Correlation of Riparian Vegetation and Stream Attributes

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Riparian plant assemblages give clues of the conditions of the soil and other physical characteristics of their stream-side environment. The plight of the spring/summer, and fall Snake River chinook salmon has aroused interest in fish habitat and the effects of riparian plants on fish habitat. This study was launched to determine if riparian plant species assemblages could be used as an efficient assessor of fish habitat and the effects of land use on riparian areas and streams in the Payette National Forest in Central Idaho. Five plant communities are described. Stream attributes of streambank undercut width and streambank stability were different between communities, while fish habitat type and substrate particle size were not. Management implications for each plant community type were drawn from the current condition of the riparian area and stream attributes.

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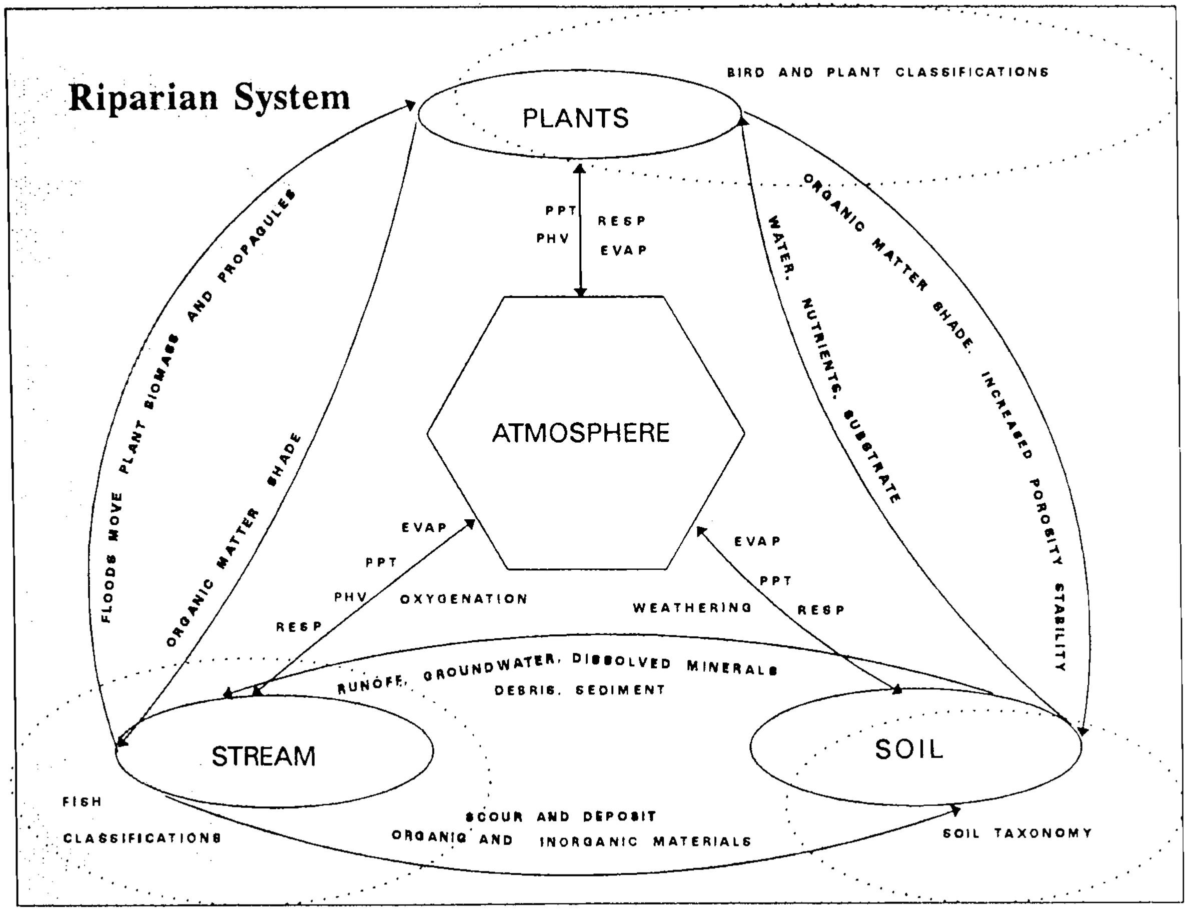
Correlation of Riparian Vegetation and Stream Attributes.

INTRODUCTION

IMPORTANCE OF RIPARIAN AREAS TO LAND MANAGERS

New, integrated methods of plant classification can serve as a foundation to inform managers of the conditions of all components of riparian areas and the consequences of land use on those components. The land/water interface of riparian areas is essential to many organisms and has usually been studied by examining only components with direct, obvious effects on a particular study organism (Figure 1). Long-term sustainable management for multiple resources will require the use of a single system for mapping and describing riparian areas (Sedell, 1989; Frissel et al. 1986). Developing these fundamental map units will require an integrated approach to ensure that each component is represented in the riparian classification (Swanson et al. 1988).

Plant species have tolerance for the environmental factors of the site they occupy (Larcher, 1983). Riparian plants respond to the soil, hydrology, nutrient, and disturbance conditions of riparian areas (Clifton, 1989; Bilby, 1988; Breen et al. 1988; Dawson, 1988; Elmore and Beschta, 1987; Harris, 1986). As a result, riparian plant assemblages are an integrated expression of all the environmental components of the sites where they reside. The same can be said of riparian soil types. Identification of plants, however, requires less invasive investigation than the excavation required for determination of soil type. Furthermore, plants provide



EVAP = EVAPORTATIO
PHV = PHOTOSYNTHESIS
PPT = PRECIPITATION
RESP = RESPIRATION

Figure 1. Riparian systems are comprised of interdependant functions. An elipse of dashed lines shows how studies usually focus on only a portion of a riparian system because they are centered around one function.

habitat for birds, mammals, insects and amphibians (Sedgwick and Knopf, 1992; Bury, 1988; Cross, 1988; Knight, 1988; Raedeke et al. 1988; Erman, 1984; Anderson, 1977). Thus, a very reasonable approach to mapping riparian areas for management in terms all disciplines can use, starts with classifying plant assemblages.

Several riparian plant community classification systems have been described in many areas (Padgett et al. 1989; Kovalchik, 1987; Youngblood et al. 1985; Mutz and Queiroz, 1983; Tuhy and Jensen, 1982). Most riparian classifications include only those plant assemblages that require a high water table (Swanson et al. 1988). Many classifications have included useful information on basal area of harvestable trees and amount of forage for grazing ungulates (Padgett et al. 1989; Kovalchik, 1987; Youngblood et al. 1985). These studies substantiate the idea that plants are indeed integrators of the many physical conditions that create riparian environments by showing that different communities occupy sites with different water table levels, soil types, and slopes (Padgett et al. 1989; Kovalchik, 1987; Youngblood et al. 1985; Mutz and Queiroz, 1983; Tuhy and Jensen, 1982).

Riparian vegetative information alone, however, is not enough for a land manager to make decisions that will ensure maintenance of water quality in streams adjacent to the riparian area, and the preservation of wetlands as required by the Clean Water Act 1972 (CWA), or preservation of species as required by the Endangered Species Act 1973 (ESA) (Gregory et al. 1991; Lotspeich and Platts, 1982).

Riparian areas with no plants on the Federal Register of Threatened, Endangered and Sensitive Species list are primarily of interest to managers not for their plants species, but for what the riparian area and plants provide to wildlife species dependant on them, and provide to the stream and the species within the stream. For example, plants adjacent to streams create shade that maintain cool water temperatures (Beschta and Taylor, 1988). Plant roots stabilize stream banks and create conditions that allow the formation of undercut, overhanging stream banks (Elmore and Beschta, 1987; Elmore, 1989). In addition, their roots filter nutrients from ground water (Peterjohn and Correll, 1984). Stable stream banks with undercuts provide cool, hidden places of refuge for fish at many stages of their life history (Sedell et al. 1982). Trees and shrubs provide the large wood that falls into streams that becomes structures fish seem to seek (McMahon and Hartman, 1989; Dolloff, 1986; Angermeier and Karr, 1984; Sedell et al. 1982). Riparian plants can relate directly to ESA when a fish species or other aquatic organism is listed on the Federal Register of Threatened, Endangered and Sensitive Species. Similarly, shading and nutrient filtering are always an issue in compliance with temperature and nutrient limits of the CWA.

A riparian vegetation classification system that does not provide explicit information on the status of streams in terms of the guidelines of the ESA and CWA loses potential usefulness to decision makers (Kovalchik and Chitwood, 1990; Lotspeich and Platts, 1982). Furthermore, a riparian plant classification that limits itself to species that are mainly restricted to hydric soils ignores that streams are functionally affected by any plant assemblage that is shading, stabilizing banks, filtering nutrients, and providing structure and organic matter whether or not the assemblage always occupies sites with high water tables (Leonard et al. 1992; Gregory et al. 1991).

Thus, the aim of this study was to use the concept of plants as integrators, and report correlations between riparian plant assemblages and selected stream attributes that are important to land managers, i.e. those stated in the CWA or alluded to in the description of critical habitat in the ESA. This study was not an attempt to unravel successional stages of plant communities. [1] Plant community types were delineated, correlations with physical attributes of interest to managers were examined. The resulting classification system can aid in the design of studies of other riparian organisms.

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[1] The use of the phrase "plant community" throughout this paper is not an endorsement of the idea of plant communities. This paper follows the USFS convention for naming plant associations by their dominant tree and shrub species and calling them "plant communities".

METHODS

Methods were, in part, adapted from the United States Forest Service methods for delineating riparian plant community types as described in Platts et al. (1987). The methods applied in this study were slightly different because the objectives were not solely confined to describing riparian plant communities. The Snake River Spring/Summer and Fall chinook salmon were listed on the Federal Register as threatened species in May 1992. Many streams that produce, or have historically produced, these fishes run through the Payette National Forest. Forest decision-makers are looking for efficient methods of assessing the condition of fish habitat. This methodology was developed to see if fish habitat units, i.e. pools and riffles, the condition of the units, i.e. streambank stability, and substrate particle, size could be predicted by adjacent riparian vegetation. Because this was the first attempt to test these hyphotheses on the Payette National Forest, I tried to eliminate the role of perturbations caused by human activity. Tree-harvest or road building can increase peak-flows and decrease particle size of stream substrate, or otherwise disrupt the relationship between riparian areas and streams.

Site Selection

Boulder Creek was selected because it is known to support threatened spring/summer chinook salmon and was without previous work in riparian vegetation typing. There were no large scale tree harvests above the highest road crossing in the Boulder Creek Basin. Individual trees may have been removed by pioneers and floated down the river, which may have altered the streambanks. The reaches of Boulder Creek that I walked did not have stumps as evidence of such activity in riparian areas. There have been no large wild fires in the basin in recent history. In the early part of this century, the basin supported many sheep herds, but the number has been reduced to two since the 1970's. The herds may have created areas of unstable banks or changed the species assemblage of an area (Schulz and Leininger, 1990; Kauffman et al. 1983; Szaro and Pase, 1983). Hopefully, enough time has elapsed for Boulder Creek to have reestablished a relationship with its riparian area that may have been altered by grazing or tree removal.

The studied reaches of Boulder Creek are in Adams County, Idaho, T21N, R1W, sec 32, and T20N, R1W, sec 5, 8, and T21N, R1E sec 7, 18. In these reaches, the highest average annual stream-flow, or bank-full, dimensions of Boulder Creek range from eight feet wide and one foot deep to thirty feet wide and one to three feet deep at the lower end. Geology of the basin includes Idaho Batholith granitics and basalts (Thompson et al. 1973). Upslope soils are fine sandy to gravelly loams from ten to sixty inches deep (Thompson et al. 1973). However, the riparian soils have not been described. The climate is continental; only 8% of yearly precipitation falls from July through September, with nearly 90% of yearly precipitation delivered as snow (Thompson et al. 1973).

Boulder Creek has a diversion called Yantis Ditch at 5320 ft elevation. The area of the watershed above the diversion is 6.5 square miles and has an average peak plow of 153 cubic feet/second (Thompson et al. 1973). The diversion removes as much as one-third of the flow during low flow periods. Every effort was made to work above Yantis Ditch to insure that the study areas were exposed to the approximate natural hydrograph.

Above Yantis Ditch and the highest road crossing on Boulder Creek, the grazing plan indicated that there was no domestic grazing in riparian areas of Boulder Creek itself. Boulder Creek is in a sheep allotment. The designated path of the herd was near the ridges, meaning sheep should have crossed only tributary riparian areas, far from their confluence with Boulder Creek.

The first tributary entering Boulder Creek from the west at about 5800 ft elevation and upstream from the highest road crossing was used as the start. Michael Radko, a fisheries researcher from the Boise Intermountain Station Forest Sciences Laboratory, and I settled on the place because it would be easy to pinpoint with the GIS system, and in the field. The plan was to follow the left bank up about a mile, to the highest western tributary, at 6360 ft elevation, then follow it back down the right bank. Fifty plots were completed on the left streambank before the plan was halted by the descent of the sheep herd into the riparian area; they had grazed from the headwaters to about 5800 ft elevation on the stream. After the unauthorized grazing, data collection in this length of stream was abandoned because visual estimation of the percent cover of each species was virtually impossible due to the removal of the foliage and flowers in much of the riparian area.

Forty-four plots were completed in an alternative transect near the junction of Pollack and Boulder at 4500 ft elevation. This area was selected because it was far from roads and trails to minimize the effects of human access. There was no grazing permitted there, and no evidence of unpermitted grazing in the area. It was downstream of Yantis Ditch, however, and did not have the same influence on its hydrograph as the first transect.

Plots

Plots were not subjectively placed in preconceived homogeneous community types. Starting at the tributary, the first plot extended thirty feet upstream. The second plot started sixty feet from the end of the first. Sixty feet of stream length separated all subsequent plots. The position of a plot was not changed to centralize it in what may be perceived as a homogeneous community. With "*p*"s representing the length of a plot, and "." space between plots, the configuration would look something like this along a straight river.

ppppp............*ppppp*............*ppppp*............*ppppp*...

The shape of the plot was never changed to accommodate, so called, stringer communities of hydrophilic plants, because all plants adjacent to the stream are affecting and affected by the stream, and help to describe stream-side sites. One 30 ft boundary of each plot ran along the water's edge. The 15 feet boundaries were situated perpendicular to the stream.

Vegetative Attributes

The name and percent cover of each species present was occularly estimated and recorded. Species were identified according to Hitchcock and Cronquist (1973). A tree or shrub with branches overhanging the plot was included in the plot regardless of whether or not it was rooted within the plot.

Terrestrial Attributes

Soil classification was not attempted due to lack of time and technical expertise. In an effort to make a gross classification of soil differences, the percent of the surface occupied by rock, litter, wood, and bare soil were recorded to describe the site. The aspect of the plot and percent-slope perpendicular to the stream were identified.

Leaning trees are often associated with soil instability due to earthflows or slumps (Waring and Schlesinger, 1985). The percent of leaning trees within each plot was recorded to approximate areas of soil movement. Trees may also lean in the direction of high winds and floods. Phototropism may also cause trees to lean towards open areas, such as a stream channel. Riparian areas of Boulder Creek are generally not in closed canopy conditions, and the trees are shade tolerant. Therefore, the role of phototropism is small in Boulder Creek.

Stream Attributes

Stream attributes estimated were: dominant particle size, percent stable bank, presence of pool or riffle as described by (Platts et al. 1987). Stream gradient and minimum and maximum undercut widths were measured (Platts et al. 1987). Streambank stability was estimated ocularly by trained USFS technicians. The streambank from water's edge to bank-full was examined for evidence of recent erosion or threat of erosion in the near future, such as cracks in the surface of the soil. Percent stable streambank was calculated by:

100 * (30 ft - length displaying instability) / 30 ft

RESULTS AND DISCUSSION

DATA ANALYSIS

Vegetative data were grouped by reciprocal averaging analysis using Twinspan software (Hill, 1979). The data set from the 94 plots contained 162 plant species, many of which occurred in some plots, and other species that occurred only in a different set of plots. Clustering algorithms require more replicates than variables (more plots than species) and are confounded by singularities which result from data matrices with large numbers of zeros. Reciprocal averaging does not have these limitations, and was selected for defining communities from the vegetative data.

The data were run through three iterations of dichotomous splitting, creating $2^3 = 8$ groups. The eight groups are indicated by the lowercase (a-h) letters in Appendix A and Table 1. The 8 groups were inspected for differences in species composition and abundance. Twinspan groups (a and b), (c and d), and (e and f) were indistinguishable vegetatively and were lumped together to form a new set of five vegetatively distinct groups, shown in Appendix A and Table 2 by capital letters (A-E).

The eight Twinspan sample groups were also tested for differences in all measured physical attributes using Statistical Analysis Systems (SAS) procedure General Linear Model (proc GLM) and mean comparison using Fisher's protected Least Significant Difference (Table 1). The same procedures were used on the five groups (Table 2). Comparison of Tables 1 and 2 indicates that the five groups show as much difference in physical attributes as

Table 1. Physical differences in eight Twinspan groups.

alpha = .05

GROUPS	a	b	c	d	e	f	g	h
a								
b	B							
c	B,U							
d	L,S	L,	L,S					
e	B,I,W	I,W	I,W	L,I,W				
f	B,C,I,W	B,C,L,I,W	B,C,R,U,I,W	B,C,S,U,I,W	L			
g	B,C,L,R,I,W	B,C,L,R,I,W	B,C,L,R,I,W	B,C,L,R,I,W	L	L		
h	B,L,R,I	L,R,I	L,R,I	L,R,I	L,R	L,R,I	R	

Table 2. Physical differences in five, vegetatively distinct groups.

alpha = .05

GROUPS	A	B	C	D	E
A					
B	U				
C	B,C,L,I,W	B,C,U,I,W			
D	B,C,L,R,I,W	B,C,L,R,I,W	L		
E	B,L,R,I	L,R,I	L,R,I	R	

Symbol = difference in ________ using Fisher's protected LSD alpha = .05.

C = Constrained channel
B = Bank Stability
U = Undercut maximum width
R = Surface Rock
S = Surface Soil
L = Slope of the plot
I = Litter
W = Wood
grey box indicates self comparison

Note: Group numbers in Table 3 correspond to community types named later.
A = Subalpine fir. Engelmann spruce/ mixed shrub/ mixed forb.
B = Subalpine fir, Engelmann spruce/ hucklberry.
C = Engelmann spruce/ Pachistima.
D = Grand fir, Engelmann spruce/ service berry.
E = Douglas-fir, Ponderosa pine/ Pachistima.

eight, because there were no difference in means in the (a-d) and the (f-h) groups in Table 1 in many of the variables. Because the number of t-tests performed is greatly decreased when comparing only five groups, as indicated by the reduced number of cells in Table 2, the likelihood of committing a type I error is also greatly decreased.

Thus, the eight Twinspan groups were lumped to five sample groups because: the five groups have distinct vegetative characteristics. The five groups display the same amount of physical differences as the eight groups in a much simpler structure. Table 3 displays values of the measured physical attributes of the five community types. Pool, riffle and dominant substrate size were not different across community types.

It is apparent from Table 3 that there are differences in the conditions of the streambank between the upper, grazed community types, and the lower, ungrazed community types. I wanted to see if the physical differences between the types were associated with the differences in the streambank conditions.

Giant Sized Regressions (GSR) were constructed in SAS as a way to detect relationships between bank stability and physical characteristics of the plots, and between undercut maximum widths and physical characteristics (Stafford and Sabin, 1992). The two community types confined to the upper, grazed reach of Boulder Creek, **Subalpine fir, Engelmann spruce/ mixed shrub/ mixed forb and Subalpine fir, Engelmann spruce/ globe huckleberry type,** were lumped into the grazed group. The other three community types, **Engelmann spruce/ Pachistima, and Grand**

Table 3 Physical attributes of community types.

A Subalpine fir, engelmann spruce/ mixed shrub/ forb

Attribute	Minimum	Maximum	Mean	Std Dev
BANKST	0.0	100.0	59.0	36.3
SLOPE	8.0	43.0	17.3	9.1
SOIL	0.0	8.0	1.3	1.9
LITTER	75.0	95.0	87.0	5.6
LNTREE	0.0	25.0	3.1	7.8
UCMAX	0.0	2.0	0.5	0.6
ROCK	0.0	8.0	3.3	2.5
WOOD	1.0	10.0	5.3	2.7
ELEV	5880.0	6360.0	6056.0	90.3
POOL	0.0	1.0	0.1	0.4

B Subalpine fir, Engelmann spruce/ globe huckleberry

Attribute	Minimum	Maximum	Mean	Std Dev
BANKST	2.0	100.0	71.0	30.0
SLOPE	2.0	72.0	27.1	17.4
SOIL	0.0	12.0	1.6	2.7
LITTER	8.2	95.0	80.2	15.6
LNTREE	0.0	44.0	6.4	11.8
UCMAX	0.0	3.1	0.9	0.8
ROCK	0.0	16.0	3.1	3.7
WOOD	2.0	25.0	8.2	5.3
ELEV	5880.0	6040.0	5957.2	58.5
POOL	0.0	1.0	0.4	0.5

C Engelmann spruce/ Pachistima

Attribute	Minimum	Maximum	Mean	Std Dev
BANKST	50.0	100.0	97.6	9.6
SLOPE	1.0	78.0	29.4	21.5
SOIL	0.0	5.0	0.8	1.6
LITTER	30.0	90.0	53.4	22.0
LNTREE	0.0	37.0	3.8	10.2
UCMAX	0.0	3.0	0.3	0.6
ROCK	0.0	25.0	7.0	6.7
WOOD	5.0	40.0	23.3	12.5
ELEV	4320.0	4445.0	4390.4	34.3
POOL	0.0	1.0	0.1	0.3

D Grand fir, Engelmann spruce/ service berry

Attribute	Minimum	Maximum	Mean	Std Dev
BANKST	40.0	100.0	94.2	17.3
SLOPE	33.0	124.0	66.7	28.5
SOIL	0.0	5.0	1.1	2.0
LITTER	30.0	85.0	51.7	21.1
LNTREE	0.0	40.0	5.8	13.8
UCMAX	0.0	2.0	0.7	0.8
ROCK	1.0	30.0	11.3	9.0
WOOD	2.0	30.0	18.1	11.1
ELEV	4335.0	5880.0	4526.3	427.8
POOL	0.0	1.0	0.3	0.5

Table 3 Continued from previous page

E Douglas-fir, Ponderosa pine/ Pachistima

Attribute	Minimum	Maximum	Mean	Std Dev
BANKST	100.0	100.0	100.0	0.0
SLOPE	57.0	115.0	86.0	41.0
SOIL	0.0	0.0	0.0	0.0
LITTER	2.0	50.0	26.0	33.9
LNTREE	0.0	2.0	1.0	1.4
UCMAX	0.0	0.0	0.0	0.0
ROCK	15.0	91.0	53.0	53.7
WOOD	2.0	30.0	16.0	19.8
ELEV	4385.0	4410.0	4397.5	17.7
POOL	0.0	1.0	0.5	0.7

BANKST = streambank stability
SLOPE = slope of plot
SOIL = percent of plot surface of bare soil
LITTER = percent of plot surface of litter
LNTREE = percent of trees in plot leaning
UCMAX = width of maximum undercut
ROCK = percent of plot surface of rock
WOOD = percent o plot surface of wood
ELEV = elevation of the plot
POOL = 1 if present 0 if not

fir, Engelmann spruce/ service berry, and Douglas-fir, Ponderosa pine/ Pachistima were lumped into the ungrazed group (Table 4). Inspection of scatterplots did not indicate the need for transformations of the data. The full regression of the GSR fitted separate terms for grazed and ungrazed community types as well as separate terms for the independent variables within each community type. Example:

$$\text{Bank stability} = B_{11}\ (\text{Grazed}) + B_{12}\ \text{Rock (Grazed plots)} + B_{21}\ (\text{Ungrazed}) + B_{22}\ \text{Rock (Ungrazed plots)}$$

The full regression model fits two regression lines, i.e. an intercept and slope for both grazed and ungrazed, and uses the degrees of freedom from the entire data to make statistical tests more powerful. The reduced regression model of the GSR includes the independent variable once, fitting one slope.
Example:

$$\text{Bank stability} = B_{11}\ (\text{Grazed}) + B_{21}\ (\text{Ungrazed}) + B_{2}\ (\text{Rock})$$

This allows us to compute the F statistic (H_o: $B_{12} = B_{22} = B_2$) to test the need for two, condition specific slopes. The reduced regression indicates the importance of the Rock in the example independent of the condition (grazed or ungrazed). If the F is significant, then the full regression equation retains the condition-specific slopes, which estimate the importance of the independent variable within the two conditions (grazed and ungrazed).

As indicated by Table 4, only two of the sixty lines formed by twenty GSR had significant slopes (alpha = 60.05). They were:

Bank stability = B_{11} (Grazed) + B_{12} Rock (Grazed plots)

and

Bank stability = B_{11} (Grazed) + B_{12} Slope*Rock (Grazed plots).

An F-test, of H_o: $B_{12} = B_{22} = B_2$ performed on both of these individual lines from the two GSR showed that at least one slope was different from another

$p\ (F > F) < .01$, and 0.05 respectively.

The fact that no lines were significant for the entire group, or for the ungrazed portion suggests that no combination of measured physical characteristics is linearly associated with unstable streambanks in undisturbed streams. If an area is grazed, one would expect that factors that discourage livestock entry such as steep slopes, or negate the effects of trampling, such as rock armoring would be associated with areas of greater stability. The two regression equations with significant negative slopes, however, suggest that the presence of rock is associated with areas of instability. Three possible explanations follow.

This may be explained by the low range of the percent rock in the grazed areas, 0% to 16%, mean = 3.2% In the grazed area, that leaves .84% of the stream unarmored in the plots with the largest amount of rock. Perhaps, then, the presence of rock is so low that there is no armoring effect, and the negative slopes are an artifact of the small range and relatively small data set.

Table 4. Giant Sized Regressions.

BANKSTABILITY vs independent variable

	REDUCED MODEL		FULL MODEL			
	COMBINED		GRAZED		UNGRAZED	
independent	slope	p (slope = 0)	slope	p (slope = 0)	slope	p (slope = 0)
slope	-0.066	0.557	-0.319	0.187	0.004	0.973
rock	-0.076	0.76	-3.3	0.003	0.1	0.6925
lntree	-0.267	0.28	-0.192	0.585	-0.34	0.33
slope*lntree	-0.007	0.241	-0.004	0.788	-0.007	0.25
slope*rock	-2E-4	0.96	-0.041	0.048	0.002	0.7096
rock*lntree	-0.01	0.736	-0.172	0.134	0.002	0.94
soil	-0.343	0.788	-0.279	0.856	-0.486	0.833
litter	-0.174	0.233	-0.089	0.754	-0.205	0.231
slope*soil	0.01	0.686	0.034	0.38	-0.007	0.836
slope*litter	-0.002	0.148	-0.004	0.157	-0.002	0.483

UNDERCUT MAXIMUM vs independent variable

	REDUCED MODEL		FULL MODEL			
	COMBINED		GRAZED		UNGRAZED	
independent	slope	p (slope = 0)	slope	p (slope = 0)	slope	p (slope = 0)
slope	-0.001	0.65	-0.002	0.75	-0.001	0.733
rock	-0.007	0.363	-0.02	0.535	-0.006	0.433
lntree	0.004	0.566	0.002	0.847	0.006	0.541
slope*lntree	1E-4	0.486	2E-4	0.713	1E-4	0.55
slope*rock	-1E-4	0.207	-5E-4	0.411	-1E-4	0.266
rock*lntree	6E-4	0.592	0.002	0.516	-7E-4	0.46
soil	0.055	0.12	0.046	0.281	0.075	0.238
litter	-4E-5	0.991	0.012	0.126	0.004	0.362
slope*soil	8E-4	0.212	3E-4	0.746	0.001	0.179
slope*litter	-1E-5	0.818	-4E-5	0.631	7E-6	0.919

REDUCED MODEL = B11 (GRAZED) + B21 (UNGRAZED) + B2 ROCK
FULL MODEL = B11 (GRAZED) + B12 ROCK (GRAZED PLOTS) + B21 (UNGRAZED) + B22 ROCK (UNGRAZED)

slope = percent slope of plot perpendicular to the stream
rock = percent of plot surface occupied by rock
lntree = percent of trees in plot leaning
slope*lntree = slope*percent leaning trees
rock*lntree = percent rock * precent leaning trees
soil = percent of plot surface occupied by bare soil
litter = percent of plot surface occupied by litter
slope*litter = percent slope * litter
slope*soil = percent slope * percent soil

Shading indicates slope significantly different than zero, alpha = 0.05.
COMBINED = all data, GRAZED = data from grazed areas, UNGRAZED = data from ungrazed area

The following hypothesis may be another possible reason for the negative slopes. The parent material of the soils in these community types is basalt, which weathers to fine clays and silts. Most of the rocks in these areas were cobble sized (less than one foot diameter). These soils are stabilized by plant roots, which cannot penetrate rocks. Rocks in these soils, then, are supported by fine particles and networks of roots around, but not through them. The weight of an animal applied to a rock in such a situation, may cause more soil movement than weight applied to soil without rock inclusions because there are fewer roots per volume in an area with rocks than in an area without rocks.

A final explanation for the negative slope requires scrutiny of the entire GSR analysis. The slopes of sixty lines were tested independently using Student's t-test at the alpha = 0.05 level. At the alpha = 0.05 level, for every twenty tests performed one test may be expected to show false significance, type-I error. Thus, we may expect three of sixty tests to indicate that the slope was not equal to zero, though it truly was equal to zero. The two slopes that appear different than zero in this analysis may be due to type-I error.

Physical attributes may exist which were not measured and that are highly correlated with unstable streambanks. Barring the existence of such important characteristics as yet undiscovered, I would speculate that all sites in the absence of perturbation can support nearly 100 % stable streambanks. I would further speculate that the large range of stability in the grazed reaches, **Subalpine fir, Engelmann spruce/ mixed shrub,** and **Subalpine fir, Engelmann spruce/ globe huckleberry,** (Table 3) are related to varying degrees of grazing disturbance among the plots in those community types. Because the entire length of the grazed communities was above Yantis Ditch, and therefore exposed to the same hydrograph, the disturbance is probably not related to differences in flow, but instead related to the occasional invasion of domestic sheep herds and wild herds of deer and elk. This assumption is strengthened by fish habitat data collected by Michael Radko and a team from the USFS Intermountain Research Station Boise Forestry Sciences Laboratory.

Rapid River is designated as Wild by the USFS and is the next drainage to the northwest of Boulder Creek and the two share similar geology. Radko's data from a reach of Rapid River with similar gradient and elevation, but no riparian grazing was compared to Radko's data from Boulder Creek where my first, transect was located (Myers, 1993; Radko, 1992). A one-tailed Student's t-test for data sets with unequal variances showed that the reaches of Boulder Creek described above have less stable streambanks (8%, $p = 0.00005$) than the similar, nearby, ungrazed reaches of the designated Wild River area of Rapid River.

The data from my study were to be overlaid by fish habitat data (based on Hankin and Reeves, 1988) collected by the USFS Boise Forestry Sciences Laboratory team that used Global Position System (GPS) Locators. The team described the stream in terms of fish habitat, such as habitat unit classification and lengths, width and depth measurements, temperature, estimates of percent fines, and gradient. The entire length of Boulder Creek was classified in habitat units of varying length and mapped. This continuous description was to be used to check for spatial relationships between vegetation and fish habitat conditions not detectable with plot data. Such analysis was confounded by different methods of measuring stream distance used by the two teams; I used a fiberglass tape, while the fish bilogists used GPS locators.

In later studies this can be easily remedied. Because all of the fish habitat units are stored in GPS files, all that remains to be done is to walk the stream and enter the beginning and end of the vegetative communities along the bank in the GPS locator memory. The data can be used to generate maps showing both vegetative and fish habitat unit boundaries. The maps and stream distances can be used to check for spatial relationships between vegetation and stream conditions.

Description of Riparian Community types of Boulder Creek

The key to the five vegetative groups appears in Figure 2. The key can be used to determine the community type of an area based on a series of questions asked about the plants present in the area. Community types were named using the dominant tree/ dominant shrub format (Platts et al. 1987). A Table of the mean frequency and mean canopy cover for each species in each commmunity type is listed in Appendix B.

Figure 2. Key to Riparian Community Types of Boulder Creek between 4000 and 6500 feet elevation.

1a. Pachistima (mountain-lover) and/or Red-osier dogwood present..2
1b. Pachistima and Red-osier dogwood not present......4

2a. Queencup beadlily (Clintonia uniflora) and/or Foam flower (Tiarella trifoliata) present.....**Engelmann spruce/Pachistima community type,** *C* below.
2b. Neither Queencup beadlily nor Foam flower present 3

3a. Percent cover of surface rock at least 15, slopes at least 55 percent, sego lily (Calochortus buckwheat (Eriogonum sp.) present....**Douglas-fir, Ponderosa pine/ Pachistima community type,** *E* below.
3b. Species not as in 3a, licorice root (Ligusticum canbyii) and/or lady fern (Athyrium filix-femina) present....**Grand fir, Engelmann spruce/ service berry community type,** *D* below.

4a. Huckleberry present....**Subalpine fir, Engelmann spruce/globe huckleberry community type,** *B* below.
4b. Huckleberry not present...**Subalpine fir, Engelmann spruce/ mixed shrub/forb community type,** *A* below.

A. Subalpine fir, Engelmann spruce/ mixed shrub/forb community type.

Trees - Subalpine fir, Engelmann spruce.

Shrubs - twinberry (Lonicera involucrata), prickly current (Ribes lacustre), less common were whortleberry (Vaccinium scoparium), fool's hucklberry (Menziesia ferruginea). Note the absence of huckleberry.

Graminoids - no species common in large amounts, Carex nebraskensis, smooth brome (Bromus vulgaris), red-top (Agrostis alba) and others present in small amounts.

Forbs - many common in varying amounts, including but not restricted to: little pyrola (Pyrola secunda), grass of parnassus (Parnassia fimbriata), Lewis's mimulus (Mimulus lewisii), false bugbane (Trautvettaria caroliniensis), Jeffrey's shooting star (Dodecatheon jeffreyi), Monkshood (Aconitum columbainum), Licorice root (Ligusticum canbyi), arrow-leaf groundsel (Senecio triangularis), Jacob's ladder (Polemonium pulcherrimum); little willow-herb (Epilobium glandulosum), brook saxifrage (Saxifraga arguta), pyrola (Pyrola uniflora and Pyrola minor) and meadowrue (Thalictrum venulosum), musk-flowered monkeyflower (Mimulus moschatus) Case's corydalis (Corydalis caseana).

Trees - up to 70 percent. Mean 20 percent.
Shrubs - up to 42 percent. Mean 18 percent.
Graminoids - up to 15 percent. Mean 5 percent.
Forbs - between 10 and 100 percent. Mean 54 percent.
Ferns, Mosses and Liverworts - mostly mosses and liverworts up to 13 percent cover. Mean 4 percent.

Physical attributes:
Elevation - 5500 - 6500 feet.
Slope - between 5 and 45 percent. Mean 17 percent.
Bare soil - less than 10 percent bare soil.
Rock - less than 10 percent rock cover.
Litter - at least 75 percent litter cover.
Bank stability - ranged from 0 to 100 percent of the length stable. Mean of 59 percent.
Undercut width - ranged from 0 to 2 feet. Mean .5 feet.

Management implications:

Many of the plots of this community type had 100 percent stable banks (Table 3). Plots of this community type with very low percent stable banks were often associated with animal trails near the stream (personal observation). Within this community there were no significant correlations between any measured physical attribute and streambank stability, or undercut width. That suggests that no combination of measured physical characteristics is associated with unstable streambanks. I believe the sites that support this community type, in the absence of perturbation, can support nearly 100% stable banks. The maximum undercut width of 3.1 feet indicates that this area has high potential in the absence of perturbations that accelerate erosion of forming undercuts that provide habitat for fish (Sedell, 1989). The data suggest that sites with this community type are susceptible to damage by sheep herds.

B. Subalpine fir, Engelmann spruce/ globe huckleberry community type.

Trees - Subalpine fir, Engelmann spruce.

Shrubs - huckleberry (Vaccinium globulare), twinberry (Lonicera involucrata), prickly current (Ribes lacustre), less common were honeysuckle (Lonicera utahensis), whortleberry (Vaccinium scoparium).

Graminoids - nothing common in large amounts, many Carex species, smooth brome (Bromus vulgaris), red-top (Agrostis alba) and others present in small amounts.

Forbs - many common in varying amounts, including but not restricted to: little pyrola (Pyrola secunda), grass of parnassus (Parnassia fimbriata), Lewis's mimulus (Mimulus lewisii), false bugbane (Trautvettaria caroliniensis), Jeffrey's shooting star (Dodecatheon jeffreyi), Monkshood (Aconitum columbainum), Licorice root (Ligusticum canbyi), arrow-leaf groundsel (Senecio triangularis), Jacob's ladder (Polemonium pulcherrimum), little willow-herb (Epilobium glandulosum), brook saxifrage (Saxifraga arguta), pyrola (Pyrola uniflora and Pyrola minor) and meadowrue (Thalictrum venulosum).

Trees - between 0 and 95 percent cover. Mean 36 percent.
Shrubs - between 1 and 89 percent cover. Mean 34 percent.
Graminoids - between 0.5 and 6 percent cover. Mean 2 percent.
Forbs - between 13 and 56 percent cover. Mean 31 percent.

Ferns and Moss and Liverworts - mostly mosses, between 0 and 38 percent cover. Mean 5 percent.

Physical attributes:

Elevation - 5500-6500 feet.
Slope - between 0 and 70 percent slope. Mean 27 percent.
Bare soil - less than 15 percent bare soil.
Rock -less than 20 percent rock cover.
Litter - at least 10 percent litter cover.
Bank stability - ranged from 2 to 100 percent of the length of the bank stable. Mean of 70 percent stable.
Undercut widths - ranged from zero to 3.1 feet. Mean .9 feet.

Management implications:

Sites with **Engelmann spruce/ globe huckleberry community type** also possess a large range of streambank stability values. Based on the assumptions made in the descriptions of the **Subalpine fir, Engelmann spruce/ mixed shrub/ mixed forb community type**, the **Engelmann spruce/ globe huckleberry community type** sites also have both the potential to maintain stable streambanks and a susceptibility to damage. Undercut widths also indicate potential good fish habitat (Sedell, 1989).

***C.* Engelmann spruce / Pachistima community type.**

Trees - Engelmann spruce, Grand fir, few subalpine fir.

Shrubs - Pachistima (<u>Pachistima myrisinites</u>), red-osier dogwood (Cornus stolonifera), alder (Alnus sinuata), prickly currant (Ribes lacustre) thimbleberry (Rubus parviflora), and less common were rose (Rosa gymnocarpa and Rosa woodsii), stinking currant (Ribes hudsonianum), service berry (Amalnanchier alnifolia), spirea (Spirea betufolia), honeysuckle (Lonicera untahensis) twinberry (Lonicera involucrata), huckleberry (Vaccinium golbulare), mountain ash (Sorbus scoparium).

Graminoids - no species common in large amounts, many Carex species, smooth brome (Bromus vulgaris), red-top (Agrostis alba), Nevada bluegrass (Poa nevadensis), and others present in small amounts.

Forbs - many, including queencup beadlily (Clintonia uniflora), foamflower (Tiarella trifoliata), trillium (Trillium ovatum), stream violet (Viola glabella), starry solomon's seal (Smilacina stellata), trail plant (Adenocaulen bicolor) little pyrola (Pyrola secunda), baneberry (Actaea rubra) windflower (Anenome piperi).

Ferns - lady fern (Athyrium filix-femina) very common, rock ferns (Cystopterisa fragilis and Cystopteris montana)less common.

Trees - up to 80 percent. Mean 30 percent.
Shrubs - between 32 and 152 percent (multiple layers). Mean 80 percent.
Graminoids - up to 33 percent cover. Mean 7 percent.
Forbs - between 7 and 144 percent cover (multiple layers). Mean 49 percent.
Ferns, Mosses and Liverworts - mostly ferns up to 31 percent cover. Mean 8 percent.

Physical attributes:

Elevation - near 4500 feet.
Slope - between 1 and 80 percent. Mean 29 percent.
Bare soil - less than 5 percent.
Rock - up to 25 percent.
Litter - at least 30 percent.
Bank Stability - greater than 50 percent. Mean 98 percent.
Undercut Widths - up to 3 feet. Mean .3 feet.

Management Implications:

Using the logic developed in the **Subalpine fir, Engelmann spruce/ mixed shrub/ mixed forb community type** description, sites with **Engelmann spruce/ Pachistima community type** seem somewhat less susceptible to bank damage than the **Subalpine fir, Engelmann spruce/ globe huckleberry and mixed shrub community** sites. The speculative reasons for this are: the streambanks are more armored as evidenced by the slightly higher rock cover, and the steeper slopes may deter animals from trampling through the community and disturbing soil (Pinchak et al. 1991). Sites with the **Engelmann spruce/ Pachistima community type** are capable of maintaining undercut banks, though to a much less of a degree than the **Subalpine fir, Engelmann spruce/globe huckleberry community type.** Again, the difference may be due to the presence of rock that may inhibit the formation of undercuts.

***D.* Grand fir, Engelmann spruce/ service berry community type.**

Trees - Grand fir, Engelmann spruce, western larch, occasional subalpine fir.

Shrubs - Service berry (Amalanchier alnifolia), Pachistima (Pachistima myrisinites), red-osier dogwood (Cornus stolonifera), alder (Alnus incana), prickly currant (Ribes lacustre) thimbleberry (Rubus parviflora), and less common were rose (Rosa gymnocarpa and Rosa woodsii), stinking currant (Ribes hudsonianum), spirea (Spirea betufolia), honeysuckle (Lonicera untahensis) twinberry (Lonicera involucrata), huckleberry (Vaccinium golbulare), mountain ash (Sorbus scoparium).

Graminoids - Nevada bluegrass (Poa nevedensis), Carex geyeri, nodding trisetum (Trisetum cernuum), smooth brome (Bromis vulgaris), and red-top (Agrostis alba) common in small amounts.

Forbs - sandwort (Arenaria macrophylla), fairy bells (Disporum hookeri), gooseberry-leaved alumroot (Heuchera grossulariifolia), windflower (Anenome piperi), little pyrola (Pyrola secunda), pussy toes (Antenaria racemosa), prince's pine (Chimaphila umbellata).

Ferns - Horsetails (Equisetum arvense), lady fern (Athyrium filix-femina), very few rock ferns (Cystopterisa fragilis and Cystopteris montana).

Trees - between 4 and 80 percent cover. Mean 32 percent.
Shrubs - between 5 and 101 percent (multiple layers). Mean 56 percent.
Graminoids - between 1 and 16 percent cover. Mean 7 percent.
Forbs - between 15 and 42 percent cover. Mean 25 percent.

Ferns, Mosses and Liverworts - mostly ferns up to 14 percent cover. Mean 6 percent.

Physical attributes:

Elevation - 4500 - 5000 feet.
Slope - between 30 and 125 percent. Mean 67 percent.
Bare soil - less than 5 percent. Mean 1 percent.
Rock - less than 30 percent. Mean 11 percent.
Litter - between 30 and 85 percent. Mean 52 percent.
Bank Stability - greater than 40 percent. Mean 94 percent.
Undercut widths - up to 2 feet. Mean .65 feet.

Management Implications:

As with the **Engelmann spruce / Pachistima community type**, high rock content may provide armor, and steep slopes may protect the streambanks of sites with **Grand fir, Engelmann spruce/ service berry communities** from erosion due to animal use. Sites with this community are associated with deep undercuts as evidenced by widths of up to 2 feet. Due to the amount of rock armor, however, the stream is unable to carve undercuts for much of the length occupied by this community. Sites with **Grand fir, Engelmann spruce/ service berry community** have very steep slopes that would cause disturbed soil on or near the banks to be delivered to the stream at a far greater rate than on more gentle slopes (Cooke and Doornkamp, 1974).

***E.* Douglas-fir, Ponderosa pine/ Pachistima community type.**

Trees - Douglas-fir, ponderosa pine, spruce.

Shrubs - Pachistima (Pachistima myrisinites), Service berry (Amalanchier alnifolia), ninebark (Physocarpus malvaceum), red-osier dogwood (Cornus stolonifera), prickly currant (Ribes lacustre) thimbleberry (Rubus parviflora), and less common were rose (Rosa gymnocarpa and Rosa woodsii), spirea (Spirea betufolia and Spirea pyramidifolia), honeysuckle (Lonicera untahensis), huckleberry (Vaccinium golbulare).

Graminoids - bluebunch wheat grass (Agropyron spicatum), elk sedge (Carex geyeri) and others present in small amounts.

Forbs - Fireweed (Epilobium angustifolium), pentstemon (Penstemon wilcoxii), meadow rue (Thalictrum venulosum), sego lily (Calochortus sp), yarrow (Achillea millefoilia), buck wheat (Eriogonum sp), dandelion (Taraxacum officianale), sweet cicely (Osmorhiza chilensis).

Trees - up to 16 percent cover. Mean 8 percent.
Shrubs - between 43 and 113 percent cover. Mean 78 percent.
Graminoids - between 6 and 9 percent cover. Mean 8 percent.
Forbs - between 8 and 19 percent cover. Mean 13 percent.
Ferns, Mosses, Liverworts - mostly ferns up to 3 percent cover. Mean 2 percent.

Physical Attributes:

Elevation - near 4500 feet.
Slope - greater than 55 percent. Mean 86 percent.

Bare Soil - none
Rock - greater than 15 percent. Mean 53 percent.

Litter - less than 50 percent. Mean 26 percent.
Bank Stability - 100 percent. Mean 100 percent.
Undercut widths - 0. Mean 0 feet.

Management Implications:

Sites of this community type are the most armored of the five described, which creates conditions for very stable banks, while diminishing the possibility of forming stable undercut banks. The very steep slopes, as in the case of the **Engelmann spruce/service berry community type**, create conditions for rapid sediment delivery in the case of nearby disturbed soil, while discouraging animal access (Pinchak et al. 1991; Cooke and Doornkamp, 1974). Collection of more vegetative data would likely indicate the presence of two distinct vegetative assemblages. The two assemblages, however, would probably have very similar physical attributes, and management implications (personal observation).

SIMILARITIES TO PREVIOUS CLASSIFICATIONS

The Boulder Creek **Subalpine fir, Engelmann spruce/ globe huckleberry type** and **Subalpine fir, Engelmann spruce/ mixed shrub/forb type** are similar to the Engelmann spruce/ queencup beadlily community type (Kovalchik, 1987), the Subalpine fir/ licorice root type (Steel et al. 1981) and Subalpine fir/ twisted stalk community type (Steele et al. 1981), (Jensen and Tuhy, 1982) and the Conifer/ bugbane and Conifer/ monkshood community types (Padgett et al. 1989). These previously-described types, however, contain species not present in the Boulder creek communities, most notably lodgepole pine, along with many shrubs, forbs and graminoids. The Boulder Creek community types also contain species not present in the others.

The Boulder Creek community types **Grand fir, Engelmann spruce/ service berry** and **Engelmann spruce/ pachistima** resemble many other previously described types including: Picea/ equisetum community (Youngblood et al. 1985), the Grand fir / Queencup beadlily community type (Steele et al. 1981), the Conifer/ red-osier dogwood type (Padgett et al. 1989) and the Grand fir/ Rocky-mountain maple community type (Steele et al. 1981). Again, the previously-described community types have species that the Boulder Creek communities do not, and vice versa.

The Boulder Creek community type, **Douglas-fir, Ponderosa pine/ Pachistima** is somewhat like the Douglas-fir/ Spirea habitat type (Steele et al. 1981). The Boulder Creek **Douglas-fir, Ponderosa pine/ Pachistima** type has many hydric species that the other does not.

CONCLUSION

The **Subalpine fir, Engelmann spruce/ mixed shrub/mixed forb**, and the **Subalpine fir, Engelmann spruce/ globe huckleberry** have probably been damaged by sheep herds. The **Engelmann spruce/ Pachistima community type** sites share many of the same physical characteristics as the two that were grazed and may also be susceptible to trampling by grazing ungulates and hikers. If grazing is to occur in the basin, perhaps special care should be taken to ensure that the animals do not stray near the stream in areas occupied by **Engelmann spruce/ Pachistima** and the **Subalpine fir, Engelmann spruce/ mixed shrub/mixed forb**, and the **Subalpine fir, Engelmann spruce/ globe huckleberry community types**. More herders and the construction of exclosures around these community types may help prevent further degradation of streambank stability in these riparian areas. Recreation trails should not be constructed in these community types because they appear to be susceptible to trampling. If a stream crossing must be constructed, the use of a log bridge or board walk may help prevent streambank damage.

The other two community types, the **Grand fir, Engelmann spruce/ service berry**, and the **Douglas-fir, Ponderosa pine/ Pachistima community types** may be less susceptible to grazing, due to the less enticing nature of their steep slopes and well armored banks. Exclosures around these areas are probably not needed. The steep slopes, however, create conditions for rapid delivery of disturbed soil. Ground disturbing activity should be situated far from the stream because increased sediment may harm chinook.

Previously-described riparian community types give timber site indices, and/or amount of browse for domestic livestock grazing. Timber and forage data were not collected in this study and so the community types described in this paper do not have these informative indices.

Areas within 100 ft of perennial streams are not in the timber base of the 1988 Land Management Plan for the Payette National Forest. Many other National Forests and states have similar regulations that increasingly prevent legal tree removal in riparian areas. This and many other studies indicate the merits of more careful grazing of domestic ungulate herds there as well. Land managers, then, will need more than information on basal area of riparian trees. Current interest in the amount of domestic animal forage in damage-prone riparian areas will most certainly diminish as evidence mounts in support of more restrictive grazing regimes, especially for areas that support threatened fish.

The riparian community types described here diverge from many previously described in several ways. Data were not collected from sites that had only plants affiliated with hydric soils. Data was collected from systematically located plots on transects instead of areas considered homogeneous using preconceived ideas of about the structure and composition of plant communities. These methods resulted in the formation of riparian communities that included "upland" species. In addition, some communities named here may be considered ecotones or transitional community types by plant ecologists that adhere to the community theory. This classification may not conform to the conventions of plant communities. A vegetative classification of this type, however, does outline the current condition of the riparian area, and the possible effects of past management on the riparian area and Boulder Creek, using plants as indicators.

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Appendices

Appendix A. Species and Plot order from Twinspan. Rows represent species, columns individual plot percent cover.

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SPECIES '                                         PLOT
           aaaaaaaaaabbbbbbbbbcccccccccccccccccccccccccdddddeeffffffffffffffffffffffffffffggggggggggghh.
           AAAAAAAAAAAAAAAAAAAABBBBBBBBBBBBBBBBBBBBBBBBBBBBBCCCCCCCCCCCCCCCCCCCCCCCCCCCCDDDDDDDDDDDEE
ABLA XXXX  41145-5-2-155-1-4-54345544-555454555552-35535-55524---------------------------3324----32--4--
SYMP ALBA  ---------------------------------------------1------------------------------------------------
VACC SCOP  --1---43---12-----1----3---21---1-22---3--5-4122-4-1-------------------------------------------
AGRO OREG  ------1-----------------------------------------------------------------------------------------
CARE AQUA  -------------------------11-------------1--11---------------------------------------------------
CARE INTE  ---------------------11-------------------11----------------------------------------------------
CARE LUZU  -----1------------------------------------------------------------------------------------------
CARE ROSS  -----------------1----11------1---------11-----111-----------------------1----------------------
CARE SPEC  ---21--2-4-1--1-1-11---------2--211-1--1-11121-----1--------------------1---1----1-------------
JUNC ACCU  ----1-------------------------------------------------------------------------------------------
AGOS AURE  -------------------1----------------------------------------------------------------------------
ASTE FOLI  122--2-2121--112--1-11211--1-1--1--11-1-112--22-12---------------------------------------------
COLO PARV  ----------------------------------------------1-------------------------------------------------
DESC RICH  -----1------------------------------------------------------------------------------------------
DISP TRAC  -------------1-------1--------1----11-------1---1-----------------------------------------------
DODE JEFF  1--1-11--11-1111----1-111-11111-11-11---111-------------1-------------------1-------------------
FRAG VIRG  ---1---1------1---1-2---11-----1--1---2-11---11111--------------------------11-----------------
GAUL HUMI  -------------------1----------------------------------------------------------------------------
GERA VISC  -------------------------------------1--------1-------------------------------------------------
LUPI CAUD  -------2111-----11--111-----1-----11-1--122-112233-----1-------------------------1---1----------
PARN FIMB  1123------1-1112211--111---1-1---112--1-111-111--1----------------------------------------------
PENT ATTE  ----------------------------------------------1-------------------------------------------------
POLE PULC  ----1---1----------111-------1-11111-1-11211---2-1----------------------------------------------
POTE GLAN  ----1---1------------1---------1----1--11-------1-----------------------------------------------
POTE GRAC  -----1------------------------------------------------------------------------------------------
PYRO MINO  ------------------11---1-1--1211---1----1-------------------------------------------------------
PYRO UNIF  ------1------1------11----2--------1-1-11--1----------------------------------------------------
SENE PSEU  ------------------------1---------1--1-------1--------------------------------------------------
SISY ANGU  ---------------------------------------------1--------------------------------------------------
TROL LAXU  ---1---------1---1------1-11--------11----------------------------------------------------------
VALE STIC  -12-1--2-1--1--11111-11--------11-111111-121---11------1------------------1-------1-------2-----
VERO SERP  -----------1----2-------------------------------------------------------------------------------
LIVE RWOR  -1112-12-22-22---121-11-222121111--11---122111-112--1-1----1-----------------------1-----------
ALNU SINU  5----------2-5-3--221-------5-------------5---------------------------------------------3-------
MENZ FERR  -4---------54--43442--------------2---5---------45-----2-------------2442----------2-----------
VACC GLOB  -------------------15145435511555441554-542-1-22-----21-1--23322---22-1111-2--124213-2-2432-3
CARE NEBR  ------2---34124------------------------------------1--------------------------------------------
ACON COLU  12111111111-1112-21211111-111111-1111111111111111--1111---11-11--111-11111--111-1--1-----1-----
ANAP MARG  111--1---11--1----1-211------------1--1------2-1--1---------------------2------1----------------
ARNI CORD  ----3-----11--4433--1-1-12122------111-4----1---------1--1---------11---------------111---312---
ARNI MOLL  ---------------1-1--------1---------------------------------------------------------------------
ARTE LUDO  -----1------1---1------------------------------------------------------------------------1------
EPIL GLAN  21322111-22-11-13-111111-1-12111111111111211111-1--11------111-11-1--11---1-111-111-----1111----
HABE SACC  1-1--111-1--1--1--1-------1---1-1--1--1------11------------------------1--1----1----------------
HERA CLXX  3--234-4-22-1-2-2-2-41122112-4-2-1--1-1-221--11--2-3-4------1---132-1-1111--1---2--------------
MERT CILI  222-1222-11-1112--1-21-1-1-2-213-121111-2211-11112-1-211-1-1-11-111-112-3------1---1------------
MIMU LEWI  112-21-1-21-11--21---112-1------11--1-1--21--11-------------------------------------------------
MIMU MOSC  ---1111-----1---1--------1------1-11--1--------1---1-----------------------1--------------------
MONT CORD  42444234-21-11-2--221112111-1223245223-1121211111-23--1-2--1-1--------112---1-1-2-----1---------
PEDI RACE  -1----11------1---1-----------1----1----111-----12---------------------------------------21-----
SAUS AMER  1122------1--1-1-1--1111------11-121------11-1---1--1--2----1--22--------------11---------------
SAXA ARGU  12222122-11-1111--1121-111111111111212-1-1-111111-----1-----11----------4-----2---112-----------
STEL OBTU  --5--1---1-------------------2----2----1-----------1-1-------------------------------------------
THAL VENU  23253532-1335222-4343222-111-223-11442231432322l-22-32--11-11131-1112--1-22-2--32111-1-121---2
TRAU CARO  -2141324-15-24-542231-2211112142111221-21221322112-1423-11323-11111212-112----243--1--1--12-3-
VIOL ORBI  11--1--1-1-111-1111111111111121111-12-1211221112114--1-1-1121-11-1-12-1---2211----111111---11--
MOSS XXXX  21122-32-11-42-2-1321222-122211431-22322-221111225--2-2222-2---------5-----------2-2-----------
AGRO SPIC  ---------------------------------------------------------------------------------------------1-
CALA RUBE  --------------------1-------------------------------------------------------------1-----------
LUZU HITC  ---------1-------1--------1--11-1-1---------------------------------------11--------2----------
ACHI MILL  ---------1---1--1---1-------------------1-----------------------------------------1-1------1-
```

Appendix A continued

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           aaaaaaaaabbbbbbbbbccccccccccccccccccccccccddddeeffffffffffffffffffffffffffffgggggggggghh
           AAAAAAAAAAAAAAAAAAAABBBBBBBBBBBBBBBBBBBBBBBBBBBBBBBCCCCCCCCCCCCCCCCCCCCCCCCCCCCCDDDDDDDDDDDEE
ANGE ARGU  2-121221-211211231211-1-1-1211-2112121--1221-1111-121-1--1----12--221----2-11--221--21-2-1321-
CARD CORD  -1---1---1------------------------------1-1------11----------------1---------------------
CORY CASE  ---111---1----1-------1---------1-------------------3----------------2--------------------
EPIL ANGU  -11----1-1---1-------1---------------1-111--1-111----------------------2----------2-1----32
HIER ALBA  -1---1---1-1---------11-------1---11-1-1-1-111-11----1-------1-----------1-1--1---111--2-21--
LIGU CANB  31223-22-11-134532111-12--12111221111112-21211-12--12-1111111111-11--22-----22221111-12-232--
PENT WILC  ---------------------------------------------------------------------------------------1-
RUDB OCCI  ----1221-11--1--2--1--111-11--111--11-1-21--1---1--2--1--11--1--111----1----12-12----11---2---
SENE TRIF  12323-23-43-12224224312312-41121124312212322133112222111111-1112-11121121111122224121-22221121-
LONI INVO  12223123--11-1-22--2-2-1112-1--23221--1-2---212-13----1--1-32-14--242-4--11-223-132-221----2--
RIBE LACU  545-2444---331-12332421242211-354122244232112-1--32-33323-4534244313233434333-4343543-13343233
SAMB ....  ---------------------------1------1-----------5---------------1-------3-------------1------
BROM VULG  112213---2121111112-2111111111-1-11111111111-121-2--11112-11-121113214-1114153-421-1311-221---
AREN MICR  ---------------1-----1-----------111---111-----111-----1---1--------------------111-11-11-1---
ASTE MODE  ---22-33----111-11-21--1--1--11122-2111-311-1111-112111-11-21-11---1--21--1-231221211-122-131-
GALI TRIF  1111--11---1111111-1--1111-111111-1-111111111----121111111121311111111-121-11-1-11-1--111111--
MITE PENT  11-111-1-1--11-11-12111-1--1121-12-1111--11--1-1--1312-1-11-----------31212-------11-2-----1--
OSMO CHIL  1-1-1----11---11-111211--1--1-1--111-2-1--1-111112----111111--1111-111-2-11111-221-1111111---2
PYRO ASAR  ---------------3-14--------------1----------------2----------------------4--11-1-----------1--
STRE AMPL  1212211-----11141-121111121-21211111-21111-1211--12-112111-213121122-322-221323211112223223-1-
PIEN XXXX  3-133--4-245-55-4-34444422-12-541---5115554354515---5534555555545-455-4555-543554514524--455--
RIBE HUDS  ----42-4---13---2-2--1----1--1-----1-11--2--11----43-2-----2-2-2--2---1---14-11------2-22----
AGRO ALBA  1-111-11---111-11---11-2-11---1-11--111--1-1112-1-34-11-1-1-12-11131-1-12-1--5424--11-11-122--
JUNC ENSI  ----------------1------------------------------1-------------------------------------------1--
GEUM MACR  --1-1----1----1----1------1--1-----------11----------2-1-----1-1---111----1-1-1---11------1-----
VERO AMER  ---------1-1----1------1--------------------1-------1-------11---1----1------1-1--------------
PYRO SECU  -------------1-----2----1111----11--1-1-123--1--12-3-1-11-2-12----1-12211-1211322112-11211---
LAOC XXXX  -------------------------------------------------------------3--------------------3---34----
PIPO XXXX  ------------------------------------------------------------------------------------------1-
PSME XXXX  ----------------------------------------------------------43----------3--1--------23-3-4---4-
AMAL ALNI  -------------------------------------------------2-1-2----1------2-1-----21---421233313-234
LONI UTAH  -------------------1---11--1-----1--1----2-2-1-----2-211--2--2-2--31--2-22--1-2-42-2--32-1-32
PHYS MALV  ---------------------------------------------------------------------------------2--------
PRUN EMAR  ------------------------------------------------------------------------------------------1
ROSA GYMN  -------------------------------------------------------------------------------------3-----
SPIR BETU  ------------------------------------------------3--2-24---11---1-2----12-----3---2223-222-
SPIR PYRA  -------------------------------------------------------------------------------------------2-
CALA CANA  -------------------------------------------------------------------1----1---1----11-----1
CARE GEYE  -------------------1121-1---1---------------1-12-1--2-------1---12---2-1------2-211-21-343223
CARE MICR  -----1-1----------------------------------------1----------------------------------2-1---1--
ELYM GLAU  -----------------------------------------------2-------------1-------------1--1-1-------11-
FEST ....  ------------------------------------------------------------------------------1----1---
POA. NEVA  -----11-------1----1-------------------------------13-----1-1------1---1-----122--1---1-1111---
TRIS CERN  -----3----------1-------------------------------------1---------1-1-------------1---------11-1-11-
AGOS GLAU  ----------------------------------------------------------------------------1----------
ANEN PIPE  -------------------11--1--1------1-1---------11-----1-11-11-111111-111-1-11----111-1111-1111-1
ANTE RACE  ----------------------------------------------------------------------------2-4----21--
CALO ....  ------------------------------------------------------------------------------------1-
CHIM UMBE  ------------1-----------11-----------1-----1----1-----1---1--11-----1----2-----1-11-1--11112--
COLO TINC  --------------------------------------------------------------------------------------1
ERIG SPEC  -------------------------------------------------------------------------------------1-
ERIO ....  -------------------------------------------------------------------------------------1-
ERYT GRAN  -----------------------------------------------------------------------------1----------
GALI APAR  -------------------11----1-----------------------22----2-2------------------1----2--111------
GOOD OBLO  ------------------------------------------------------------1-1---------1--1-----1---
HEUC GROSS ---------------------------------------------------1-----------------1--------11-1----1---
HIER ALBE  ---------------------------------------------------------------------------------1------1-
MENT ARVE  ------------------------------------------------------------------------2----------
MITE NUDA  ------------------------------------------------------------------1------------1------
POLO DOUG  -------------------------------------------------------------------------------------1-
RANU ACRI  -----------------------------------------------1-----------------------------------------1--
SEDU STEN  -----------------------------------------------------------------------------1--------
SMIL RACE  -------------------1------------------------------1---1-----------------------------1-------1-
TARA OFFI  --------------------1----------------1-------1---11-------1--1-1--------------1----1-11-----11
```

Appendix A continued

	aaaaaaaaaabbbbbbbbbbcccccccccccccccccccccccccdddddeefffffffffffffffffffffffffffffggggggggggggghh.
	AAAAAAAAAAAAAAAAAAAABBBBBBBBBBBBBBBBBBBBBBBBBBBCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCDDDDDDDDDDDEE
EQUI ARVE	----------1-------1--11---1---------------1---1-11-3--1--1-2---14-----21--11-23---211412---22-
CYST FRAG	---1-------------1--------1---1-111-1-1-1-
WOOD	--1-------------
ABGR XXXX	---324-41--2-----1---4144344----2-41412--3--
SORB SCOP	--4-3-1---4--34----3---21-2----2---2--24-3--
ACER GLAB	---1-----2-2-1---4-----------
ALNU INCA	---35553555-254555554-5545455334----3-51--1---
CORN STOL	--5544255-45543-53-4-34455454553-34-2-45342-44
PACH MYRI	--2-4-53253222455-214322-22223-2-5415452351235
ROSA WOOD	--3-------1----1-----------2----3---------
RUBU PARV	1------------------------------------1----------3-3521253242433-3324-1422-23-342-235425322-4
SALI DRUM	--3---------------------12----1-----------
SALI WOLF	--1-----------------------------
CARE LENT	--1---
ACTE RUBR	-----2-------1----2-1-----11---------------------3-24----2322--14-22421311---333--1--1--1----
ADEN BICO	--11-22111--32-1-212111--2211------11---
CIRC AEAX	---------------------1--------------------------1-111-11------11-----1--1----1------1----1--
CIRC VULG	---1-----3-----------------------1----------------
CLIN UNIF	---243134415141525444-2444-2-2553--2----11---
DISP HOOK	---1111-1--------1-1111---1----1-1-111--
FRAG VESC	----------------------------------1---------------1111---1--111--1-1-1-1-1----11111111-11--1
LINE BORE	---2----2--3----312----4----1---22---1-11--
LIST	---------------1--------------------------------------11--------112---------------------
MITE CUAL	--1------3------1--------------------
PLAN LANC	---1-----------------
PRUN VULG	--1------------1----------------
PYRO PICT	---1------------------------------------
SMIL STEL	--------------111------1------------------2------21----13-11-12354112----1---52--1----------
STEL CRIS	---1----------------------------------
TIAR TRIF	--1-3221--2453--3251453-21--1-415---------1---
TRIL OVAT	-------------------1----------------1-----------1--111-11111-1-11---222-11----2--1-1---1----
UTRI IOXX	---------------------------------1---------------3-2----------112-1---3-----2---------------
VERA CALI	---1----21-------------2-------------
VIOL ADUN	---1--------------------------------------
VIOL GLAB	---21-111111111--12----11----22122-----1----1--
ATHE FILI	---532-224412223-2243-4344311445332342--2-2-4--
CYST MONT	--1--------------------
	AAAAAAAAAAAAAAAAAAAABBBBBBBBBBBBBBBBBBBBBBBBBBBCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCDDDDDDDDDDDEE
	aaaaaaaaaabbbbbbbbbbcccccccccccccccccccccccccdddddeefffffffffffffffffffffffffffffggggggggggggghh

Note:
Lowercase letters corrspond to the eight Twinspan groups.
Capital letters correspond to Community types.
A = Subalpine fir, Engelmann spruce/ mixed shrub/forb.
B = Subalpine fir, Engelmann spruce/ huckleberry.
C = Engelmann spruce/ Pachistima.
D = Grand fir, Engelmann spruce/ service berry.
E = Douglas-fir, Ponderosa pine/ Pachistima.

Species names are represented by the first four letters of the genus followed by the first four letters of the species. Exceptions to this format are: Trees are represented by only the first two letters of genus followed by the first two of the species, and species for which only the genus was determined use only the first four letters of the genus.

Dashes represent zero percent canopy cover, and were not used in the reciprocal averaging procedure.
The other values as follows, 2% gets a 1 rating, all border percentages were assigned to the lower rating:
1 = 0 - 2%
2 = 2 - 5%
3 = 5 - 10%
4 = 10 - 20%
5 = > 20%

Appendix B. Mean percent cover and percent frequency of each species in each Community Type.

SPECIES CODES	SUBALPINE FIR, SPRUCE MIXED SHRUB		SUBALPINE FIR SPRUCE HUCKLEBERRY		SPRUCE PACHISTIMA		GRAND FIR, SPRUCE SERVICE BERRY		DOUGLAS-FIR PONDEROSA PINE PACHISTIMA	
	ave	freq	ave	freq	ave	freq	ave	freq	ave	freq
TREES										
ABGR	0.0	0.0	0.0	0.0	3.4	14.0	2.6	58.3	0.0	0.0
ABLA	10.4	70.0	21.6	83.9	0.6	3.0	4.2	50.0	0.0	0.0
LAOC	0.0	0.0	0.0	0.0	0.2	1.0	1.9	25.0	0.0	0.0
PIEN	9.5	65.0	14.1	74.2	23.3	26.0	19.4	83.3	0.0	0.0
PIPO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	50.0
PSME	0.0	0.0	0.0	0.0	0.7	4.0	2.0	33.3	7.5	50.0
SOSC	0.0	0.0	0.0	0.0	2.1	10.0	2.1	41.7	0.0	0.0
TREE TOTAL	19.8		35.7		30.2		32.2		8.0	
SHRUBS										
ACER GLAB	0.0	0.0	0.0	0.0	0.3	4.0	0.8	8.3	0.0	0.0
ALNU INCA	0.0	0.0	0.0	0.0	30.6	27.0	3.3	33.3	0.0	0.0
ALNI SINU	3.2	30.0	1.6	9.7	0.0	0.0	0.7	8.3	0.0	0.0
AMAL ALNI	0.0	0.0	0.0	0.0	0.4	8.0	3.1	83.3	7.5	100.0
CORN STOL	0.0	0.0	0.0	0.0	20.3	26.0	8.1	66.7	12.5	100.0
LONI INVO	1.7	75.0	1.2	54.8	2.0	16.0	1.8	58.3	0.0	0.0
LONI UTAH	0.0	0.0	0.3	25.8	1.2	14.0	2.0	58.3	5.0	100.0
MENZ FERU	4.5	40.0	3.2	12.9	0.9	5.0	0.3	8.3	0.0	0.0
PACH MYRI	0.0	0.0	0.0	0.0	6.8	25.0	13.3	91.7	37.5	100.0
PHYS MALV	0.0	0.0	0.0	0.0	0.0	0.0	0.2	8.3	0.0	0.0
PRUN EMAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	50.0
RIBE HUDS	2.1	35.0	0.3	29.0	1.5	12.0	0.8	25.0	0.0	0.0
RIBE LACU	5.7	75.0	4.5	80.6	6.4	28.0	7.3	91.7	5.0	100.0
ROSA GYMN	0.0	0.0	0.0	0.0	0.0	0.0	0.7	8.3	0.0	0.0
ROSA WOOD	0.0	0.0	0.0	0.0	0.3	4.0	0.4	8.3	0.0	0.0
RUBU PARV	0.1	5.0	0.0	3.2	6.1	26.0	6.8	83.3	5.0	50.0
SALI DRUM	0.0	0.0	0.0	0.0	0.3	3.0	0.1	8.3	0.0	0.0
SALI WOLF	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
SAMB	0.0	0.0	1.3	9.7	0.2	2.0	0.1	8.3	0.0	0.0
SPIR BETU	0.0	0.0	0.0	0.0	1.0	10.0	1.7	58.3	1.5	50.0
SPIR PYRA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	50.0
SYMP ALBA	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0
VACC GLOB	0.0	0.0	18.8	83.9	1.2	17.0	4.2	75.0	2.5	50.0
VACC SCOP	1.1	30.0	2.4	38.7	0.0	1.0	0.2	8.3	0.0	0.0
SHRUB TOTAL	18.3		33.6		79.5		55.7		78.0	
GRAMINOID										
AGRO SPIC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	50.0
AGRO ALBA	0.4	60.0	0.4	51.6	2.8	21.0	0.9	66.7	0.0	0.0
ABRO OREG	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BROM VULG	1.4	85.0	0.7	80.6	2.7	25.0	1.6	75.0	0.0	0.0
CALA CANA	0.0	0.0	0.0	0.0	0.1	2.0	0.3	25.0	0.5	50.0
CALA RUBE	0.0	0.0	0.0	3.2	0.0	0.0	0.1	8.3	0.0	0.0
CARE AQUA	0.0	0.0	0.1	12.9	0.0	0.0	0.1	8.3	0.0	0.0
CARE GEYE	0.0	0.0	0.4	29.0	0.5	8.0	2.8	75.0	6.0	100.0
CARE INTE	0.0	0.0	0.1	9.7	0.0	0.0	0.1	8.3	0.0	0.0
CARE LENT	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
CARE LUZU	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CARA MICR	0.1	10.0	0.0	0.0	0.0	1.0	0.3	25.0	0.0	0.0
CARA NEBR	1.8	30.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
CARA ROSS	0.0	5.0	0.1	25.8	0.0	1.0	0.0	0.0	0.0	0.0
CAREX	1.0	45.0	0.5	35.5	0.0	3.0	0.0	8.3	0.0	0.0
ELYM GLAU	0.0	0.0	0.0	0.0	0.1	3.0	0.1	25.0	0.5	50.0
FESTUCA	0.0	0.0	0.0	0.0	0.0	0.0	0.1	16.7	0.0	0.0
JUNC ACCU	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JUNC ENSI	0.0	5.0	0.0	0.0	0.0	1.0	0.0	8.3	0.0	0.0
LUZU HITC	0.1	10.0	0.1	16.1	0.0	2.0	0.2	8.3	0.0	0.0
POA NEVA	0.1	20.0	0.0	0.0	0.5	9.0	0.5	50.0	0.0	0.0
TRIS CERN	0.3	10.0	0.0	0.0	0.1	4.0	0.2	33.3	0.3	50.0
GRAMINOID TOTAL	5.2		2.3		6.8		7.2		7.8	

Appendix B Continued

SPECIES CODES	SUBALPINE FIR, SPRUCE MIXED SHRUB ave	freq	SUBALPINE FIR SPRUCE HUCKLEBERRY ave	freq	SPRUCE PACHISTIMA ave	freq	GRAND FIR, SPRUCE SERVICE BERRY ave	freq	DOUGLAS-FIR PONDEROSA PINE PACHISTIMA ave	freq
FORBS										
ACH ACHI MILL	0.1	15.0	0.0	6.5	0.0	0.0	0.1	16.7	0.3	50.0
ACON CILU	1.1	90.0	0.6	83.9	0.4	20.0	0.1	25.0	0.0	0.0
ACTE RUBR	0.4	15.0	0.1	9.7	3.1	20.0	0.2	25.0	0.0	0.0
ADEN BICO	0.0	0.0	0.0	0.0	1.0	18.0	0.2	33.3	0.0	0.0
AGOS AURE	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0
AGOS GLAU	0.0	0.0	0.0	0.0	0.0	0.0	0.1	8.3	0.0	0.0
ANAP MARG	0.3	45.0	0.3	22.6	0.1	3.0	0.0	0.0	0.0	0.0
ANEN PIPE	0.0	5.0	0.1	19.4	0.4	19.0	0.4	83.3	0.3	50.0
ANGE ARGU	1.7	95.0	0.8	67.7	0.7	15.0	1.3	66.7	0.3	50.0
ANTE RACE	0.0	0.0	0.0	0.0	0.0	0.0	1.7	33.3	0.0	0.0
AREN MICR	0.0	5.0	0.2	32.3	0.1	3.0	0.3	58.3	0.0	0.0
ARNI CORD	1.9	40.0	0.7	38.7	0.1	4.0	1.0	50.0	0.0	0.0
ARNI MOLL	0.1	10.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0
ARTE LUDO	0.1	15.0	0.0	0.0	0.0	0.0	0.1	8.3	0.0	0.0
ASTE FOLI	0.9	60.0	0.7	54.8	0.0	0.0	0.2	8.3	0.0	0.0
AST MODE	1.1	55.0	0.8	61.3	0.9	20.0	1.3	83.3	0.3	50.0
CALOCHOR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	50.0
CARD CORD	0.1	15.0	0.0	6.5	0.0	3.0	0.0	0.0	0.0	0.0
CIRC ALPI	0.0	0.0	0.0	3.2	0.2	11.0	0.1	16.7	0.0	0.0
CIRC VULG	0.0	0.0	0.0	3.2	0.2	2.0	0.0	0.0	0.0	0.0
CHIM UMBE	0.0	5.0	0.1	16.1	0.2	7.0	0.5	66.7	0.0	0.0
CLIN UNIF	0.0	0.0	0.0	0.0	9.2	26.0	1.0	33.3	0.0	0.0
COLL PARV	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0
COLL TINC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	50.0
CORY CASE	0.2	30.0	0.1	6.5	0.2	2.0	0.0	0.0	0.0	0.0
DESC RICH	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DISP HOOK	0.0	0.0	0.0	0.0	0.2	11.0	0.3	41.7	0.0	0.0
DISP TRAC	0.0	5.0	0.1	19.4	0.0	0.0	0.0	0.0	0.0	0.0
DODE JEFF	0.3	50.0	0.4	51.6	0.0	2.0	0.0	0.0	0.0	0.0
EPIL ANGU	0.2	30.0	0.2	29.0	0.1	1.0	0.3	16.7	3.5	100.0
EPIL GLAN	1.9	85.0	0.6	80.6	0.3	15.0	0.3	58.3	0.0	0.0
ERIG SPEC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	50.0
ERIOG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	50.0
ERYT GRAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3	0.0	0.0
FRAG VESC	0.0	0.0	0.0	3.2	0.3	14.0	0.4	75.0	0.3	50.0
FRAG VIRG	0.2	20.0	0.4	38.7	0.0	2.0	0.0	8.3	0.0	0.0
GALI APAR	0.0	5.0	0.1	9.7	0.4	5.0	0.4	33.3	0.0	0.0
GALA TRIF	0.5	70.0	0.4	67.7	0.9	27.0	0.3	66.7	0.0	0.0
GAUL HUMI	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0
GERA VISC	0.0	0.0	0.1	6.5	0.0	0.0	0.0	0.0	0.0	0.0
GEUM MACR	0.2	30.0	0.1	12.9	0.3	11.0	0.1	16.7	0.0	0.0
GOOD OBLO	0.0	0.0	0.0	0.0	0.0	2.0	0.1	25.0	0.0	0.0
HABE SACC	0.2	45.0	0.1	19.4	0.0	3.0	0.0	8.3	0.0	0.0
HERA LANA	2.7	60.0	1.6	58.1	1.3	13.0	0.0	8.3	0.0	0.0
HEUC GROS	0.0	0.0	0.0	0.0	0.0	2.0	0.3	33.3	0.0	0.0
HIER ALBA	0.1	20.0	0.2	41.9	0.1	5.0	0.5	50.0	0.0	0.0
HIER ALBE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3	0.3	50.0
LIGU CANB	3.6	90.0	1.1	77.4	0.9	21.0	1.5	75.0	0.0	0.0
LINN BORE	0.0	0.0	0.0	0.0	1.1	8.0	0.5	41.7	0.0	0.0
LIST	0.0	5.0	0.0	0.0	0.1	5.0	0.0	0.0	0.0	0.0
LUPI CAUD	0.3	30.0	0.9	48.4	0.0	1.0	0.3	25.0	0.0	0.0
MENT ARVE	0.0	0.0	0.0	0.0	0.0	0.0	0.2	8.3	0.0	0.0
MERT CILI	1.4	75.0	1.2	71.0	0.7	16.0	0.1	16.7	0.0	0.0
MIMU LEWI	0.9	65.0	0.3	35.5	0.0	0.0	0.0	8.3	0.0	0.0
MIMU MOSC	0.2	30.0	0.1	19.4	0.1	2.0	0.0	0.0	0.0	0.0
MITE CAUL	0.0	0.0	0.0	0.0	0.2	3.0	0.0	0.0	0.0	0.0
MITE NUDA	0.0	0.0	0.0	0.0	0.0	1.0	0.0	8.3	0.0	0.0
MITE PENT	0.5	65.0	0.5	58.1	0.7	12.0	0.4	33.3	0.0	0.0
MONT CORD	3.8	80.0	2.5	83.9	0.6	12.0	0.1	16.7	0.0	0.0
OSMO CHIL	0.4	55.0	0.5	54.8	0.6	21.0	0.5	75.0	1.0	50.0

Appendix B Continued

SPECIES CODES	SUBALPINE FIR SPRUCE MIXED SHRUB ave	freq	SUBALPINE FIR SPRUCE HUCKLEBERRY ave	freq	SPRUCE PACHISTIMA ave	freq	GRAND FIR SPRUCE SERVICE BERRY ave	freq	DOUGLAS-FIR PONDEROSA PINE PACHISTIMA ave	freq
PARN FIMB	0.9	60.0	0.4	48.4	0.0	0.0	0.0	8.3	0.0	0.0
PEDI RACE	0.2	25.0	0.2	22.6	0.0	0.0	0.3	16.7	0.0	0.0
PENT ATTE	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0
PENT WILC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	50.0
PLAN LANC	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
POLE PULC	0.1	15.0	0.4	51.6	0.0	0.0	0.0	0.0	0.0	0.0
POLY DOUG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	50.0
POTE GLAN	0.1	10.0	0.1	19.4	0.0	0.0	0.0	0.0	0.0	0.0
POTE GRAC	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PRUN VULG	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0
PYRO ASAR	0.8	15.0	0.0	3.2	0.5	5.0	0.1	8.3	0.0	0.0
PYRO MINO	0.0	5.0	0.2	29.0	0.0	0.0	0.0	0.0	0.0	0.0
PYRO PICT	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
PYRO SECU	0.0	5.0	0.7	41.9	1.1	20.0	1.0	83.3	0.0	0.0
PYRO UNIF	0.1	10.0	0.2	25.8	0.0	0.0	0.0	0.0	0.0	0.0
RANU ACRI	0.0	0.0	0.0	0.0	0.0	1.0	0.0	8.3	0.0	0.0
RUDB OCCI	0.8	50.0	0.4	46.4	0.4	13.0	0.3	25.0	0.0	0.0
SAUS AMER	0.6	45.0	0.3	41.9	0.3	7.0	0.0	0.0	0.0	0.0
SAXI ARGU	1.1	80.0	0.8	77.4	0.5	5.0	0.3	33.3	0.0	0.0
SEDU STEN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3	0.0	0.0
SENE PSEU	0.0	0.0	0.1	9.7	0.0	0.0	0.0	8.3	0.0	0.0
SENE TRIF	4.5	90.0	2.8	90.3	1.5	29.0	1.8	91.7	0.5	50.0
SISY AUGU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3	0.0	0.0
SMIL RACE	0.0	5.0	0.0	0.0	0.0	2.0	0.0	8.3	0.5	50.0
SMIL STEL	0.1	15.0	0.1	6.5	3.0	17.0	0.0	8.3	0.0	0.0
STEL CRIS	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
SEL STEL OBT	1.8	15.0	0.2	9.7	0.0	2.0	0.0	0.0	0.0	0.0
STRE AMPL	1.3	70.0	0.8	77.4	1.9	27.0	2.5	91.7	0.5	50.0
TARA OFFI	0.0	0.0	0.0	6.5	0.1	6.0	0.2	33.3	0.5	100.0
THAL VENU	8.5	95.0	3.3	80.6	1.3	20.0	0.8	66.7	1.0	50.0
TIAR TRIF	0.0	0.0	0.0	0.0	7.2	22.0	0.1	8.3	0.0	0.0
TRAU CARO	6.7	90.0	2.1	87.1	2.2	23.0	0.5	41.7	2.5	50.0
TRIL OVAT	0.0	0.0	0.0	6.5	0.5	18.0	0.1	25.0	0.0	0.0
TROL LAXU	0.1	15.0	0.1	16.1	0.0	0.0	0.0	0.0	0.0	0.0
URTI DIOC	0.0	0.0	0.0	3.2	0.6	8.0	0.0	0.0	0.0	0.0
VALE STIC	0.5	55.0	0.4	45.4	0.0	2.0	0.2	16.7	0.0	0.0
VERA CALI	0.0	5.0	0.0	0.0	0.2	4.0	0.0	0.0	0.0	0.0
VERO AMER	0.1	15.0	0.0	6.5	0.2	7.0	0.0	0.0	0.0	0.0
VERO SERP	0.2	[illegible]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VIOL ADUN	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
VIOL GLAB	0.0	0.0	0.0	0.0	0.8	20.0	0.1	16.7	0.0	0.0
VIOL ORBI	0.5	75.0	1.2	57.1	0.6	16.0	0.8	75.0	0.0	0.0
FORB TOTAL	54.0		30.6		45.7		24.6		13.3	
FERNS &										
EQU EQUISETU	0.1	10.0	0.3	39.4	1.0	12.0	1.8	66.7	1.0	50.0
LIVE LIVERWO	1.1	65.0	0.9	71.0	0.0	3.0	0.1	8.3	0.0	0.0
MOSS	2.3	75.0	3.6	83.9	1.1	7.0	0.4	25.0	0.0	0.0
ATHY FILI	0.0	0.0	0.0	0.0	0.2	28.0	3.2	58.3	0.0	0.0
CYST FRAG	0.0	0.0	0.0	0.0	0.0	3.0	0.3	50.0	0.5	50.0
CYST MONT	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
WOODSIA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3	0.0	0.0
FERN TOTAL	3.5		4.9		8.5		5.8		1.5	
TOTAL COVER	100.8		107.0		173.7		125.5		108.5	