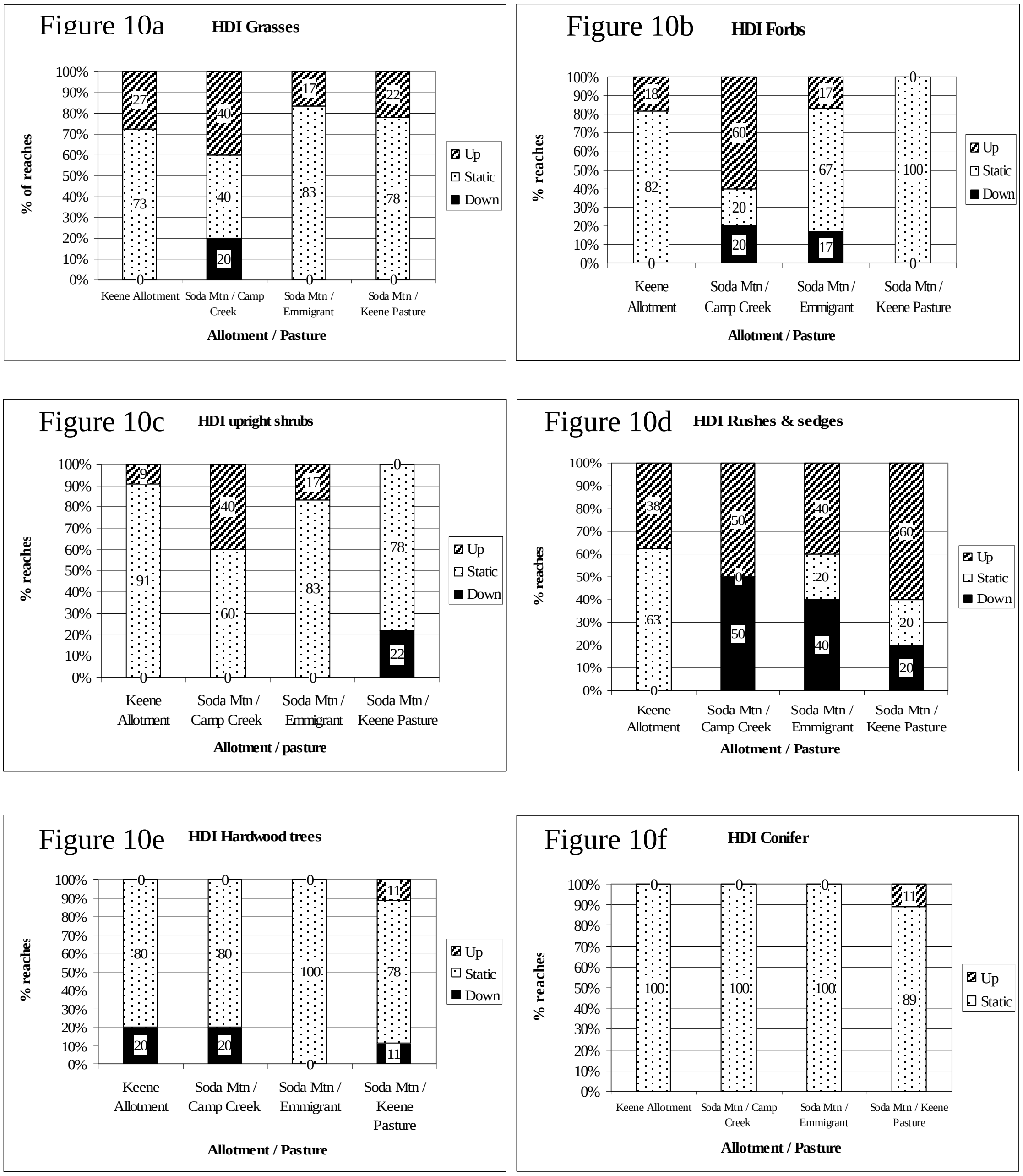

Figure 10. Percentages of stream reaches surveyed increasing, decreasing, or remaining static in abundance of life form since 1981-1982 surveys, by pasture.

Of the 39 stream segments associated with historic surveys, four sites did not merit a riparian assessment, and 27 were considered in proper functioning condition. Seven stream segments were considered not functioning. Three of the segments considered to be not functioning were on a downward trend (two in Keene Allotment, and one in the Emigrant Pasture of the Soda Mountain Allotment) , three on an upward trend (two in Emigrant Pasture, and one in Skookum Pasture of the Soda Mountain Allotment), while one did not have an apparent trend.

Soda Mtn. Keene Pasture also had the highest percentage of actively eroding banks (21%, Figure 11).

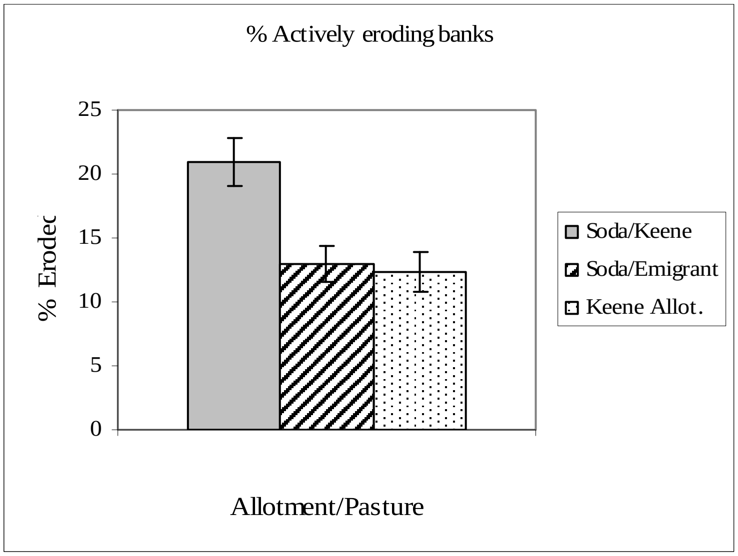

Figure 11. Percent stream reaches with actively eroding banks.

CONCLUSIONS

The repeat surveys, photos, and the literature are mutually supportive of observed changes in riparian vegetation composition, structure, and dynamics. Data from riparian areas identifies several patterns of change: bare ground colonized by herbaceous vegetation (grass or sedge); and the replacement of sedges by riparian shrubs. Paired sites outside of exclosures show similar vegetation dynamics, though of a lesser magnitude. Several photo-pairs in lotic systems indicate that the exclusion of livestock results in a more complex vegetation structure. Lack of change, or the loss of plant life-forms, within small lentic systems indicate livestock have a stronger localized influence at point sources of water. This is supported by the large changes in sedge and riparian shrubs associated with stockponds incorporated in livestock exclosures. Different vegetation dynamics are associated with rocky substrates versus those dominated by alluvial soils.

The increase of riparian shrubs within and outside of exclosures indicate that change in ecological processes such as fire (or the suppression thereof), recovery from past floods, or historic changes in livestock management (seasonality, and intensity) are eliciting changes in lotic riparian structure and composition. Areas not prone to damage from floods or fire (for example, the sag ponds identified as the Parsnip Lakes) show similar patterns of change, implicating more benign livestock management as playing a role in improved riparian condition across the landscape. The increase in aspen stand density both inside and outside exclosures, and close to livestock point water sources is further evidence that recent livestock management since the old photos were taken (15-25 years) has allowed improvement of riparian conditions.

Most observations of weeds are in high use areas within or adjacent to riparian areas, an observation supported by Hosten (2007). Livestock removal from the Box O Ranch allowed the recovery of riparian vegetation resulting in the loss of yellow starthistle.

By observation only, the inability of riparian vegetation to extend beyond cutbanks in exclosures without beaver activity may be indicative of long-lasting soil compaction. Girdling of conifer and hardwoods within riparian areas favors vegetative resprouters including willow, aspen, and white alder. The past history of trapping and observations of beaver activity within the monument area identify a key role for beaver in the restoration of riparian areas.

While conditions appear to be improving across the landscape, patterns of change following livestock exclusion, stream reaches not in proper functioning conditions, and areas with erosion indicate that areas of excessive livestock use still occur within the CSNM. This is supported by the observation of riparian shrub utilization at the end of the grazing season (Hosten et al. 2007b).

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