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Title: ECOLOGY OF THE SALIX AND POPULUS SPECIES OF THE CROOKED RIVER NATIONAL GRASSLAND

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Riparian communities dominated by members of the Salicaceae (*Salix lasiandra*, *S. lutea*, *S. lemmonii*, *Populus trichocarpa*, *P. tremuloides* and *S. exigua*) were studied at the Crooked River National Grassland in central Oregon. The objectives of this study were to examine the relationships between the *Salix* and *Populus* species and microsite to identify the principal environmental gradients that may determine the distribution of these species.

One hundred twenty five stands of riparian vegetation dominated by the above members of the Salicaceae were intensively sampled. A predetermined set of physical variables were collected to characterize their habitats. These variables included surface soils, stream characteristics, vegetative characteristics, and other physiographic variables. Canonical discriminant function analysis was used to separate the *Salix* and *Populus*

species based on the set of 19 environmental variables stratified according to size class (i.e. sapling, intermediate and decadent).

The Salicaceae, as a family, occupy specific habitats in terms of surface soil characterisitics. The Salicaceae require surface soils which have a mean pH of 7.3, a mean macroporosity of 27.08%, a mean sand content of 53.42%, a mean organic matter content of 6.0%, a mean coarse material content of 28.59%, and a mean organic horizon of 0.58 cm. The remaining physical variables change for each species.

The variables which most readily separated the species were stream gradient and average stand distance from the wetted channel. These two variables represented an environmental gradient of depth to an effective water table in relation to headwater versus valley-bottom stream systems. *P. tremuloides* and *S. lemmonii* occupy areas of steep stream gradient (headwater areas) and deep water tables (more xeric microsites). Conversely, *S. lasiandra*, *S. lutea*, *S. exigua* and *P. trichocarpa* occupy areas of lesser stream gradient (valley bottoms) and higher water tables (more mesic microsites).

Ecology of the *Salix* and *Populus* Species of the Crooked River National Grassland

by

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INTRODUCTION

A wide diversity of natural resource values are associated with riparian ecosystems. These values include recreation, timber, water, fisheries, wildlife, aesthetics and livestock grazing (Thomas et al. 1979, Johnson and Carothers 1982, Claire and Storch 1983, Kauffman and Krueger 1984). Because of the multiple values of these areas, riparian zones have become a controversial focal point of land management. This focus has concentrated on the deterioration of these ecosystems, especially in the semi-arid and arid rangelands of the Western United States (Davis 1982, Boles and Dick-Peddie 1983, Medina 1986). The decline in the productivity of riparian zones has become a prime concern to scientists, the livestock industry and the concerned public. Much of the rhetoric discussed on the subject of riparian management has been based on opinion, hearsay or personal bias rather than conclusions drawn from scientific research (Kauffman and Krueger 1984).

In riparian ecosystems of semi-arid regions, members of the Salicaceae (Populus and Salix spp.) are critical sources of diversity for many wildlife species (Thomas et al. 1979, Kauffman and Krueger 1984 and Kauffman 1988). In rangeland ecosystems, they are often the only arboreal species present. The highest densities of noncolonial breeding birds ever reported were in cottonwood-dominated riparian communities of Arizona (Johnson et al. 1977). When woody species are eliminated from the riparian zone, habitat quality declines for those species which require the arboreal riparian species. Shade from these arboreal species also acts in the modification of the stream/riparian microclimate thereby facilitating the survival of many native aquatic and terrestrial species, both plant and animal (Cummins 1974 and Everest et al. 1985).

In order to improve riparian structure and productivity, additional knowledge of the ecology of riparian plant species is necessary. Therefore, autecological studies are warranted. Because of the value to fisheries, wildlife, livestock and aesthetics, woody riparian species, especially of the Salicaceae family, are receiving increased attention from land managers as well as the scientific community. To date, there has been a scarcity of published scientific research on the basic autecology of the Salicaceae.

In this study, the autecology of Salix lasiandra Benth., S. lutea Nutt., S. lemmonii Bebb, Populus trichocarpa (Torr. & Gray Ex Hook), P. tremuloides (Michx.) Loeve & Loeve and S. exigua Nutt. will be examined. These species are intimately associated with the presence of free water, and are therefore termed riparian obligates (Kovalchik 1986). The ecology of these species is not well understood, although the ecology of *P. trichocarpa* and *P. tremuloides* has been more intensively studied (Glinski 1977 and Pielou et al. 1986) than that of the *Salix* species. This research study proposes to examine the aforementioned *Populus* and *Salix* species in time and space at the Crooked River National Grassland (CRNG) in central Oregon. Specifically, habitat conditions and the population structure of these important species will be examined.

OBJECTIVES

The riparian species examined in this study are *Salix lasiandra* Benth., *S. lutea* Nutt., *S. lemmonii* Bebb, *Populus trichocarpa* (Torr. & Gray Ex Hook), *P. tremuloides* (Michx.) Loeve & Loeve and *S. exigua* Nutt. The study area was located at the Crooked River National Grassland (CRNG) in central Oregon. The objectives of this study were:

1. To examine the relationships between *Salix* and *Populus* species and microsite, in order to identify the principal environmental gradients that may determine the distribution of the above species (i.e. a spatial gradient).

2. To quantitatively describe microsites occupied by the above species within a chronosequence (i.e. a temporal gradient).

3. To quantify the population structure by size class of the above Salicaceous species.

STUDY AREA

Location

The Crooked River National Grassland (CRNG) is one of the five districts of the Ochoco National Forest, Oregon. The Grassland lies to the east of the Cascade Mountains of central Oregon with the majority occurring east of the Deschutes River (Figure 1). Topography of the CRNG is gently rolling hills and low buttes separated by wide flats. There are deep canyons along the Deschutes and Crooked Rivers, in addition to less dramatic canyon relief along Squaw and Willow Creeks. The western portion of the Grassland is plateau-like while the eastern part is gently rolling, low mountainous land with the greatest relief at the southern boundary (Hopkins and Kovalchik 1983).

On the portion of the CRNG which lays to the east of the Deschutes river, tributaries feed into Willow Creek, which eventually enters the Deschutes River south of Warm Springs, Oregon.

Elevation ranges from 683 meters near Madras to 1557 meters on Gray Butte. The riparian areas that were sampled ranged in elevation from 866 meters at Haystack Reservoir to 1207 meters feet on the west side of Grizzly Mountain. This range represented the entire elevational gradient over which the riparian ecosystems of the CRNG occurred.

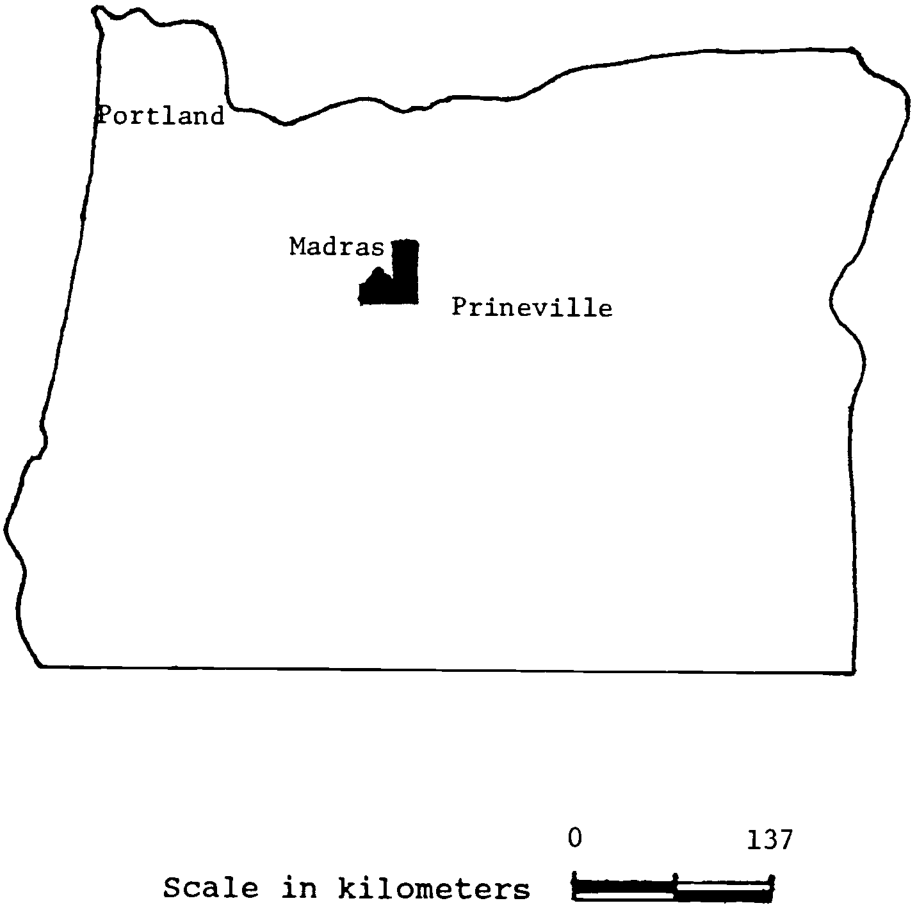
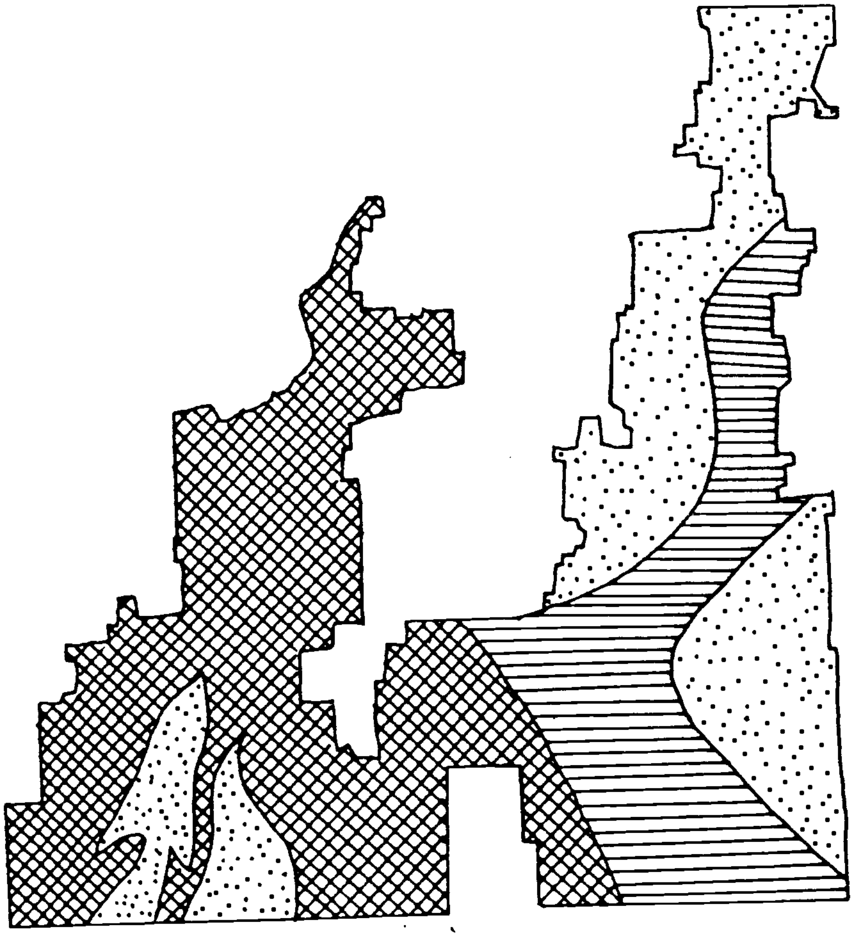


Figure 1. Study area location (shaded area).

Geology and Physiography

The Deschutes river flows through the John Day and the Clarno Formations. The rock exposures found along the canyon walls of the Deschutes were restricted to formation during the Miocene (Orr and Orr 1985). Present in the portion of the Deschutes river canyon which flows though John Day materials are numerous prehistoric landslides, which created debris clogs causing high stream velocities and rapids throughout the length of the river. The area of the river influenced by the Clarno Formation is dominated by the presence of rhyolitic ash.

The Crooked River National Grassland is in the southwestern corner of the Columbia Basin Physiographic Province (Franklin and Dyrness 1973). The main portion of the Columbia Basin Province was formed due to geologic events which occurred during the Miocene era. During this time, a large outpouring of lava flowed to form the Columbia River Basalts. The formation is from 600 to 1500 meters in total thickness, with isolated flows from 8 to 30 meters thick (Franklin and Dyrness 1973). The Columbia River Basalts are extensivley covered by Plio-Pleistocene deposits, typified by the Palouse loess. A general view of the bedrock types of the CRNG (Paulson 1977) may be seen in Figure 2.



Sedimentary rocks

Highly weathered tuffaceous sediments

Basalts and andesites

Figure 2. Bedrock types of the Crooked River National Grassland.

Climate

The mean monthly temperatures and precipitation at two locations near the study area are given in Table 1. The majority of precipitation comes mainly as snow during the winter months. Temperatures tend to be moderate (-1.8 to 20.3 °C) throughout the year (Table 1). The frost-free season is very short with the average growing season approaching only 100 days. Frost can occur any month of the year (Paulson 1977).

Table 1. Monthly mean temperatures (^{o}C) and precipitation (mm) for the Crooked River National Grassland.

Location:	Madras (Elev. 688 m)		Grizzly (Elev. 1109 m)	
Month	Temp. (30 yrs.)	Precip. (10 yrs.)	Temp. (15 yrs.)	Precip. (10 yrs.)
January	-1.1	32.3	-1.8	35.8
February	1.9	28.7	1.1	33.0
March	4.8	25.1	2.8	35.1
April	8.4	15.0	6.7	21.3
May	12.5	33.8	10.8	53.8
June	16.1	21.6	14.0	31.8
July	20.3	9.1	18.5	6.1
August	19.0	6.9	17.4	9.9
September	15.2	10.4	14.5	16.5
October	9.5	15.7	8.9	29.0
November	3.7	34.5	3.5	41.7
December	1.0	34.0	1.0	40.6
ANNUAL	9.2	267.2	8.1	354.6

Vegetation

Arboreal or shrub-dominated riparian communities of the CRNG are predominantly influenced by *Salix lasiandra*, *S. lutea*, *S. lemmonii*, *Populus trichocarpa*, *P. tremuloides* and *S. exigua*. The remaining communities are dominated by various *Carex*, *Juncus* and graminoid species. The major understory dominants in the *Salix* and *Populus* communities include *Poa pratensis* L., *Agrostis alba* L., *Juncus ensifolius* Wikst., *Achillea millefolium* L., *Epilobium glabberimum* Barbey and *Mimulus guttatus* DC.

As of 1988 on the CRNG, 372 hectares of the estimated 958 hectares of riparian zones, creeks and springs, (81%) have been closed to cattle grazing through the construction of corridor fencing. To date, of the total 89.1 kilometers of riparian fence designated to be constructed, 58.7 kilometers (66%) have been completed.

The upland vegetation of the Crooked River National Grassland falls into the juniper-sagebrush-bunchgrass zone (Franklin and Dyrness 1973). Upland vegetation associated with the riparian zones of this area are dominated by *Juniperus occidentalis* Hook. (western juniper) and *Artemisia tridentata* Nutt. (big sagebrush). Areas of higher elevation are dominated by *Pinus ponderosa* Dougl. Ex P. & C. Lawson (ponderosa pine).

A large portion of the CRNG, primarily abandoned croplands, were seeded to *Agropyron cristatum* (L.) Gargth. (crested wheatgrass), *Agropyron spicatum* (Pursh) Scribn.

and Smith (bluebunch wheatgrass) and *Agropyron inerme* (Scribn. and Smith) Rydb. (beardless bluebunch wheatgrass). These species occur on approximately 24,282 hectares of the total 45,326 hectares (54%) which comprise the CRNG. The majority of this seeding was done around 1960 when the Forest Service assumed the management responsibility of this area.

LITERATURE REVIEW

The definition of riparian zones has become more precise over time as a result of increased research, even though a single definition is not universally accepted. The simplest definition of riparian vegetation is "vegetation rooted at the water's edge" (Campbell and Franklin 1979). A more precise definition is: "areas where soil moisture is sufficiently high to support unique plant and animal communities that differ from the surrounding drier uplands" (Johnson and Carothers 1982). The inherent diversity of these ecosystems is a result of "assemblages of plant, animal and aquatic communities whose presence can be either directly or indirectly attributed to factors that are stream-induced or related" (Kauffman and Krueger 1984). The definition proposed by Carter (1978) has been chosen as the most appropriate: "those areas associated with streams, lakes and wet areas where plant communities are predominantly influenced by their association with water".

Riparian zones within the rangelands of the West have the following in common: (1) they create well-defined habitat zones within the much drier surrounding areas; (2) they make up a minor proportion of the overall area; (3) they are generally more productive in terms of biomass -- plant and animal -- than the remainder of the area and (4) they are a critical source of diversity (Thomas et al. 1979).

Importance of Riparian Zones

Wildlife

The importance of riparian zones for wildlife habitat is well documented (Johnson et al. 1977, Thomas et al. 1979, Stauffer and Best 1980, Krausman et al. 1985). Riparian habitats support many of the wildlife species of North America: 42% of mammals, 38% of birds, 33% of reptiles and 13% of amphibians (Hubbard 1977). Thomas et al. (1979) stated that 299 out of 363 species present in the Great Basin of southeast Oregon utilized riparian habitat at some time in their life cycle. They suggested that the reasons riparian zones are so important to so many species of wildlife are: (1) the presence of water lends to an increased occurrence of food, cover and water for use by wildlife; (2) the availability of water causes an increase in plant biomass, especially of those species dependent on high amounts of available water; (3) the exhibition of "edge effect" creates structural diversity and (4) the microclimate attracts wildlife species.

Fisheries and Aquatic Ecosystems

Fish depend on riparian ecosystems for their survival and growth, due to the water temperature regulating abilities of the riparian vegetation. In lower order (headwater) streams, this relationship is especially critical. Anadromous salmonids require cool, moving water, clear migration routes to the ocean, particular gravel bed characteristics for spawning, adequate water quality (related to sediment load and dissolved oxygen content), instream cover and organisms for food (Everest et al. 1985). Resident species have many of the same requirements (Wesche et al. 1985).

Vegetation bordering streams, along with undercut banks and woody debris, provides cover for fish (Armour 1978). It also provides habitat for terrestrial and aquatic insects which are a substantial portion of the fish diet, and allochthonous inputs into the energy pool of the aquatic ecosystem as a whole (Cummins 1974). Vegetation also acts to moderate stream temperature fluctuations over the seasons (Everest et al. 1985).

Streambanks vegetated by herbaceous and/or woody species are better able to dissipate the energy of accelerated stream velocities than are unvegetated streambanks due mostly to the anchoring abilities of roots (Brinson et al. 1981). Armour (1978) stated that this function is similar to that of streambank protection from ice floes, large woody debris and animal trampling.

Livestock

Cattle are attracted to riparian zones for many of the same reasons that wildlife species are. These include the availability of water, a more desireable microclimate, relatively level topography and the quality and variety of forage (Kauffman and Krueger 1984). Cattle may spend more than half of their time in the riparian zone where microclimate tends to be more favorable (Bryant 1982). Roath and Krueger (1982) stated that an eastern Oregon riparian zone accounted for 1.9% of the total allotment and produced about 21% of the total available forage. Eighty-one percent of the total herbaceous vegetation utilized by the cattle was from the riparian zone.

Cattle grazing is the most extensive land use of the interior Pacific Northwest (Skovlin 1977). The majority of literature on riparian zones in semi-arid and arid rangelands suggests that improper grazing by livestock is the primary source of riparian degradation. Many different authors working in a variety of riparian ecosystems have offered solutions to the problem. These range from total exclusion to various manipulations of the animals through changes in management. Total exclusion of livestock from the riparian zone is a restorative practice that has been instituted on many streams (Davis 1982). This exclusion is achieved by fencing the entire riparian zone. Several authors have suggested that livestock exclusion is the only known method of riparian rehabilitation in which functioning, reproducing riparian zones are perpetuated (Davis 1982, Platts 1985, Stuber 1985). Though not without problems, many land managers have also come to view this practice as their only choice for natural riparian rehabilitation. However, this conflicts with one of the current major uses of the semi-arid rangelands of the West: livestock grazing. Therfore, it may not be feasible to all riparian zone managers.

Improving the productivity and structural complexity of riparian zones without the removal of livestock may be an alternative. Authors have suggested that changing the season of grazing in these areas helps to reduce the adverse effects of cattle use (Marlow and Pogacnik 1985). Others stated that the degree of utilization is the key to "successful" grazing of riparian zones. In a Montana riparian ecosystem, Marlow and Pogacnik (1985) reported that little or no degradation of riparian habitats occurred if utilization was 20% or less. Bryant (1985), working in an Oregon riparian area speculated that riparian productivity would increase if forage utilization was less than 70%. Many cattle producers agree with this approach because the riparian zone is often the highest forage producing area of the pasture, and the only place for cattle to water (Swan 1979). Grazing management strategies for riparian zone rehabilitation and/or maintenance include specialized grazing systems, managing riparian zones as special use pastures, and several basic range management practices (e.g. salting, artificial reestablishment of riparian species, upland water development and herding (Bryant 1982, Davis 1982, Kauffman et al. 1983, Platts and Nelson 1985). A grazing strategy which may promote riparian recovery should allow for the recovery of both biological and physical components of the riparian system (Elmore and Beschta 1987).

Riparian Vegetation and the Physical Environment

Quantification of the occurrence of vegetation along any given environmental continuum is an interesting approach to the study of vegetation ecology (Johnson and Lowe 1985, Warren and Anderson 1985). This approach has been applied to the study of riparian vegetation, even though difficulty often arises in establishing causal relationships between the distribution of species and environmental factors (Merry et al. 1981, Warren and Anderson 1985).

Research concerning the vegetation-environmental relationships of the Saskatchewan River riparian ecosystem has resulted in the identification of some pertinent environmental factors that influence vegetation distribution. Walker and Coupland (1968) concluded that the two overriding factors responsible for species presence were a combination of anthropogenic disturbance factors (i.e. mowing and water table fluctuation due to change in water depth or soil moisture). The effects of disturbance resulted in a competitive advantage for some species over others (i.e. Scolochloa festucacea practically eliminated Carex atherodes when the disturbance was mowing). Water level fluctuation was also found to influence species presence (i.e. Senecio congestus was a dominant in the spring and decreased by mid-July which in this case was attributed to seasonal change - a temporal gradient). Dirschl and Coupland (1972) found that the moisture regime (nature of the water supply - water depth class for mid-June and August), position and stability of the water table over the growing season, nutrient status and pH were the most significant physical factors related to species distribution. They concluded that the most applicable physical characterization can be attained through recognition of "landform" (i.e. bog, aquatic, fen, alluvial levee or wooded fen) and "drainage patterns" (i.e. moisture gradient).

Similar results were found by Merry et al. (1981) on the River Wye in Wales. They found that gradients associated with length of growing season such as, pH, nutrient levels and river flow were the significant environmental components affecting vegetation abundance and distribution. A subsequent study encompassing a larger land area in Wales produced different results (Curry and Slater 1986). They concluded that the major environmental factors influencing vegetation distribution appeared to be altitude, intensity of shade and soil nutrient status.

In a study on the distribution of *Salix* species in Wyoming, Patten (1968) described a correlation between physical factors and species occupancy. He found that relative proximity to the river and therefore soil moisture, influenced growth, mortality, cover and height of willows (*Salix farriae*, *S. lutea*, *S. drummondiana* and *S. exigua*). *S. lutea* and *S. exigua* exhibited a lack of vitality, (i.e. vigor), as well as high mortality. Results were further complicated due to heavy browsing by elk which caused dwarfed, clubbed twigs on *S. lutea* and *S. exigua*. All other wilow species exhibited the same damage to a lesser degree. A significant correlation of sand content and willow growth and cover was reported (Patten 1968). Soils which supported willow stands were either sandy loams (53-85% sand) or loamy sands (70-90% sand).

A study in southwestern New Mexico (Medina 1986) quantitatively examined riparian vegetation that had been greatly disturbed. Disturbance was attributed to anthropogenic factors of excessive past livestock grazing and upland deforestation. Medina (1986) concluded that this past disturbance manifested itself through substantial influences on stream morphology and riparian vegetation. The effect of past disturbance was substantiated through observation of changes in size class structure and species composition.

METHODS

Reconnaissance

In the summer of 1986, a reconnaissance of all willow, cottonwood and aspen dominated communities of the Crooked River National Grassland was conducted. These communities represented all types of riparian ecosystems ranging from hydric and mesic streamside communities to xeric upland seep/spring communities. A wide variety in community diversity, composition and structure within the study area was selected for detailed study in an attempt to include the widest range in the physical variables over which the species occurred. Selection of study sites was based on the presence of the Salicaceous dominants chosen for study. All study stands were located within riparian exclosures which had been established to exclude cattle. These exclosures ranged from 1 to 29 years old (Appendix A). Data were collected in a total of 125 stands which were dominated either by Salix lasiandra (n = 69), by S. lutea (n = 21), by S. lemmonii (n = 11), by Populus trichocarpa (n = 9), by P. tremuloides (n = 8) or by S. exigua (n = 7) (Appendix A). A stand of vegetation was delineated by the area falling under the canopy of the Salicaceous dominant. The canopy area could have included one to many individual plants depending on the Salicaceous species (i.e. S. lasiandra stands tended to exist as a single plant, whereas S. exigua stands tended to occur as a group of many stems). The sample numbers reflect the relative abundance of each Salicaceous species on the CRNG.

During initial reconnaissance, identification of the overstory dominants (especially the willows), as well as the understory species began. Often, collection of both male and female flowers of the *Salix* species was not possible until the following field season at which time they were collected for later identification. Taxonomy and nomenclature of the *Salix* species follows that of Brunsfield and Johnson (1985) and Kovalchik (1986), while that of the *Carex* and *Juncus* species follows that of Kovalchik (1986). Taxonomy and nomenclature of the understory species follows that of Hitchcock and Cronquist (1973). Appendix B lists the species encountered.

Vegetation

Salicaceous dominants were classified into three size classes (sapling, intermediate and decadent) based on diameter at 35 cm above the ground surface (Table 2). Size classes were selected based on natural breaks in the diameter for each species. A grand assumption that an increase in stem diameter reflects an increase in age, was made. Because these species are multi-stemmed, the largest stem of the largest individual within each stand was measured. The diameters within each size class varied

Table 2. Classification by diameter range and approximate age of the Salicaceae.

SAPLING

Species	Diameter (cm)	Approximate Age (yrs)
S. lasiandra	.56 - 1.97	5 - 10
S. lutea	1.33 - 2.15	4 - 6
S. lemmonii	.32 - 5.99	1 - 9
P. tremuloides	1.33 - 4.38	3 - 8
S. exigua	2.06 - 2.74	3 - 6

INTERMEDIATE

Species	Diameter (cm)	Approximate Age (yrs)
S. lasiandra	2.11 - 15.28	10 - 15
S. lutea	3.08 - 6.62	6 - 9
S. lemmonii	6.77 - 12.86	9 - 17

DECADENT

Species	Diameter (cm)	Approximate Age (yrs)
S. lasiandra	20.37 - 53.16	42 - 46
S. lutea	13.82 - 29.29	18 - 50
S. lemmonii	20.37 - 23.87	20 - 40
P. trichocarpa	25.40 - 79.90	35 - 66
P. tremuloides	7.80 - 13.69	17 - 42
S. exigua	3.84 - 9.72	10 - 25

among the species due to differences in growth characteristics (i.e. *S. lasiandra* tended to be an arboreal species when large (old), whereas *S. lutea* were smaller, medium-sized shrubs (old)) (Table 2).

The stands were aged by counting growth rings. The larger individuals were cored using an increment borer, while the smaller individuals were sacrificed (Table 2).

Average stand distance from the wetted channel was measured in meters. This was defined as the distance of the center of the stand from the most adjacent free water. Average riparian zone width, in meters, was measured for each stand. This zone was defined as the distance over which riparian vegetation occurred, including the channel if one was present. The age of the exclosures in years (grazing seasons) in which all stands occurred was also recorded.

Water

Wetted channel width (the width of the free water surface) in meters and stream gradient (percent), at base flow (August) were measured for each stand.

Soils

The following soil measurements were taken for each sampled stand.

Bulk density (g/cm3) was measured according to the core method as described in Black and Hartge (1986). A single core (approximately 5.0 cm in diameter by 3.5 cm in height) was taken within the surface soil immediately below any organic horizon that may have existed. The same cores were used for the macroporosity determination.

Measurements of macroporosity in percent were accomplished through the use of a pressure chamber (OSU Soil Physics Laboratory). The cores were allowed to saturate over a 24 hour period and subsequently weighed. The saturated cores were placed in a pressure chamber and allowed to equilibrate with 5.879 kPa of pressure. This standard pressure is equivalent to 60 cm of suction which is the tension at which water in pores >0.05 mm in diameter (macropores) is vacated (Danielson and Sutherland 1986). Upon equilibration, the cores were removed from the chamber and weighed. Oven dry weight (24 hours at 100 ^{o}C) was obtained. Percent macropores was calculated using the following formula:

$$MP = \frac{W(1) - W(2)}{W(3)} \times 100 \times BD$$

MP = macropores, % by volume
W(1) = saturated soil weight (g)
W(2) = soil weight after equilibration with 5.879 kPa (g)
W(3) = oven dry soil weight (g)
BD = bulk density (g/cm3)

Depth to root restricting layers (i.e. impenetrable or gleyed horizons), were measured in meters utilizing a soil (wheatland) auger. If depths were greater than one meter they were recorded as 1.01 m for data analysis purposes. Four estimates were taken within each stand.

To describe the influence of edaphic characteristics on species occupancy, percent organic matter, particle size analysis and percent coarse and fine materials were measured. Composite samples from 5 selected locations within the stand were collected for analysis. The composite sample was composed of the upper 10 cm of the surface mineral horizon. Organic horizons (if present) were not included in the sample. Samples were placed in air-tight plastic bags until analyzed. Samples were air dried and mixed thoroughly prior to analysis.

The percent coarse materials (>2 mm diameter) and percent fine materials (< 2 mm diameter) were obtained by dry sieving a known quantity of the air dry sample through a 2mm diameter sieve (Berg and Gardner 1978).

Determination of percent organic matter of the <2 mm diameter fraction was accomplished utilizing a hydrogen peroxide (H202) digestion technique (Day 1965). This determination was done on 2 subsamples from each composite sample.

Particle size analysis was determined on an organic matter free sample. A modified Buoyoucos hydrometer method (Gee and Bauer 1983) was used to determine soil textural class. Duplicate subsamples from each composite were included. Textural classes were assigned according to the guidelines of the SCS (1975).

Soil pH (2:1 water:soil) was determined using a glass electrode pH meter (Berg and Gardner 1978) on the <2 mm diameter fraction of the soil sample. This determination was done on 2 subsamples from each composite sample.

Depth of an organic horizon, if present, in centimeters was measured at four locations within each stand. The four measurements were then averaged to get mean organic horizon depth.

Other Data

In addition to soils and physical location of the stand, other data were also collected to further characterize habitat including: 1) height and canopy cover of the dominant in meters, 2) width and length of the stand in meters, 3) aspect in degrees and 4) elevation in meters.

Acronyms for the physical variables as they occur in subsequent tables can be found in Appendix C.

Data Analysis

To aid in the identification of the habitats occupied by the various Salicaceous species, the 19 environmental (physical) variables were subjected to canonical discriminant analysis (CANDISC, SAS 1987). Discriminant analysis represents a multivariate approach to "pattern recognition and interpretation" (Williams 1983). The data input to discriminant analysis was composed of several individuals each having a grouping index (species) and an associated vector of measurements (physical variables). The two major objectives of this type of analysis are 1) prediction and 2) separation (Williams 1983). The purpose of this discriminant analysis was for group separation of the *Salix* and *Populus* species based on an accompanying set of 19 environmental variables stratified according to size class (i.e. sapling, intermediate and decadent). This type of discriminant analysis "seeks to exhibit differences among populations by means of linear combinations of the observation variables which results in maximizing among-group variation relative to within-group variation" (Williams 1983).

The analytical process used for this data set was to
1) use multivariate analysis of variance (MANOVA) to
determine significant difference among groups,
2) classify each sample (vector of physical variable
measurements for each stand) according to size class,
3) determine Mahalanobis' distances between group (class)
centroids and 4) display group separations in discriminant
space (Pimentel 1979).

RESULTS

Analysis of Salix and Populus Habitat

Sapling Size Individuals

A very apparent attribute of the riparian stands dominated by Salicaceous plants at the CRNG was the complete lack of newly establishing *P. trichocarpa*. Young cottonwoods from root suckering occurred across the study area, but nowhere were there "new" stands of young cottonwood. This may be a result of the loss of the habitat that this species requires (see discussion).

Within the sapling size class, means of all variables listed in Table 3 were tested for differences between species using an F test. There were significant differences between species for 6 variables ($p \leq .15$). These variables were wetted channel width, average riparian zone width, average stand distance from the wetted channel, stream gradient, aspect and exclosure age. Average stand distance from the channel, stream gradient and aspect were significant at the $p \leq .05$ level. The differences associated with wetted channel width, average riparian zone width and exclosure age are heavily influenced by the presence of a lake (relatively large body of water) which has been exclosed for a relatively long period of time. When these three variables were removed from the analysis, the remaining three variables (average stand distance from the wetted channel, stream gradient and aspect) were still highly significant ($p \leq$

Table 3. Means and test statistics (ANOVA) associated with physical variables of the sapling size class.

	Sala	Salu	Sale	Potr	Saex	Pr > F
N	16	8	4	4	4	
pH	7.20	7.20	7.00	7.40	7.30	0.5201
MP (%)	23.63	29.21	27.78	32.34	28.12	0.3406
BD (g/cm3)	0.89	0.95	0.81	0.80	0.85	0.8082
CLAY (%)	20.20	22.00	24.17	16.15	22.70	0.6680
SAND (%)	56.08	52.94	47.82	67.10	50.75	0.6921
SILT (%)	23.81	25.16	28.08	16.85	26.68	0.8174
OM (%)	5.42	6.18	6.96	5.04	4.06	0.4814
COARSE (%)	34.51	29.63	23.63	19.40	41.69	0.2469
FINE (%)	65.49	70.37	76.37	80.60	58.31	0.2459
O HORIZON (cm)	0.76	0.46	0.36	0.42	0.26	0.5936
IMPENETR (m)	0.50	0.45	0.74	0.68	0.52	0.7649
GLEYING (m)	0.73	0.81	>1.00	>1.00	>1.00	0.3700
WET CHAN (m)	36.14	138.09	1.06	0.46	274.13	0.1264 *
RIP ZONE (m)	15.00	42.33	8.72	5.21	78.71	0.1392 *
DIST FRO (m)	3.33	27.72	1.52	1.86	50.32	0.0432 **
GRADIENT (%)	9.00	8.00	20.00	19.00	4.00	0.0148 **
ASPECT (σ)	169.00	90.00	248.00	225.00	11.00	0.0069 **
ELEVATION (m)	1066.00	1012.00	1114.00	1086.00	973.00	0.3611
EXCLOSURE (yrs)	10.00	13.00	10.00	7.00	20.00	0.1466 *

* - physical variables with class means significantly different at the $p < .15$ level

** - physical variables with class means significantly different at the $p < .05$ level

Multivariate Statistic	F	Pr > F
Wilks' Lambda	1.3244	0.1354

.05), with Pr > F values of .0432, .0148 and .0069 respectively. When the species groups were tested by MANOVA over all physical variables, Pr > F = .1354.

Differences in average stand distance from the channel for the sapling size members of the Salicaceae were attributed to where the species occurred in response to fluctuation in water table depth. Species were ordered from those which occur on flat valley bottoms up to those that occur at the headwaters. The species occurred as follows ranked from valley bottom to headwater: S. exigua (50.32m ± 7.65m), S.lutea (27.72m ± 6.80m), S. lasiandra (3.38m ± 3.36m), P. tremuloides (1.86m ± 1.20m) and S. lemmonii (1.52m ± 1.01m) (Table 3). This phenomenon was readily apparent in the field.

Stream gradient was another physical variable which segregated species within the sapling size class. The variable is also related to the tendency for certain species to occupy headwater stream systems, while others occurred on the flatter bottoms. S. lemmonii occupied areas of steep stream gradient (20% ± 3%), while P. tremuloides also tended to occur in headwater systems (19% ± 2%). S. lasiandra and S. lutea occupied streams of similar gradient, 9% ± 3% and 8% ± 3%. The species which most obviously, (statistically and through observation), occupied relatively flat streambeds was S. exigua (4% ± 1%).

The two variables above, very accurately describe the positions of these species related to stream-valley geomorphology.

Aspect proved to be an interesting physical variable which the sapling size individuals "responded" to very strongly ($Pr > F = .0069$). S. exigua was found on streams with a generally northeast flow ($11^{\circ} \pm 5^{\circ}$), S. lutea on streams with an easterly direction ($90^{\circ} \pm 11^{\circ}$), S. lasiandra on streams with a southeasterly direction ($169^{\circ} \pm 10^{\circ}$), with P. tremuloides and S. lemmonii on streams with a southwesterly flow ($225^{\circ} \pm 7^{\circ}$ and $248^{\circ} \pm 9^{\circ}$ respectively). This attribute of these data is probably more indicative of the drainage direction (aspect) on the CRNG than any vegetative response. The absence of the Salicaceae of this size class on north- and northwest-facing slopes is readily apparent though, suggesting a possible need for higher soil temperatures as an establisment requirement for these species.

Of equal importance to these 'separating' variables are those which remain relatively constant for these species within this size class. These consistent variables include all soil-related variables (Table 3). Salicaceous species of the sapling size class occupied similar microsites of surface soil texture.

Canonical discriminant function analysis further substantiated the segregatory abilities of the above variables (Table 4). Canonical discriminant functions

Table 4. Summary of canonical discriminant function analysis of physical variables for the sapling size class.

CANONICAL DISCRIMINANT FUNCTIONS

FUNCTION	EIGENVALUE	PERCENT OF VARIANCE	CUMULATIVE PERCENT	CANONICAL CORRELATION
1	3.6923	0.5555	0.5555	0.8871
2	1.8502	0.2784	0.8338	0.8057
3	0.8072	0.1214	0.9553	0.6683
4	0.2973	0.0447	1.0000	0.4787

TOTAL CANONICAL STRUCTURE

VARIABLE	FUNCTION 1	FUNCTION 2	FUNCTION 3	FUNCTION 4
pH	0.0831	0.1501	0.1427	0.5404
MP (%)	0.2342	0.3555	-0.0020	0.1685
BD (g/cm3)	-0.1590	0.0330	-0.2502	0.0383
CLAY (%)	-0.0385	0.0700	-0.1108	-0.5185
SAND (%)	0.0607	-0.0425	0.0995	0.5078
SILT (%)	-0.0649	0.0210	-0.0770	-0.4236
OM (%)	0.1772	-0.0777	-0.3774	-0.2167
COARSE (%)	-0.4092	-0.0193	0.1527	-0.2424
FINE (%)	0.4092	0.0193	-0.1527	0.2424
O HORIZON (cm)	-0.1343	-0.3006	-0.0803	0.1846
IMPENETR (m)	0.2359	-0.0371	0.1418	-0.1001
GLEYING (m)	0.2518	0.2506	0.2490	-0.1729
DIST FROM (m)	-0.2517	0.5482 *	0.0751	-0.2770
GRADIENT (%)	0.6240 *	-0.1465	0.0099	0.0534
ASPECT (o)	0.4803	-0.5098 *	-0.0250	0.1711
ELEVATION (m)	0.2650	-0.3319	-0.0008	0.0370

* - highest r value

(CDFs) are linear combinations of those variables which best separate the species groups (S. lasiandra, S. lutea, S. lemmonii, P. trichocarpa, P. tremuloides and S. exigua). Canonical discriminant function analysis was run on each size class within each species group. The eigenvalue, percent variance, cumulative percent variance and canonical correlation related to each canonical discriminant function are indications of that function's dicriminatory power (Noon 1981). CDF 1 and CDF 2 explained 83.38% of the variation in species groups. The values of total canonical structure (Table 4) are the correlations between 16 of the original 19 physical variables (three were omitted to remove the overpowering influence of the lake) and the computer generated canonical discriminant functions.

A graph of the sapling sized individuals displayed in canonical discriminant space exhibits these individuals grouped by species (Figure 3). P. tremuloides and S. lemmonii are very different in their habitat according to stream-valley geomorphology than are the remaining three species. Further substantiation for the existence of these groups in discriminant space are the Mahalanobis' distances between group centroids (Table 5). P. tremuloides and S. lemmonii are very similar (distance of 6.5968) while at the other extreme, these two are very dissimilar with S. exigua (distance of 37.5591 and 27.9585 respectively). The discriminant analysis indicated that

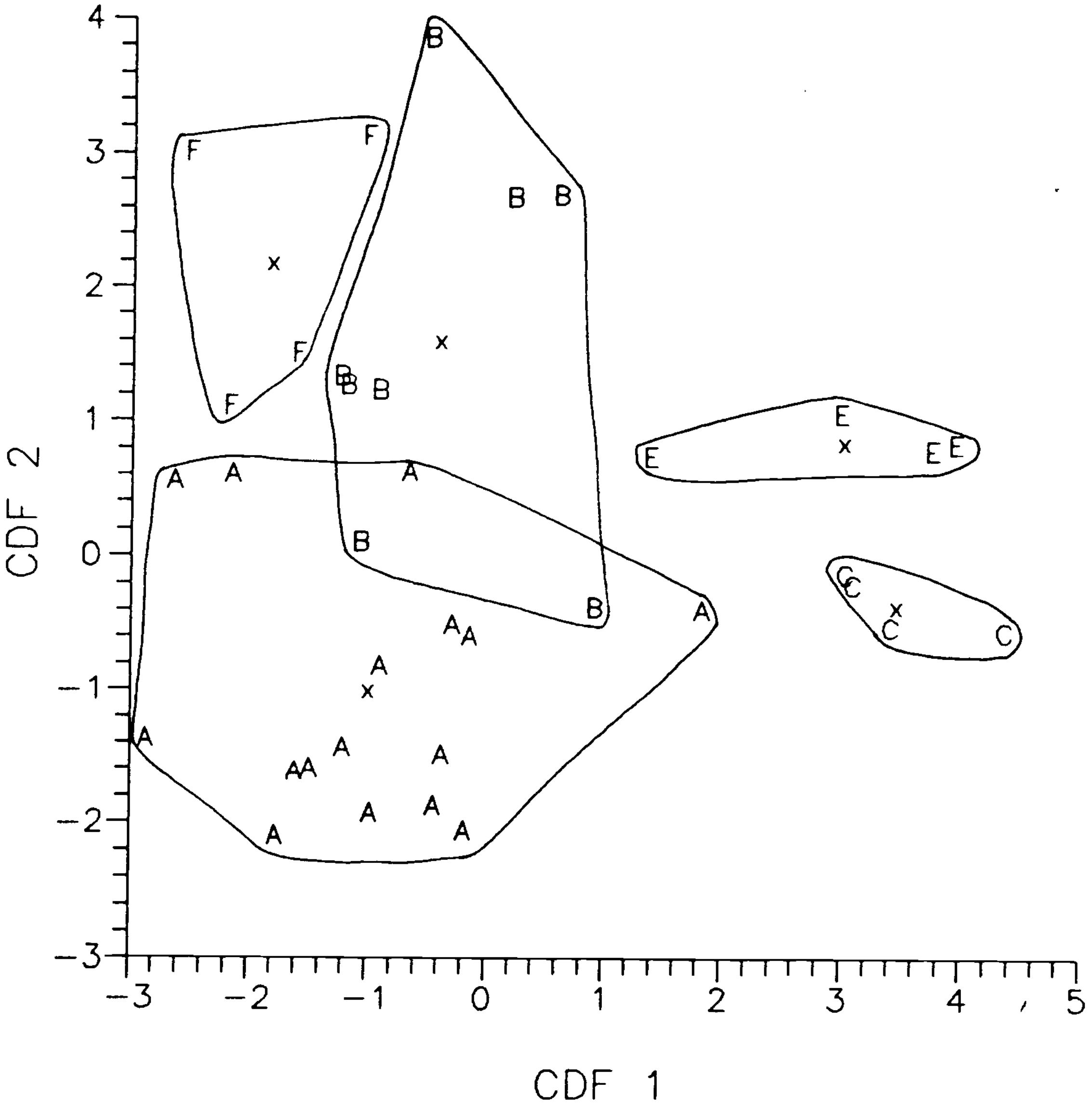


Figure 3. Plot of Canonical Discriminant Functions 1 and 2 for Sapling Size Individuals. Symbols: (A) S. lasiandra; (B) S. lutea; (C) S. lemmonii; (E) P. tremuloides; (F) S. exigua.

Table 5. Mahalanobis' distances between group centroids for the sapling size class.

	Squared Distance To				
Distance From	Sala	Salu	Sale	Potr	Saex
Sala	0				
Salu	8.7622	0			
Sale	21.4594	21.1903	0		
Potr	20.8338	17.3658	6.5968	0	
Saex	13.4922	10.5853	37.5591	27.9585	0

CDF 1 was most highly correlated with increasing stream gradient (r = .6240) while CDF 2 was most correlated to increasing distance from the stream channel (r = .5482) and a decreasing response to aspect (r = -.5098) (Table 4). Relative to these two variables, the *Salix* and *Populus* species occupied different locations along these gradients.

Along an environmental gradient of increasing stream gradient (i.e. an elevational gradient from downstream up to headwater stands), the species occurred as follows: *S. exigua*, *S. lasiandra*, *S. lutea*, *P. tremuloides* and *S. lemmonii* (Figure 3).

Along the secondary gradient of increasing average stand distance from the wetted channel, the species occurred as follows: *S. lasiandra*, *S. lemmonii*, *P. tremuloides*, *S. lutea* and *S. exigua* (Figure 3).

Intermediate Size Individuals

This data set consisted of only three of the six species studied: *S. lasiandra*, *S.lutea* and *S.lemmonii*. There were no other species of this size class at the CRNG (Table 2). Hypothetically, during the time frame when these individuals of the intermediate size class were establishing, the exclosures did not exist. As a result those species that were apparently more sensitive to past cattle use (*P. trichocarpa*, *P. tremuloides* and *S. exigua*) did not establish during this time period and are conspicuously absent from the current population.

The intermediate size class of Salix species exhibited significant differences in the following physical variables at the $p \leq .15$ level: soil macroporosity, soil organic matter content and depth to an impenetrable layer (Table 6). Of these three variables, soil macroporosity and soil organic matter content were significant at the $p \leq .05$ level (MANOVA of all physical variables, $Pr > F = .0095$). These significant edaphic variables suggest that the Salix species of this size class vary in their habitats according to soil structure. Soil macroporosity and soil organic matter content of the surface soil are indicative of the moisture retention ability of the soil. Depth to an impenetrable layer is also indicative of moisture retention, but at a deeper level in the soil. If an impermeable layer is present in the soil profile, water tends to pond upon this layer creating a perched water table. Riparian plant species vary in their abilities to exist in this type of soil condition.

Differences in soil macroporosity for this size class is interpreted as one of an increasing need for unbound water (i.e. water available for plant growth and maintenance). The species occurred as follows, ranked according to increasingly macroporous surface soils: S. lutea (25.30% ± 2.50%), S. lasiandra (27.00% ± 1.61%) and

Table 6. Means and test statistics (ANOVA) associated with physical variables of the intermediate size class.

	Sala	Salu	Sale	Pr > F
N	30	9	3	
pH	7.40	7.30	7.10	0.5739
MP (%)	27.00	25.30	44.80	0.0039 **
BD (g/cm3)	0.87	0.95	0.71	0.2877
CLAY (%)	25.62	22.61	22.00	0.5414
SAND (%)	48.13	53.91	53.43	0.6853
SILT (%)	26.32	23.54	24.60	0.8651
OM (%)	5.54	7.54	11.41	0.0131 **
COARSE (%)	27.77	36.93	36.07	0.2903
FINE (%)	72.22	63.01	63.93	0.2873
O HORIZON (cm)	0.62	0.41	0.37	0.7378
IMPENETR (m)	0.54	0.24	0.38	0.0681 *
GLEYING (m)	0.87	0.81	0.77	0.7873
WET CHAN (m)	75.47	61.63	1.40	0.7951
RIP ZONE (m)	29.94	20.34	10.21	0.7620
DIST FROM (m)	10.83	14.05	5.88	0.9061
GRADIENT (%)	8.00	8.00	15.00	0.1575
ASPECT (o)	130.00	90.00	195.00	0.2747
ELEVATION (m)	1019.00	1053.00	1128.00	0.2309
EXCLOSURE (yrs)	11.00	11.00	8.00	0.7200

* - physical variables with class means significantly different at the $p < .15$ level

** - physical variables with class means significantly different at the $p < .05$ level

Multivariate Statistic	F	Pr > F
Wilks' Lambda	2.1158	.0095

S. lemmonii (44.80% ± 4.58%). Depth to a gleyed horizon also supports this observation. A gleyed horizon (indicative of water table depth) was closest to the soil surface for S. lemmonii and deepest for S. lutea.

Percent soil organic matter content was another physical variable which readily segregated the intermediate sized individuals. This variable was indicative of the relative degree to which the leaves of these species decayed. In other words, the leaves of these species appeared to contain varying amounts of recalcitrant materials. This phenomenon of increasing soil organic matter content was interpreted to also be indicative of the relationship to surface soil structure. The species were ordered as follows: S. lasiandra (5.54% ± 1.62%), S. lutea (7.54% + 1.83%) and S. lemmonii (11.41% ± 2.94%).

Depth to an impenetrable layer was a physical variable which influenced these species. This gradient was interpreted to indicate species response to water table depth. S. lutea occupied areas where the water table was close to the surface (.24m ± .55m), S. lemmonii at deeper water tables (.38m ± .65m), with S. lasiandra occurring in areas of the deepest water tables (.54m ± .58m) (Table 6).

As was apparent in the sapling size class, the soil-related variables (except for the three above) did not vary within this size class between all species (Table 6). Salicaceous species of the intermediate size class occupied similar microsites based on most of the surface soil characteristics.

Canonical discriminant function analysis further supported these observations of the separating powers of the above variables (Table 7). CDF 1 and CDF 2 explained 100% of the variation (the maximum number of CDFs is equal to the number of classes minus one: 3 classes minus 1 equals 2 CDFs) in species groups (Figure 4).

Further substantiation for the existence of these groups in discriminant space are the Mahalanobis' distances between group centroids (Table 8). S. lasiandra and S. lutea were very similar with a distance of 5.6318, while S. lemmonii was very dissimilar from them with distance values of 27.2597 and 25.6197. The analysis indicated that CDF 1 was most highly correlated with increasing soil macroporosity ($r = .5590$) and increasing soil organic matter content ($r = .5334$), while CDF 2 was most highly correlated to depth to an impenetrable layer ($r = .4651$) (Table 7). CDF 1 was interpreted to be an environmental gradient in response to soil structure (surface soil moisture retention capacity) and CDF 2, an environmental gradient due to depth to water table. Overall, areas closest to the stream origin are driest, while those areas farther away from the origin are wettest.

Table 7. Summary of canonical discriminant function analysis of physical variables for the intermediate size class.

CANONICAL DISCRIMINANT FUNCTIONS

FUNCTION	EIGENVALUE	PERCENT OF VARIANCE	CUMULATIVE PERCENT	CANONICAL CORRELATION
1	1.9236	0.6753	0.6753	0.8521
2	0.9248	0.3247	1.0000	0.7551

TOTAL CANONICAL STRUCTURE

VARIABLE	FUNCTION 1	FUNCTION 2
pH	-0.2056	0.0229
MP (%)	0.5590 *	0.2948
BD (g/cm3)	-0.1996	-0.2725
CLAY (%)	-0.1601	0.1713
SAND (%)	0.1085	-0.1544
SILT (%)	-0.0526	0.1078
OM (%)	0.5334 *	-0.1590
COARSE (%)	0.1926	-0.2777
FINE (%)	-0.1927	0.2794
O HORIZON (cm)	-0.1125	0.1219
IMPENETR (m)	-0.1941	0.4651 *
GLEYING (M)	-0.1146	0.0860
DIST FROM (m)	-0.0469	-0.0865
GRADIENT (%)	0.3522	0.1355
ASPECT (o)	0.1771	0.3055
ELEVATION (m)	0.3248	-0.0791

* - highest r value

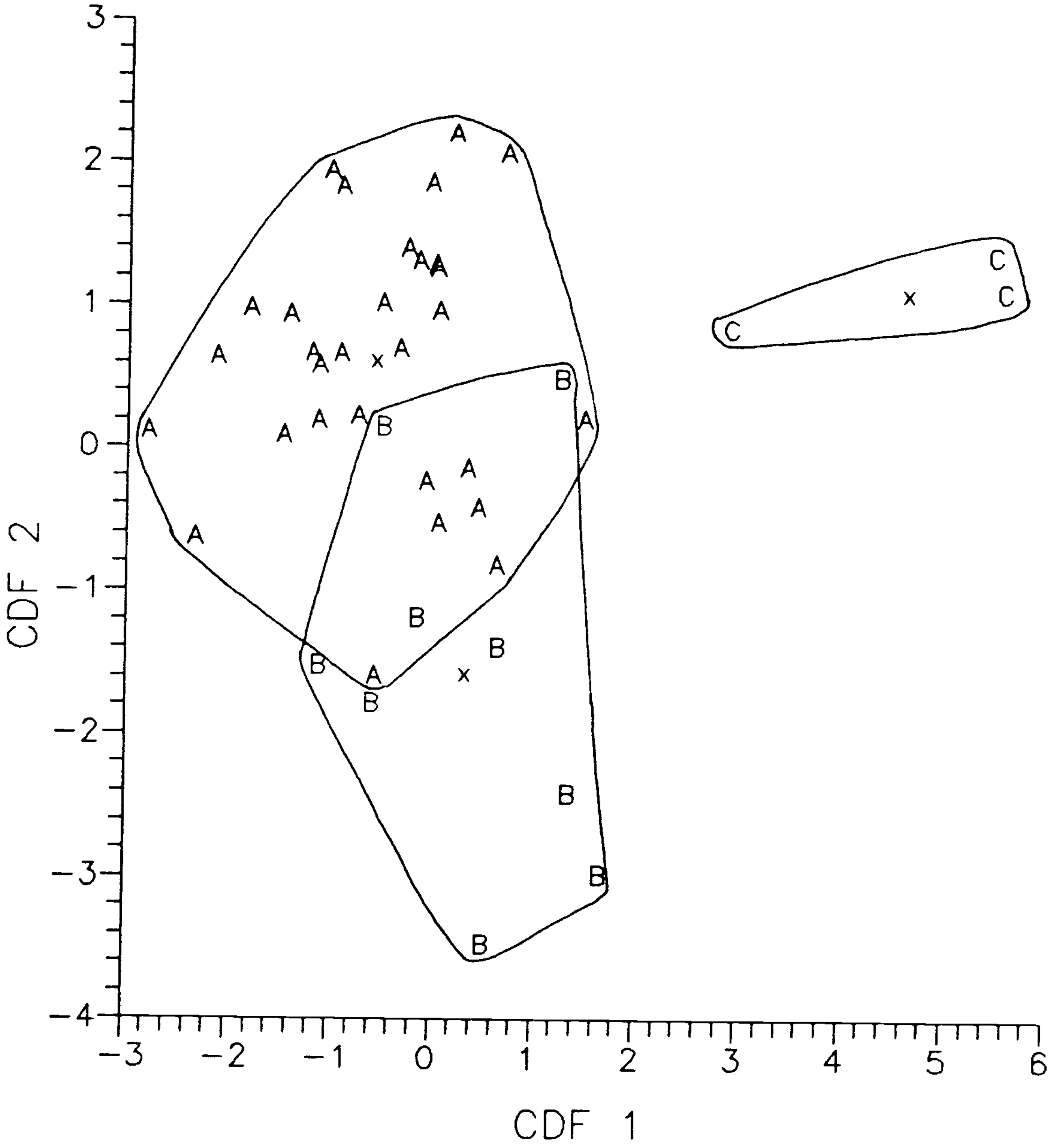


Figure 4. Plot of Canonical Discriminant Functions 1 and 2 for Intermediate Size Individuals. Symbols: (A) S. lasiandra; (B) S. lutea; (C) S. lemmonii.

Table 8. Mahalanobis' distances between group centroids for the intermediate size class.

	Squared Distance To		
Distance From	Sala	Salu	Sale
Sala	0		
Salu	5.6318	0	
Sale	27.2597	25.6197	0

Along the gradient of increasing surface moisture retention, the species occured as follows: S. lasiandra, S. lutea and S. lemmonii (Figure 4).

Along the gradient of response to water table depth, the species occurred as follows: S. lutea, S. lasiandra and S. lemmonii (Figure 4).

Decadent Individuals

All the Salicaceous species were present in this class. The individuals of this size class ranged over various stages of complete overstory dominance to extreme deterioration. The most noticeable of these, was P. trichocarpa. All of the cottonwoods of this size class across the CRNG were very decadent with a high proportion of dead crowns in all the individuals.

The physical variables associated with the decadent individuals were tested for differences in habitat (Table 9). Depth to an impenetrable layer was significant at the $p \leq .15$ level, while seven additional variables were significant at the $p \leq .01$ level. These were soil macroporosity, wetted channel width, average riparian zone width, average stand distance from the wetted channel, stream gradient, elevation and exclosure age.

As occurred in the sapling size data, the differences associated with wetted channel width, average riparian zone width and exclosure age, were heavily influenced by the presence of the lake which had been exclosed to

Table 9. Means and test statistics (ANOVA) associated with physical variables of the decadent size class.

	Sala	Salu	Sale	Potr1	Potr	Saex	Pr > F
N	22	4	4	9	4	4	
pH	7.40	7.20	7.00	7.50	7.20	7.40	0.5152
MP (%)	23.89	25.30	28.74	28.63	39.82	22.31	0.0003 **
BD (g/cm3)	0.96	1.05	0.99	0.92	0.77	0.98	0.5631
CLAY (%)	21.14	20.32	16.98	19.84	16.32	12.42	0.5262
SAND (%)	55.86	54.40	49.32	50.61	56.58	69.85	0.6332
SILT (%)	23.08	25.35	33.78	29.56	22.15	17.78	0.4981
OM (%)	5.75	12.57	5.18	4.83	5.17	3.47	0.1522
COARSE (%)	29.81	30.86	21.70	19.37	10.42	21.69	0.1957
FINE (%)	70.18	69.14	78.30	80.63	89.58	78.31	0.1957
O HORIZON (cm)	0.61	0.52	1.04	0.39	0.52	0.86	0.8164
IMPENETR (m)	0.60	0.32	>1.00	0.72	0.94	0.68	0.1002 *
GLEYING (m)	0.98	>1.00	>1.00	0.91	>1.00	0.80	0.5044
WET CHAN (m)	27.80	1.04	547.62	62.48	0.88	410.93	0.0001 **
RIP ZONE (m)	17.93	8.52	163.83	37.12	11.53	58.88	0.0001 **
DIST FROM (m)	4.50	0.75	76.58	17.29	7.79	22.14	0.0001 **
GRADIENT (%)	10.00	7.00	3.00	5.00	19.00	4.00	0.0043 **
ASPECT (o)	147.00	79.00	90.00	125.00	112.00	214.00	0.6474
ELEVATION (m)	1053.00	1141.00	866.00	915.00	1083.00	928.00	0.0021 **
EXCLOSURE	7.54	5.5	29.00	12.89	8.25	24.25	0.0001 **

* - physical variables with class means significantly different at the p < .15 level

** - physical variables with class means significantly different at the p < .05 level

Potr1 - quaking aspen

Potr - black cottonwood

Multivariate Statistic	F	Pr > F
Wilks' Lambda	2.1118	0.0001

livestock grazing for a disproportionate period of time relative to the other exclosures. When these three variables were removed from the analysis, the remaining five variables (depth to an impenetrable layer, soil macroporosity, average stand distance from the wetted channel, stream gradient and elevation) remained highly significant. Depth to an impenetrable layer was significant at $p < .15$ ($Pr > F = .1002$), while the other variables, soil macroporosity, average stand distance to the wetted channel, stream gradient and elevation were significant at $p \leq .01$, $Pr > F$ of .0003, .0001, 0043 and .0021 respectively. When the species groups were tested by MANOVA over all physical variables, $Pr > F = .0001$.

Differences in soil macroporosity for the decandent sized individuals are due to the occurrence of these species over an environmental gradient interpreted as one of an increasing need for unbound water, or oxygenation. This gradient was suggested for intermediate sized individuals as well. The species occurred as follows ranked according to this variable: _S_. _exigua_ (22.31% ± 1.66%), _S_. _lasiandra_ (23.89% ± 2.39%), _S_. _lutea_ (25.30% ± 2.78%), _P_. _trichocarpa_ (28.63% ± 2.42%), _S_. _lemmonii_ (28.74% ± 2.27%) and _P_. _tremuloides_ (39.82% ± 2.43%) (Table 9). The appearance of soil macroporosity as a separator of species groups in both the intermediate and decadent size classes, alludes to the relationship of the species to surface soil structure. The occurrence of _S_.

lemmonii and *P. tremuloides* on very sandy microsites was readily observed in the field over all size classes, but especially when decadent. As time progresses, these species seem to occupy areas of increasingly porous soils.

Depth to an impenetrable layer was a physical variable which influenced these species both in the intermediate and the decadent size classes. This was again interpreted to be an indication of the degree to which the species could tolerate a deep water table. The species ranged from *S. lutea* (.32m ± .62m) being the least tolerant, to *S. lasiandra* (.60m ± .62m), *S. exigua* (.68m ± .62m), *P. trichocarpa* (.72m ± .63m), *P. tremuloides* (.72m ± .39m) with *S. lemmonii* (>1.00m) being the most tolerant.

Differences in average stand distance from the channel for the decadent size class occurred. This variable is a function of valley bottom width, (i.e. restricted versus unrestricted stream systems). The species occurred as follows, ranked from most to least restricted stream channels: *S. lutea* (.75m ± .54m), *S. lasiandra* (4.50m ± 3.92m), *P. tremuloides* (7.79m ± 3.55m), *P. trichocarpa* (17.29m ± 5.34m), *S. exigua* (22.14m ± 5.61m), and *S. lemmonii* (76.58m ± 4.05m) (Table 9).

Not surprising was the fact that stream gradient readily segregated the decandent size individuals as it did for the saplings. This variable accounted for the tendency of certain species to occupy headwater (low order) stream systems, while others occurred on the flatter (higher order) bottoms. The species occurred as follows, from headwater (restricted) to downstream (unrestricted) systems: *P. tremuloides* (19% ± 2%), *S. lasiandra* (10% ± 3%), *S. lutea* (7% ± 1%), *P. trichocarpa* (5% ± 2%), *S. exigua* (4% ± 1%) and *S. lemmonii* (3%) (Table 9). The most significant aspect of this ranking is the presence of *P. tremuloides* in the steeper, headwater drainages of the CRNG. This same pattern was evident for the sapling size class.

The decadent sized individuals responded to an increase in elevation. They were ordered as follows from highest to lowest: *S. lutea* (1141m ± 4m), *P. tremuloides* (1083m ± 7m), *S. lasiandra* (1053m ± 12m), *S. exigua* (928m ± 11m), *P. trichocarpa* (915m ± 11m) and *S. lemmonii* (866m) (Table 9). This relationship was apparent from field observations, and represented sampling error rather than any real ecologcial phenomenon.

As was apparent in the younger size classes the soil-related variables (except for macroporosity) were not different among species (Table 9). Decadent sized Salicaceous species occupied similar microsites based on the majority of surface soil characteristics.

Canonical discriminant function analysis further substantiated the separating powers of the above variables (Table 10). CDF 1 and CDF 2 explained 81.63% of the variation in species groups. Further substantiation for the existence of these groups in discriminant space are

Table 10. Summary of canonical discriminant function analysis of physical variables for the decadent size class.

CANONICAL DISCRIMINANT FUNCTIONS

FUNCTION	EIGENVALUE	PERCENT OF VARIANCE	CUMULATIVE PERCENT	CANONICAL CORRELATION
1	2.9809	0.4368	0.4368	0.8653
2	2.5900	0.3795	0.8163	0.8494
3	0.5684	0.0833	0.8996	0.6020
4	0.4230	0.0620	0.9615	0.5452
5	0.2625	0.0385	1.0000	0.4560

TOTAL CANONICAL STRUCTURE

VARIABLE	FUNCTION 1	FUNCTION 2	FUNCTION 3	FUNCTION 4
pH	-0.1421	0.0990	-0.4054	-0.1850
MP (%)	0.7394 *	-0.0324	-0.0889	-0.0006
BD (g/cm3)	-0.2715	-0.0208	0.2924	-0.0642
CLAY (%)	-0.0489	0.1984	-0.0755	-0.2230
SAND (%)	-0.1460	0.0280	-0.1835	0.2679
SILT (%)	0.1282	-0.1943	0.2390	-0.2834
OM (%)	-0.0292	0.2800	0.5112	-0.1973
COARSE (%)	-0.3511	0.1991	0.2207	0.0326
FINE (%)	0.3511	-0.1991	-0.2207	-0.0326
O HORIZON (cm)	-0.0634	-0.1393	0.1313	0.3064
IMPENETR (m)	0.3292	-0.3460	-0.1230	0.2485
GLEYING (m)	0.1407	0.1819	0.2867	0.1201
DIST FROM (m)	0.1620	-0.7609 *	0.4787	0.2602
GRADIENT (%)	0.3849	0.4679 *	-0.2524	0.3626
ASPECT (o)	-0.1876	-0.0305	-0.3270	0.1692
ELEVATION (m)	-0.0069	0.6826 *	0.1514	0.2042

* - highest r value

the Mahalanobis' distances between group centroids (Table 11). P. tremuloides and S. exigua are extremely dissimilar with a distance value of 55.4772. This is due to the fact that neither occur in the others habitat - P. tremuloides is a headwater species, while S. exigua is a bottom land species. S. lasiandra and S. lutea occupy very similar sites with a distance value of 6.4995. The discriminant analysis indicated that CDF 1 was most highly correlated with increasing soil macroporosity (r = .7394) while CDF 2 was most highly correlated to decreasing stand distance from the wetted channel (r = -.7609), increasing elevation (r = .6826) and increasing stream gradient (r = .4679) (Figure 5). CDF 1 was interpreted to represent a gradient of aggrading soil structure, in particular moisture retention ability, while CDF 2 was interpreted to be a gradient of headwater to basin riparian systems.

Along the gradient of headwater to basin ecosystems, the species occurred as follows: S. exigua, S. lasiandra, S. lutea, P. trichocarpa, S. lemmonii, and P. tremuloides (Figure 5).

Along the gradient of decreasing stand distance from the wetted channel, the species occurred as follows: S. lemmonii, S. exigua, P. trichocarpa, S. lasiandra, P. tremuloides and S. lutea (Figure 5).

Table 11. Mahalanobis' distances between group centroids for the decadent size class.

	Squared Distance To					
Distance From	Sala	Salu	Sale	Potr1	Potr	Saex
Sala	0					
Salu	6.4995	0				
Sale	23.1080	34.4843	0			
Potr1	7.3718	16.3529	11.4553	0		
Potr	27.9691	31.1580	36.0205	23.0148	0	
Saex	11.9906	25.5534	20.6684	13.5169	55.4772	0

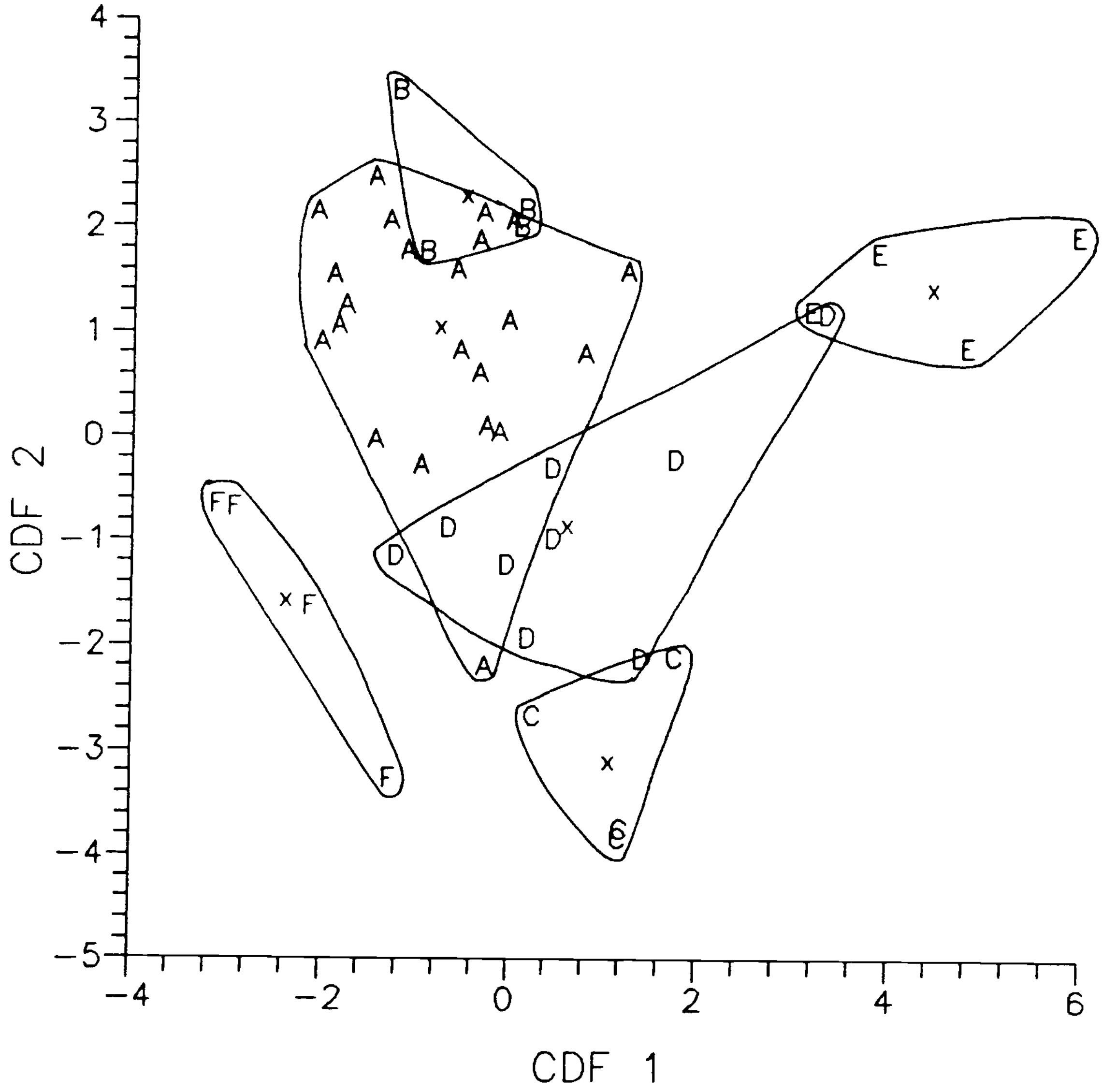


Figure 5. Plot of Canonical Discriminant Functions 1 and 2 for Decadent Size Individuals. Symbols; (A) S. lasiandra; (B) S. lutea; (C) S. lemmonii; (D) P. trichocarpa; (E) P. tremuloides; (F) S. exiqua.

DISCUSSION

Population Structure

Under-representation of a size class (usually the smaller ones) may be due to the absence of regeneration, infrequent reproductive events and/or high sapling mortality (Harcombe and Marks 1978). The estimated pre-exclusion population of the Salicaceous species at the CRNG is represented in Figure 6a. The pre-exclusion population structure was estimated by subtracting out those individuals which were younger than the age of the exclosure in which they occurred. From stem-age analysis, it is safe to assume that the individuals < 8cm in diameter were less than about nine years in age and were therefore extremely scarce. Prior to exclusion, the majority of these smaller individuals did not exist in the population. Given the preponderance of the Salicaceae since exclusion and their absence outside the exclosures, abusive grazing management practices prior to exclusion probably limited its abundance. The cattle most likely grazed any year-old seedlings that may have escaped the previous grazing season. Logic dictates that the implementation of corridor fencing (cattle exclusion) began none too soon. Without the implementation of corridor fencing, it is probable that the Salicaceae would soon disappear from the landscape.

The current population structure of the Salicaceous species, as a whole, of the Crooked River National

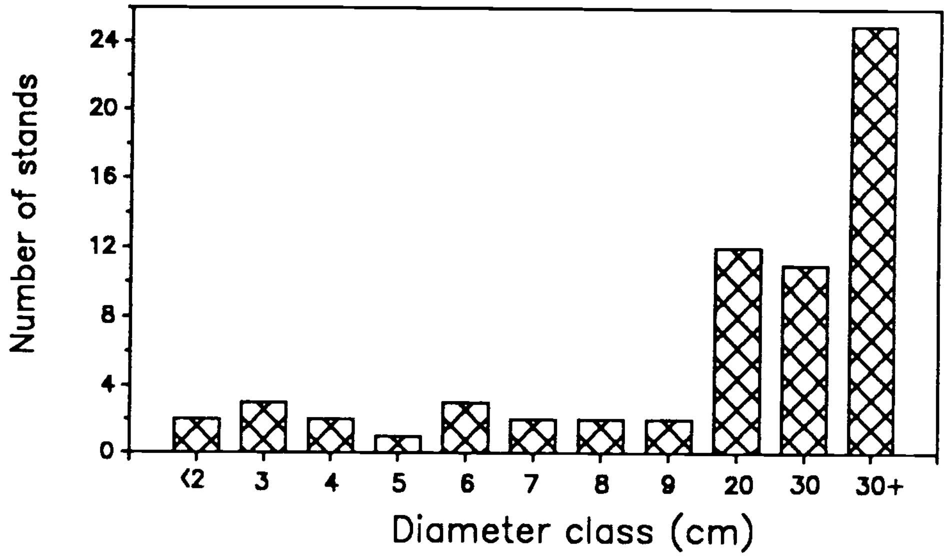


Figure 6a. Diameter class distribution of the Salicaceae present prior to exclosure construction (n=65).

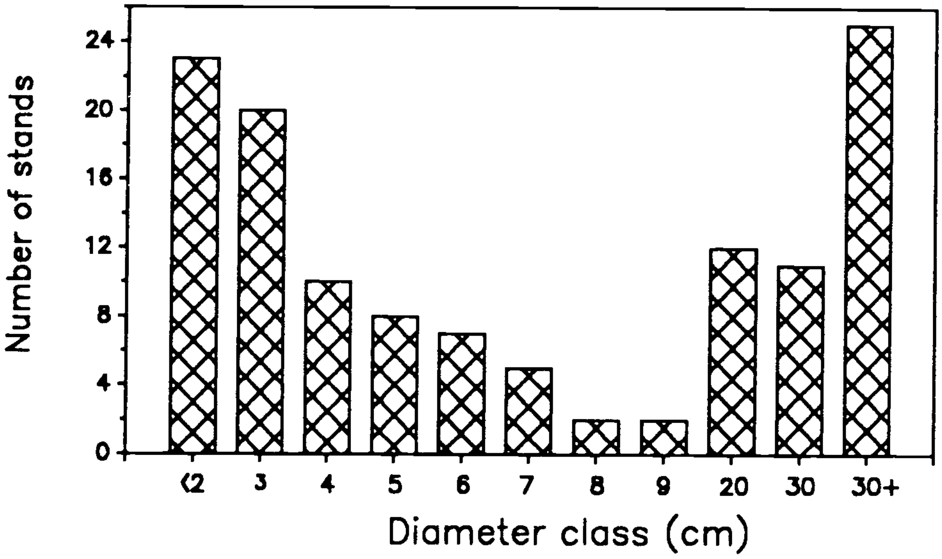


Figure 6b. Current diameter class distribution of the Salicaceae in exclosures (n=125).

Grassland shows the presence of both sapling and decadent stands with a depauperate number of intermediate sized stands (Figure 6b). The population represented in this figure has been protected from livestock grazing through the use of exclosures from 1 to 29 years old (Appendix A). Hypothetically, this is attributed to the abusive grazing practices of the past which prevented the establishment of these species. The past grazing pressure, in effect, inhibited regeneration of the Salicaceae. With the implementation of corridor fencing, individuals established and survived in an environment protected from grazing. Since exclusion, juveniles have become a substantial portion of the population. This will facilitate eventual replacement of the larger, decadent stands which is necessary for the perpetuation of Salicaceae stands and their associated values on the CRNG.

The current population structure of P. trichocarpa suggests that certain habitat requirements are still not being met for its recovery on the CRNG (Figure 7). Regardless of corridor fencing, there were no new, establishing stands of black cottonwood at the CRNG. This is attributed to the loss of the species' requirements for establishment on new sites.

In an eastern Oregon riparian area, P. trichocarpa was found to germinate and establish exclusively on young (point) gravel bars (Kauffman et al. 1985). As a result of alterations in channel physiognomy and runoff patterns,

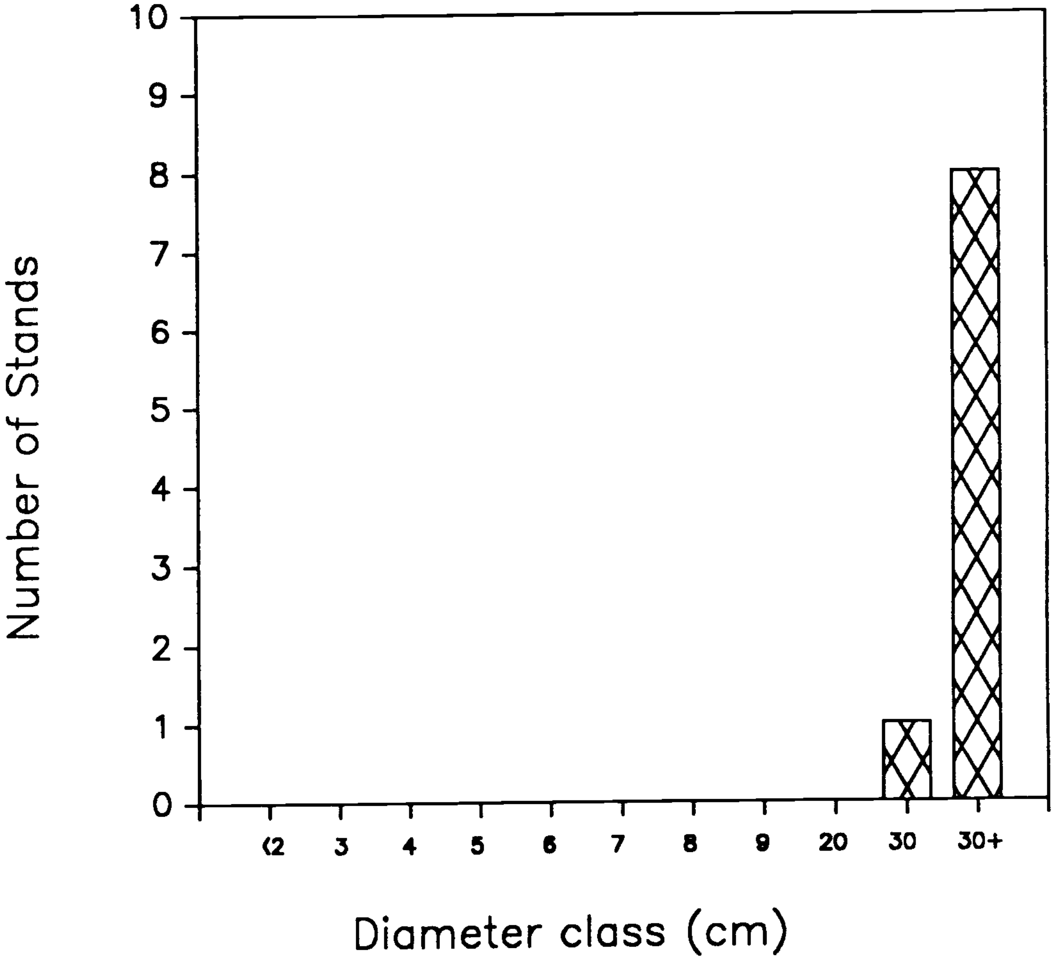


Figure 7. Diameter class distribution of Populus trichocarpa.

there was no evidence that point bars were occurring on the CRNG, which substantiates the lack of habitat for germination and establishment. Until the creeks and riparian areas reach a new equilibrium where point bars are created, cottonwood establishment will be limited to chance microsites.

In a study of _P_. _deltoides_ var. _occidentalis_ Rydb. (plains cottonwood), the best conditions for seedling recruitment were found to occur on periodically flooded point bars where rapid sedimentation and lateral migration took place (i.e. highly fluvially-disturbed environments) (Bradley and Smith 1986). These conditions occurred on an average of one in five years on a river in Alberta, Canada. Assuming that the establishment requirements are similar for _P_. _trichocarpa_ at the CRNG, the sequence of events necessary to create germination sites have not come to pass for some time. Because of channel downcutting, the floodplains are, in effect, cut off from their aquatic systems and as such are no longer a functional part of the riparian ecosystem. Sediment deposition, and therefore establishment sites for _P_. _trichocarpa_ is no longer occurring.

The ecological significance of the above is that there is high potential for the local extinction of this species on the CRNG. Through exclosures, _P_. _trichocarpa_ stands may at least remain as relict sites at their present population status.

Currently at the CRNG, the primary means of reproduction for both of the Populus spp. was though root suckering. This reproductive strategy led to an increase in size/cover of the existing stands, but no establishment of new stands was found. No observation of seedlings was made for the Populus species on the first to third order tributaries.

The Salix species of this area also tended to reproduce vegetatively. This was accomplished when at higher stream flows, branches and twigs were broken off, carried downstream and subsequently deposited into alluvial materials. Only one observation of a young S. lasiandra that germinated from seed was made.

Habitat Changes Through Time

An interesting result of this research was the similarity in surface soil characteristics among all of the Salicaeous species. The physical variables of soil texture, (i.e. percent sand, silt and clay, and percent fine and coarse materials) were consistent (Tables 12-15). These species require sandy-textured soils (47.87% to 69.85% sand) in order to establish and survive. When the consistency in the variable of soil macroporosity is coupled with those of high sand content and high percent coarse materials, the inference that these species require high amounts of unbound water and surface soil aeration can be drawn. Bulk density was relatively consistent for all species and stands (approximately .89 g/cm3). The soil pH remained consistent for these species over time, at an approximately normal level of 7.3. Intuitively, this makes sense since these soils are all effected by the same chemical processes. In other words, the pH of the rainfall and snowmelt, of the allochthonous materials that may wash onto the banks, of the soil parent materials, or of other processes that may effect the soil pH, are probably relatively consistent throughout the entire study area.

In all of the other physical variables measured, the species occupied various habitats from sapling to decadent sized stands.

Salix lasiandra

S. lasiandra was the most common willow occupying the CRNG. It also exhibited the broadest ecological amplitude of all the species examined. Given its broad ecological amplitude, it should generally be the species of choice in any transplanting endeavor in this geographic area.

Only one variable was significantly different when tested between age classes (Table 12). The physical variable which did vary slightly was average stand distance from the wetted channel. Sapling and decadent sized individuals occurred somewhat closer to the channel than did intermediate sized individuals. This was interpreted to be due to change in the channel and

Table 12. Means of the physical variables associated with SALIX LASIANDRA.

variable	SAPLING (n = 16)	INTERMEDIATE (n = 30)	DECADENT (n = 22)
pH	7.20 a	7.40 a	7.40 a
MP (%)	23.63 a	27.00 a	23.89 a
BD (g/cm3)	0.89 a	0.87 a	0.96 a
CLAY (%)	20.20 a	25.62 b	21.14 a
SAND (%)	56.08 a	48.13 a	55.86 a
SILT (%)	23.81 a	26.32 a	23.08 a
OM (%)	5.42 a	5.54 a	5.75 a
COARSE (%)	34.51 a	27.77 a	29.81 a
FINE (%)	65.49 a	72.22 a	70.18 a
O HORIZON (cm)	0.76 a	0.62 a	0.61 a
IMPENETR (m)	0.50 a	0.54 a	0.60 a
GLEYING (m)	0.73 a	0.87 ab	0.98 b
DIST FROM (m)	3.33 a	10.83 b	4.50 a
GRADIENT (%)	9.00 a	8.00 a	10.00 a
ASPECT (o)	169.00 a	130.00 a	147.00 a
ELEVATION (m)	1066.00 a	1019.00 a	1053.00 a

no significant difference between values with a letter in common (Mann-Whitney test) floodplain physiognomy at the time these intermediate sized individuals established, (i.e. stream meandering).

Statisically, depth to gleying was significantly different between age classes, attributable to sampling error only.

Salix lutea

Percent surface soil organic matter content increased over the age classes for S. lutea (Table 13). The amount remained consistent from sapling sized individuals to intermediate sized individuals, but then increased from intermediate to decadent individuals. This was attributed to an increase in litter deposition by these stands as they mature. The enhanced organic carbon content no doubt resulted in an altered soil physical environment.

The physical variable of average stand distance from the wetted channel changed between age classes (Table 13). As S. lutea matured, they occupied areas increasingly close to the wetted channel. This response could be due to a variety of events. Since establishment, the stream physiognomy (structure) could have been altered. This response could have been due to the influence of the larger and larger willows on the stream channel. This species tends to be a medium-sized, multi-stemmed shrub at maturity. The growth form of S. lutea as it matures is more of a lateral than vertical spread. Many times

Table 13. Means of the physical variables associated with SALIX LUTEA.

variable	SAPLING (n = 8)	INTERMEDIATE (n = 9)	DECADENT (n = 4)
pH	7.20 a	7.30 a	7.20 a
MP (%)	29.21 a	25.30 a	25.30 a
BD (g/cm3)	0.95 a	0.95 a	1.05 a
CLAY (%)	22.00 a	22.61 a	20.32 a
SAND (%)	52.94 a	53.91 a	54.40 a
SILT (%)	25.16 a	23.54 a	25.35 a
OM (%)	6.18 a	7.54 a	12.57 b
COARSE (%)	29.63 a	36.93 b	30.86 a
FINE (%)	70.37 a	63.01 b	69.14 a
OHORIZON (cm)	0.46 a	0.41 a	0.52 a
IMPENETR (m)	0.45 a	0.24 a	0.32 a
GLEYING (m)	0.81 a	0.81 a	>1.00 b
DIST FROM (m)	27.72 a	14.05 b	0.75 c
GRADIENT (%)	8.00 a	8.00 a	7.00 a
ASPECT (°)	90.00 a	90.00 a	79.00 a
ELEVATION (m)	1012.00 a	1053.00 a	1141.00 b

no significant difference between values with a letter in common (Mann-Whitney test).

individuals can extend over the entire stream channel. These willows are retaining organic and inorganic alluvium resulting in a deepening and narrowing of channel physiognomy.

Populus tremuloides

More than the previously mentioned species, *P. tremuloides* has very specific habitat requirements of surface soil characteristics (Table 14) on the CRNG. This could be due to the high moisture requirements of this species. The semi-arid environment of the CRNG is at the extreme end of aspen's tolerance. It is likely that its existence at the CRNG is restricted to areas of sandy-steep springs, seeps and first order tributaries only.

The most powerful variable which separated *P. tremuloides* habitat from all others was stream gradient (Table 14). This species was restricted to headwater tributaries and springs only. Habitat requirements of this species are provided only in headwater type riparian ecosystems at the CRNG. Consequently, these are the only areas where propagation, either by natural processes or transplanting should be attempted.

As *P. tremuloides* matured, it occurred farther away from the wetted channel (Table 14). As for the other three *Salix* species, this was attributed to change in channel

Table 14. Means of the physical variables associated with POPULUS TREMULOIDES.

variable	SAPLING (n = 4)	INTERMEDIATE (n = 0)	DECADENT (n = 4)
pH	7.40 a		7.20 a
MP (%)	32.34 a		39.82 a
BD (g/cm3)	0.80 a		0.77 a
CLAY (%)	16.15 a		16.32 a
SAND (%)	67.10 a		56.58 a
SILT (%)	16.85 a		22.15 a
OM (%)	5.04 a		5.17 a
COARSE (%)	19.40 a		10.42 a
FINE (%)	80.60 a		89.58 a
O HORIZON (cm)	0.42 a		0.52 a
IMPENETR (m)	0.68 a		0.94 a
GLEYING (m)	>1.00 a		>1.00 a
DIST FROM (m)	1.86 a		7.79 b
GRADIENT (%)	19.00 a		19.00 a
ASPECT (o)	225.00 a		113.00 b
ELEVATION (m)	1086.00 a		1083.00 a

no significant differnce between values with a letter in common (Mann-Whitney test).

physiognomy during the establishment periods between the sapling sized and decadent sized stands.

Salix exigua

S. exigua was the only species in which depth of the organic horizon was significant from sapling to decadent stands (Table 15). Along the successional gradient from sapling-dominated to decadent stands, the organic horizon became increasingly deeper. As with S. lutea, this was attributed to the greater amounts of leaf litter deposition onto the soil surface of the decadent sized stands.

S. exigua exhibited change in average stand distance from the wetted channel over time (Table 15). This species is increasingly closer to the wetted channel for sapling-dominated stands than decadent stands. Again, this is attributed to channel meandering. This is also indicative of the growth pattern of S. exigua. The pattern of stand expansion is such that stands of S. exigua are structurally diverse (i.e. there are often at least three obvious strata in any single stand). The tallest stratum occurs the closest to the wetted channel while the shortest occurs the farthest from the wetted channel. This could be in response to a moisture gradient. This pattern was readily repeatable across the CRNG.

S. exigua was found only in areas of very flat stream gradient (Table 15). These are the only areas where

Table 15. Means of the physical variables associated with SALIX EXIGUA.

variable	SAPLING (n = 4)	INTERMEDIATE (n = 0)	DECADENT (n = 4)
pH	7.30 a		7.40 a
MP (%)	28.12 a		22.31 b
BD (g/cm3)	0.85 a		0.98 a
CLAY (%)	22.70 a		12.42 b
SAND (%)	50.75 a		69.85 a
SILT (%)	26.68 a		17.78 a
OM (%)	4.06 a		3.47 a
COARSE (%)	41.69 a		21.69 b
FINE (%)	58.31 a		78.31 b
O HORIZON (cm)	0.26 a		0.86 b
IMPENETR (m)	0.52 a		0.68 b
GLEYING (m)	>1.00 a		0.80 a
DIST FROM (m)	50.32 a		22.14 b
GRADIENT (%)	4.00 a		3.50 a
ASPECT (°)	11.00 a		214.00 b
ELEVATION (m)	973.00 a		927.00 b

no significant difference between values with a letter in common (Mann-Whitney test).

propagation of this species, either by natural processes or by transplanting should be focused.

Management Implications

An important overall finding of this research is the remarkable response of the Salicaceae to protection of their habitat from livestock grazing. This study indicates that the Salicaceae, especially of the smaller size class, require areas in which the natural processes that govern the creation of their specific habitats (germination and establishment sites) are allowed to take place. At the Crooked River National Grassland, the only proven method of attaining these habitats through time is by the exclusion of livestock grazing. However, numerous benefits occur due to this management scheme. One such benefit is the provision of clean, potable, easily accessible water for livestock which is pumped from the riparian zone to troughs, supplied through the entire year. Many times if a water supply system does not exist in some pasture, water gaps are left in the riparian fences, for cattle to use.

Implications of riparian rehabilitation through willow transplanting arise from this research project. For moderately successful results over the largest number of riparian areas, S. lasiandra cuttings are recommended. This is due to the broad ecological amplitude of this species of all the species examined. The largest of the sapling sized (Table 2) material should be used. Material of this size is often large enough to survive the cutting process, and small enough to bend during accelerated stream flows. Proper transplanting procedure would include cutting the saplings one day prior to planting, and soaking them overnight in Root-Tone (F. Russell, personal communication). It is important to plant the cuttings immediately prior to bud burst, preferrably during the spring when stream flow is sufficiently low to allow estimation of the base flow. Surface soil characteristics should be as follows:

1. pH from 6.6 to 7.8
2. soil macroporosity from 11.55% to 41.09%
3. sand content from 29.10% to 82.20%
4. coarse materials from 5.95% to 75.28%
5. soil organic matter content from 1.98% to 10.92%
6. organic horizon from 0 cm to 2.92 cm deep

Stream characteristics concerning where the cuttings should be placed on the channel are as follows:

1. as close as possible to 1.89 m from the wetted channel
2. on a stream gradient from 2% to 27%

Planting depth should be as deep as possible in an attempt to ensure soil moisture throughout the growing season.

Should the transplanting of P. tremuloides (aspen) be desireable, the most critical aspect of site selection is stream gradient. The habitat requirements for P. tremuloides are only provided in areas of steep stream gradient (approximately 19%). This species should be transplanted using sapling size (Table 2) cuttings into headwater stream ecosystems only. Surface soil characteristics should be as follows:

1. pH from 7.2 to 7.8
2. soil macroporosity from 25.57% to 39.38%
3. sand content from 50.50% to 86.00%
4. coarse materials from 11.70% to 26.77%
5. soil organic matter content from 2.95% to 7.27%
6. organic horizon from 0 cm to 1.68 cm deep

Stream characteristics concerning where the cuttings should be placed on the stream channel are as follows:

1. as close as possible to 3.15 m from the wetted channel
2. on a stream gradient from 13% to 27%

While these recommendations are based on scientific research, the inherent problem of transplanting still remains -- a high degree of failure! The intention of making the above recommendations is to aid in the increased percent survival of willow and aspen transplants. Fifty percent survival of the transplants may often be the highest one can expect.

Transplanting is a valid means for riparian rehabilitation, especially if there are time frames involved. Invariably, public land managers are expected to take immediate action rather than to wait for natural processes. Riparian rehabilitation through the perpetuation of the Salicaceae by natural processes, is inherently more desireable than artificial transplanting. Transplanting should not be attempted until additional riparian recovery measures have been achieved (i.e. creation of the necessary surface soil characteristics). Unless natural processes are restored all plantings are doomed to failure. Rehabilitated riparian zones should be self-perpetuating sources of willows and cottonwoods. Even a successfully established willow stand is little more than an artificial habitat headed for eventual site degradaton, if the natural fluvial-biotic processes are not restored. Regardless of the means chosen for riparian enhancement, protection of the habitat through time is of paramount importance.

CONCLUSIONS

The habitat of the Salicaceae is defined by any number of environmental and physiological processes. The previous discussion defines habitat in terms of 19 physical variables. This definition of habitat by no means recognizes all the processes which govern species-site selection.

This research can aid in establishing relevant management objectives based on the ecology of the species present, their requirements and inherent characteristics. Instead of the usual fence approximately 100 feet on either side of the stream, identification of the total riparian area intimately associated with the riparian vegetation must be considered when constructing fences. Consequently, we may be better able to successfully administer these areas when they are managed as functional units rather than on an individualistic basis.

This research indicated that the Salicaceae, as a family, occupy specific habitats in terms of surface soil characterisitics. The Salicaceae require surface soils which have a mean pH of 7.3, a mean soil macroporosity of 27.08%, a mean sand content of 53.42%, a mean organic matter content of 6.0%, a mean coarse material content of 28.59%, and a mean organic horizon of 0.58cm. The remaining physical variables change for each species of the Salicaceae in time and space.

The variable of average stand distance from the wetted channel indicated the occurrence of shifts in the channel location of the streams studied. For all the species over the majority of size classes, this variable changed over time. This was attributed to the gradual meandering of the streams across their valleys.

Transplanting of willows and aspen to enhance riparian rehabilitation is very popular within the federal land management agencies. Just as prevalent is the high degree of failure of these endeavors. By identifying potential establishment sites based on surface soil characteristics as well as the associated physical characteristics of the stream, managers may be better able to select sites for successful rehabilitation. Rehabilitation may be attempted either by natural processes or by transplanting.

The importance of riparian vegetation, especially members of the Salicaceae, has gained much notority from land managers and the concerned public. The realization that riparian vegetation is a significant component of the landscape for multiple uses, has even surfaced in the political arena. As such, society needs to have information available which is drawn from scientific research on which to base decisions. More research into the synecology of riparian zones and the autecology of the components of riparian zones is necessary for a more complete understanding of these unique ecosystems and their role in global ecology.

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APPENDICES

Appendix A.

Site, Drainage, Exclosure Age and Salicaceous Dominant Species Identification.

Appendix A. Site, drainage, exclosure age and Salicaceous dominant species identification.

Site No.	Drainage	Exclosure Age	Dominant
1	South Grizzly	9	*S. lasiandra*
2			*S. lasiandra*
93			*S. lasiandra*
95			*S. lasiandra*
30			*S. lemmonii*
31A			*S. lemmonii*
31B			*S. lasiandra*
3			*S. lutea*
32			*S. lasiandra*
96			*S. lemmonii*
4	North Grizzly	5	*S. lasiandra*
74	Gray Digger	5	*P. tremuloides*
75	Kings Gap	5	*S. lasiandra*
76			*S. lasiandra*
77			*S. lasiandra*
78			*P. tremuloides*
79			*P. tremuloides*
5	Skull Hollow	10	*S. lasiandra*
6			*S. lasiandra*
80A			*P. tremuloides*
80B			*P. tremuloides*
7			*S. lemmonii*
8			*S. lasiandra*
9			*S. lutea*
10			*S. lemmonii*
11			*S. lutea*
12			*S. lemmonii*
13			*S. lutea*
14			*P. trichocarpa*
15			*S. lutea*
16			*P. tremuloides*
100			*S. lasiandra*
17			*S. lasiandra*
20			*S. lasiandra*
21			*S. lasiandra*
22			*S. lasiandra*
23			*S. lasiandra*
24			*S. lasiandra*
25			S. *lasiandra*
26A			*S. lasiandra*

26B			*S. lasiandra*
27			*S. lasiandra*
28			*S. lasiandra*
29			*S. lasiandra*
33			*S. lasiandra*
34	Upper Lithgo	4	*S. lasiandra*
35			*S. lasiandra*
36			*S. lasiandra*
37			*S. lasiandra*
38			*S. lasiandra*
39			*S. lutea*
40			*S. lutea*
41			*S. lemmonii*
44			*S. lasiandra*
45			*S. lutea*
46			*S. lasiandra*
48			*S. lutea*
50			*S. lutea*
47	Lithgo	10	*S. lasiandra*
49			*S. lutea*
51			*S. lutea*
52			*S. lasiandra*
53			*S. lutea*
54			*S. lutea*
55			*S. lutea*
56			*S. lasiandra*
57			*S. lutea*
58			*S. exigua*
59			*P. trichocarpa*
60			*S. exigua*
62			*S. lutea*
63			*S. lasiandra*
64			*S. lasiandra*
65			*S. lasiandra*
66			*P. trichocarpa*
67			*S. lasiandra*
68			*S. lasiandra*
69			*S. lasiandra*
70			*S. lasiandra*
71			*S. lasiandra*
72			*S. lasiandra*
81	Rodman	9	*P. trichocarpa*
117			*S. lasiandra*
82	East Haystack	29	*S. exigua*
83			*S. exigua*
85	Haystack	29	*S. lasiandra*
87			*S. exigua*
88			*S. lemmonii*

89			*S. lutea*
91			*S. exigua*
94			*S. lemmonii*
97			*S. exigua*
98			*S. lutea*
99			*S. lasiandra*
101			*S. lasiandra*
104			*S. lutea*
108			*S. lasiandra*
110			*S. lemmonii*
86			*S. lasiandra*
112	West Haystack	29	*S. lasiandra*
115			*P. trichocarpa*
116			*S. lemmonii*
92	Monner	4	*P. trichocarpa*
103	Culver		*P. trichocarpa*
18	Cotman	9	*P. tremuloides*
102			*S. lasiandra*
105	Mud Springs	1	*S. lasiandra*
106			*S. lasiandra*
107			*S. lasiandra*
109		2	*P. trichocarpa*
118			*S. lasiandra*
119			*S. lasiandra*
120			*S. lutea*
123			*P. trichocarpa*
121	McMeen	9	*S. lasiandra*
124	Lone Pine	10	*S. lasiandra*
125			*S. lasiandra*
127			*S. lasiandra*
128			*S. lasiandra*
129			*S. lasiandra*
130			*S. lasiandra*
131			*S. lasiandra*
132			*S. lasiandra*
133			*S. lasiandra*
134	Cyrus	9	*P. tremuloides*

Appendix B.

Scientific Name, Common Name and Alpha Code of Plant Species Occurring Within the Riparian Exclosures According to the Nomenclature of Hitchcock and Cronquist (1973), Garrison et al. (1976) and Kovalchik (1987).

Appendix B. Scientific name, common name, and alpha code of plant species occuring within the riparian exclosures according to the nomenclature of Hitchcock and Cronquist (1973), Garrison et al. (1976), and Kovalchik (1987).

GRASSES

Scientific Name	Common Name	Alpha Code
Agropyron caninum (L.) Beauv	awned wheatgrass	Agca
Agropyron cristatum (L.) Gargrth.	crested wheatgrass	Agcr
Agropyron dasystachyum (Hook.) Scribn.	thick-spiked wheatgrass	Agda
Agropyron inerme (Scribn. and Smith) Rydb.	beardless wheatgrass	Agin
Agropyron intermedium (Host) Beauv.	intermediate wheatgrass	Agin2
Agropyron repens (L.) Beauv.	quackgrass	Agre
Agropyron spicatum (Pursh) Scribn. and Smith	bluebunch wheatgrass	Agsp
Agrostis alba L.	common bentgrass	Agal
Agrostis stolonifera (L.) Smith	redtop	Agst
Agrostis tenuis Sibth.	colonial bentgrass	Agte
Bromus mollis L.	soft brome	Brmo
Bromus tectorum L.	cheatgrass	Brte
Dactylis glomerata L.	orchardgrass	Dabl
Deschampsia cespitosa (L.) Beauv.	tufted hairgrass	Dece
Elymus canadensis L.	Canadian wildrye	Elca
Elymus cinereus Scribn. & Merr.	giant wildrye	Elci
Elymus giganteus Vahl.	Siberian wildrye	Elgi
Elymus glaucus Buckl.	blue wildrye	Elgl
Festuca californica Vasey	California fescue	Feca
Festuca idahoensis Elmer	Idaho fescue	Feid

Hordeum jubatum L.	foxtail barley	Hoju
Hordeum pusillum Nutt.	little barley	Hopu
Koeleria cristata Pers.	prairie junegrass	Kocr
Oryzopsis hymenoides (R. & S.) Ricker	Indian ricegrass	Orhy
Phalaris caroliniana Watt.	Carolina canarygrass	Phca4
Phleum pratense L.	common timothy	Phpr
Poa ampla Merrill	big bluegrass	Poam
Poa bulbosa L.	bulbous bluegrass	Pobu
Poa cusickii Vasey	Cusick's bluegrass	Pocu
Poa nevadensis Vasey	Nevada bluegrass	Pone2
Poa pratensis L.	Kentucky bluegrass	Popr
Polypogon monspeliensis (L.) Desf.	annual beardgrass	Pomo
Sitanion hystrix (Nutt.) Smith	bottlebrush squirreltail	Sihy
Stipa occidentalis Thurb. Ex Wats	western needlegrass	Stoc
Stipa thurberiana Piper	Thurber's needlegrass	Stth
Taeniatherum caput-medusae L.	medusahead	Elca2

GRASSLIKES

Carex amplifolia Boott	bigleaf sedge	Caam
Carex aquatilis Wahl.	aquatic sedge	Caaq
Carex atherostachya Olney	slenderbeaked sedge	Caat
Carex microptera Mack.	smallwinged sedge	Cami
Carex nebrascensis Dewey	Nebraska sedge	Cane
Carex rostrata Stokes	beaked sedge	Caor2
Carex stiptata Muhl.	sawbeak sedge	Cast

Eleocharis palustris (L.) R. & S.	creeping spikerush	Elpa
Eleocharis pauciflora (Lightf.) Link	fewflowered spikerush	Elpa2
Juncus balticus Willd.	Baltic rush	Juba
Juncus bufonius L.	toad rush	Jubu
Juncus confusus Cov.	Colorado rush	Juco
Juncus ensifolius Wikst.	dagger-leaf rush	Juen
Juncus howellii Herm.	Howell's rush	Juho
Scirpus acutus Muhl.	hardstem bulrush	Scac
Scirpus fluviatilis (Torr.) Gray	river bulrush	Scfl
Scirpus olneyi Gray	Olney's bulrush	Scol
Scirpus subterminalis Torr.	water bulrush	Scsu

FORBS

Achillea millefolium L.	western yarrow	Acmi
Agastache urticifolia (Benth.) Kuntze	nettleleaf horsemint	Agur
Amsinckia retrorsa Suksd.	rigid fiddleneck	Amre2
Antennaria dimorpha (Nutt.) T. & G.	low pussytoes	Andi
Aquilegia formosa Fisch.	Sitka columbine	Aqfo
Arnica chamissonis Less.	leafy arnica	Arch
Artemisia ludoviciana Nutt.	prairie sage	Arlu
Asclepias speciosa Torr.	showy milkweed	Assp
Aster campestris Nutt.	meadow aster	Asca2
Aster foliaceus Lindl.	leafy bract aster	Asfo
Astragalus curvicarpos (Sheld.) Macbr.	curvepod locoweed	Ascu2
Berula erecta (Huds.) Cov.	cutleaved water parsnip	Beer

Boisduvalia densiflora (Lindl.) Wats.	dense spikeprimrose	Bode
Calochortus macrocarpus Dougl.	sagebrush mariposa lily	Cama
Castilleja sp. Mustis ex L.f.	Indian paintbrush	Cast1
Cerastium viscosum L.	sticky chickweed	Cevi
Cicuta douglasii (DC) Coult. & Rose	western waterhemlock	Cid
Circium cenovirens (Rydb.) Petr.	grey-green thistle	Cica2
Cirsium vulgare (Savi) Tenore	bull thistle	Civu
Clarkia pulchella Pursh	pink fairy	Clpu
Clematis ligusticifloia Nutt.	western clematis	Clli
Collinsia parviflora Lindl.	small flowered collinsia	Copa
Convolvulus arvensis L.	field bindweed	Coac2
Conyza canadensis (L.) Cronq.	horseweed	Coca2
Crypthantha affinis (Grey) Greene	slender cryptantha	Cica2
Daucus carota (L.)	Queen Anne's lace	Daca4
Descurania richardsonii (Sweet) Schultz	mountain tansymustard	Deri
Draba verna L.	spring draba	Drve2
Epilobium glaberrimum Barbey	smooth willowweed	Epgl
Epilobium paniculatum Nutt.	autumn willowweed	Eppa
Epilobium watsonii Barbey	Watson's willowweed	Epwa
Equisetum arvense L.	common horsetail	Eqar
Equisetum variegatum Schleich.	varigated horsetail	Eqva
Erigeron philadelphicus L.	Philadelphia fleabane	Erph
Eriogonum spaerocephalum Dougl.	rock buckwheat	Ersp3
Eriogonum vimineum Dougl.	broom buckwheat	Ervi
Erodium cicutarium (L.) L'Her.	filaree	Erci
Fragaria vesca L.	woods strawberry	Frve
Galium borale L.	northern bedstraw	Gabo
Galium multiflorum Kell.	shrubby bedstraw	Gamu

Geum macrophyllum Willd.	Oregon avens	Gama
Hypericum perforatum L.	Klamath weed	Hype
Iris pseudocorus L.	yellow iris	Irps
Lactuca serriola L.	prickly lettuce	Lase
Leppula redowskii (Harnem.) Greene	western stickseed	Lere
Lithophragma parviflora (Hook.) Nutt.	smallflowered prairiestar	Lipa
Lomatium donnellii Coult. & Rose	Donnell's lomatium	Lodo
Lomatium triternatum (Pursh) Coult. & Rose	nineleaf lomatium	Lotr
Lotus purshiana (Benth.) Clements & Clements	Spanish clover	Lopu
Lupinus lepidis Dougl.	pririe, lupine	Lule2
Lupinus leucophyllus Doug.	velvet lupine	Lule
Madia gracilis (J.E. Smith)	common tarweed	Magr
Medicago lupulina L.	black medic	Melu
Melilotus officinale (L.) Lam.	common yellow sweetclover	Meof
Mentha arvensis L.	field mint	Mear3
Microsteris gracilis (Hook.) Greene	microsteris	Migr
Mimulus guttatus DC	yellow monkeyflower	Migu
Moss		
Phacelia hastata Dougl.	whiteleaf phacelia	Phha
Phlox hoodii Rich.	Hood's phlox	Phho
Phlox muscoides Nutt.	moss phlox	Phmu2
Plantago major L.	common plantain	Plma
Plectritis macrocera T. & G.	white plectritis	Plma3
Polygonum douglasii Greene	prostrate knotweed	Podo
Potentilla biennis Greene	biennial cinquefoil	Pobi2
Potentilla gracilis Dougl.	slender cinquefoil	Pogr
Ranunculus aquatilis L.	water buttercup	Raaq
Rigiopappus leptocladus Gray	bristlehead	Rile

Rorippa nasturtium-aquaticum (L.) Schinz & Thell.	watercress	Rona
Rumex acetosella L.	horse sorrel	Ruac
Salsola kali L.	Russian thistle	Saka
Sisymbrium altissimum L.	tumblemustard	Sial
Solanum dulcamara L.	climbing nightshade	Sodu2
Solidago occidentalis (Nutt.) T. & G.	western goldenrod	Sooc2
Sonchus asper (L.) Hill	prickly sowthistle	Soas
Stephanomeria tenuiflora (Torr.) Hall	narrowleaved skeletonweed	Stte
Taraxacum officinale Weber	common dandelion	Taof
Tragopogon dubius Scop.	yellow salsify	Trdu
Trifolium repens L.	white clover	Trre
Trifolium wormskjoldii Lehm.	springbank clover	Trwo2
Typha latifolia L.	common cattail	Tyla
Urtica dioica L.	slim nettle	Urdi
Verbascum blattaria L.	moth mullein	Vebl
Verbascum thapsis L.	common mullein	Veth
Veronica americana Schwein.	American speedwell	Veam
Vicia americana Muhl.	American vetch	Viam
Viola adunca Sm.	early blue violet	Viad
Xanthium strumarium L.	common cocklebur	Xast
Zigadenus veneosus Wats.	meadow death camus	Zive

SHRUBS

Amelanchier alnifolia Nutt.	western snowberry	Amac
Artemisia arbuscula Nutt.	low sagebrush	Arar
Artemisia rigida (Nutt.) Gray	stiff sagebrush	Arri

Artemisia tridentata ssp. tridentata Nutt.	basin big sagebrush	Artrt
Artemisia tridentata ssp. vaseyana Nutt.	mountain big sagebrush	Artrv
Chrysothamnus nauseosus (Pall.) Britt.	gray rabbitbrush	Chna
Chrysothamnus viscidiflorus (Hook.) Nutt.	green rabbitbrush	Chvi
Cornus stolonifera Michx.	red osier dogwood	Cost
Lycium halmifolium Mill.	matrimony vine	Lyha
Philadelphicus lewisii Pursh	Lewis mockorange	Phle2
Prunus emarginata (Dougl.) Walp.	bittercherry	Prem
Prunus virginiana L.	common chokecherry	Prvi
Purshia tridentata (Pursh) DC.	wax currant	Rice
Rosa nutkana Fern	bristly Nootka rose	Ronu
Rosa woodsii Lindl.	Wood's rose	Rowo
Salix exigua Nutt.	coyote willow	Saex
Salix lasiandra Benth.	peachleaf willow	Sala2
Salix lemmonii Bebb.	Lemmons willow	Sale
Salix lutea Nutt.	yellow willow	Salu
Sambucus cerulea Raf.	blue elderberry	Sace
Symphoricarpos occidentalis Hook.	western snowberry	Syoc

TREES

Alnus incara (L.) Moerch.	thinleaf alder	Alin
Betula occidentalis Hook.	water birch	Beoc
Juniperus occidentalis Hook.	western juniper	Juoc
Pinus ponderosa Dougl. Ex Loud.	ponderosa pine	Pipo
Populus tremuloides Michx.	quaking aspen	Potr
Populus trichocarpa T. & G.	black cottonwood	Potr2

Appendix C.

Acronyms of the Physical Variables.

Appendix C. Acronyms for the physical variables.

Vegetation

Stand distance from wetted channel	DIST FROM
Riparian zone width	RIP ZONE
Exclosure age	EXLOSURE

Water

Wetted channel width	WET CHAN
Stream gradient	GRADIENT

Soils

Bulk density	BD
Macroporosity	MP
Depth to an impenetrable layer	IMPENETR
Depth to a gleyed horizon	GLEYED
Depth of an organic horizon	O HORIZON
Percent coarse materials	COARSE
Percent fine materials	FINE
Percent organic matter	OM
Percent clay	CLAY
Percent sand	SAND
Percent silt	SILT
Soil pH	PH

Other

Aspect	ASPECT
Elevation	ELEVATION

Appendix D.

Canonical Discriminant Function Scores for the Salicaceous Species According to Size Class.

Appendix D. Canonical Discriminant Function Scores for Salicaceous Species According to Size Class.

SAPLING (A - S. lasiandra, B - S. lutea,
C - S. lemmonii, E - P. tremuloides
F - S. exigua)

SPECIES	CDF 1	CDF 2	CDF 3	CDF 4
B	0.91199	-0.58548	-1.36494	0.23802
C	3.09132	-0.42187	-0.28682	-0.60161
B	0.21639	2.46949	-1.63923	0.01443
C	3.03020	-0.33994	0.33367	-1.70701
A	-0.17132	-2.26829	0.49315	-1.40009
A	-0.42823	-2.08290	-1.38367	0.29145
C	3.40923	-0.73714	-1.88999	-2.52918
A	-0.64074	0.40884	0.28578	0.94262
A	-2.62146	0.34528	0.10553	0.16857
B	-1.17450	1.05817	-2.29106	-0.69892
B	-0.90537	1.01583	-2.35609	1.72515
B	-1.05391	-0.09838	0.39947	0.13829
F	-2.15750	0.90142	2.83471	-0.17588
A	-2.13151	0.39280	1.53605	0.33035
F	-1.58192	1.28785	1.30795	0.10705
A	-0.96108	-2.13317	-0.09730	-0.20659
A	-0.88210	-1.02167	-1.21831	-1.81906
A	-0.27529	-0.71315	-0.70857	0.63670
E	2.99962	0.83899	1.27380	1.45282
A	-0.12876	-0.79946	-0.43389	0.40611
E	1.39482	0.52625	-0.06527	2.16095
E	3.94840	0.61831	1.97414	0.06108
E	3.75205	0.56699	0.14782	0.30785
A	-1.75475	-2.30792	-0.74700	1.35289
B	-1.22739	1.11861	0.09483	-1.90920
F	-1.00934	2.92039	-0.14118	-0.95945
A	1.84219	-0.60178	1.47521	-0.31933
A	-1.19076	-1.64212	0.05114	-0.59343
C	4.36717	-0.77112	1.33319	0.80107
F	-2.49815	2.80740	2.26516	-0.97317
B	-0.49360	3.65578	-0.86676	-0.42225
A	-2.85447	-1.57276	0.24707	-0.09009
B	0.60273	2.48459	-1.90542	1.53538
A	-1.59247	-1.82439	0.45852	0.03596
A	-0.36146	-1.69553	0.51508	1.42517
A	-1.47000	-1.79995	0.26322	0.27333

INTERMEDIATE (A - S. lasiandra, B - S. lutea, C - S. lemmonii)

SPECIES	CDF 1	CDF 2	CDF 3	CDF 4
A	-1.46321	-0.09962	0.09795	0.53119
A	0.44561	-0.61132	-1.38055	-1.18018
A	0.01993	1.07569	-1.19251	-0.61694
B	0.51216	-3.66106	4.34557	-0.99980
C	2.89287	0.65732	-0.93254	-1.54287
B	0.63769	-1.58281	-0.75193	1.19762
B	1.24338	0.29961	-0.76328	-0.02571
A	0.69182	1.87588	0.70896	-0.21680
A	-1.19021	0.47847	0.87320	-0.11867
A	-1.02618	1.75043	1.03181	-0.14895
A	-1.41073	0.74703	1.25293	-0.32039
A	0.04115	0.77558	0.09736	-0.35972
A	-0.26758	1.21203	0.72430	-0.92311
C	5.55519	0.91958	0.59042	-1.49900
A	0.18165	2.01849	0.58750	1.01517
A	0.63552	-1.00430	0.09161	0.83788
A	-1.12250	0.00118	0.41303	0.40402
A	-0.55416	-1.78448	-1.03576	1.29351
C	5.45553	1.16827	0.34212	3.04187
B	-0.50799	-0.04126	-0.39156	-0.28180
B	1.34258	-2.60562	-0.38466	-0.14573
B	-1.11293	-1.71076	-0.39165	0.60166
A	-2.31304	-0.82376	-0.88878	0.80814
B	1.66414	-3.17362	-0.45633	-1.27422
A	0.05924	-0.72111	-0.87548	-0.90546
B	-0.15431	-1.37860	-0.47239	0.72923
A	-0.73742	0.03471	0.36124	0.02374
A	-0.15642	1.12011	0.65282	-0.19057
A	-0.06604	-0.42552	-0.18274	1.68214
A	-0.91387	0.47336	0.84072	0.33627
A	1.48889	0.01756	-0.94726	-0.81605
A	-0.91618	1.63691	-0.60262	-0.02999
B	-0.59193	-1.97723	-0.73376	0.19875
A	0.33683	-0.32989	0.27082	1.05297
A	-1.79582	0.79425	0.53643	0.80845
A	-0.33746	0.51463	-0.52739	-1.17572
A	-0.50439	0.82248	0.83966	0.22062
A	-2.78246	-0.07761	0.04620	-0.63784
A	-1.12527	0.39263	-0.91829	-1.58351
A	0.00660	1.09926	-0.46531	1.20839
A	-0.04402	1.66843	0.13878	-0.65659
A	-2.11668	0.45469	-0.54861	-0.34200

DECADENT (A - S. lasiandra, B - S. lutea, C - S. lemmonii, D - P. trichpcarpa, E - P. tremuloides, F - S. exigua)

SPECIES	CDF 1	CDF 2	CDF 3	CDF 4
A	-0.29965	1.87516	-0.29379	2.26800
A	-1.10835	1.51062	-1.08374	1.68105
A	-1.75349	0.99767	0.07273	0.35513
D	3.30657	0.92951	-0.23764	-1.10821
E	3.16328	0.94679	0.03409	-1.39131
E	4.78777	0.61745	0.18168	0.74478
A	0.79444	0.54640	0.55388	-1.53888
A	-0.57688	1.33327	-0.47799	0.40052
A	-1.88340	1.28915	-0.91732	0.62829
A	-1.82999	0.80892	-0.00590	0.60181
A	1.24298	1.31816	-0.50441	-0.00973
A	-1.45436	2.22645	0.49287	0.12847
A	-1.30058	1.80465	0.46017	-0.52441
B	-0.91887	1.50603	0.58660	-0.50580
B	0.08254	1.74335	0.74824	-1.69338
A	-2.06078	1.89080	0.14705	0.43310
B	0.13676	1.90441	0.50807	0.96158
A	-0.33937	1.61357	1.27635	0.49906
B	-1.23199	3.04720	4.60214	-1.12621
F	-2.90654	-0.94445	-0.70081	0.53898
D	-0.04113	-1.49498	2.53930	0.16038
D	0.19163	-2.19384	-1.77147	-2.29992
A	0.01317	1.79819	0.27635	0.58804
A	-0.02244	0.85348	0.60211	-1.10885
A	-0.25292	-0.16127	-1.46624	0.87320
E	3.86026	1.50276	-0.88619	1.02087
D	-0.66317	-1.13472	-0.60473	-0.93461
F	-2.11165	-1.89087	-0.86932	-0.57994
F	-3.09015	-0.92249	-0.90565	0.77960
A	-0.24505	-2.45777	1.66532	1.78686
F	-1.26904	-3.53540	-0.46326	1.78484
C	1.19749	-4.01259	1.07222	0.93294
D	-1.22178	-1.41678	-1.02366	-0.39081
C	1.18077	-4.09659	1.77331	0.84573
D	0.45214	-1.24262	-1.20450	-1.48923
A	-0.53343	0.56107	-0.40997	-0.42485
A	-2.00631	0.64970	-1.06565	-0.68895
A	-0.32935	0.34153	-0.84415	-0.33133
D	0.44276	-0.56841	-1.18783	0.22246
C	1.75337	-2.37673	1.82952	0.69117
D	1.39724	-2.38944	0.41399	-1.50023

Appendix E.

Values of the Physical Variables.

Appendix E. Values of Physical Variables

stand	pH	MP %	BD gcm-3	clay %	sand %	silt %	OM %
1	7.4	30.13	0.7124	12.1	70.9	17.0	6.10
2	7.0	23.24	0.5330	13.2	72.1	14.8	5.52
3	6.8	30.66	0.8706	10.8	78.1	11.1	3.78
4	6.6	19.16	0.8063	23.7	38.9	37.6	6.48
5	7.6	21.74	0.8175	27.6	53.3	19.2	3.63
6	8.1	11.40	1.5103	24.1	57.7	18.2	9.30
7	7.4	28.93	0.7866	31.1	40.2	28.7	7.34
8	7.3	24.38	1.0005	32.0	49.2	18.8	8.36
9	7.0	23.80	0.9949	23.0	55.2	21.9	11.99
10	7.4	32.33	0.7670	28.1	42.1	29.8	12.98
11	7.4	29.49	1.2314	21.2	73.5	5.4	4.18
12	7.1	26.26	0.8224	31.7	37.2	31.2	7.60
13	7.4	30.38	0.7457	29.3	52.1	18.7	4.34
14	7.8	37.17	0.9326	18.9	54.0	27.3	8.73
15	7.3	33.01	0.7815	24.3	49.7	26.0	7.61
16	7.3	36.71	0.9875	23.8	53.6	22.6	7.03
17	7.3	36.11	0.5449	33.8	31.8	34.5	8.18
18	6.9	45.79	0.4735	18.3	54.6	27.1	4.74
20	6.7	31.28	0.8414	33.7	41.9	24.5	8.54
21	7.4	28.58	0.9529	29.6	46.0	24.6	4.33
22	7.6	25.96	0.5697	37.5	32.6	30.0	5.36
23	7.5	19.01	0.9251	37.8	37.6	24.8	5.44
24	7.4	21.75	1.1121	33.4	38.8	27.9	7.51
25	7.7	32.07	0.6903	27.2	34.8	38.1	7.98
26 A	7.5	21.01	0.9323	46.2	25.6	28.2	6.63
26 B	7.3	15.99	0.8652	33.9	35.1	31.1	6.19
27	7.8	15.62	0.8884	42.3	34.8	22.9	6.47
28	7.4	20.02	1.1382	34.3	46.2	19.6	4.14
29	7.6	11.55	1.0637	36.4	40.7	23.0	10.92
30	6.6	33.02	0.4929	14.6	61.9	23.6	19.17
31 A	6.2	23.49	0.7873	21.4	38.2	40.5	9.13
31 B	7.0	29.37	0.5927	22.6	46.3	31.1	7.64
32	7.0	35.09	0.8103	12.2	74.5	13.3	4.24
33	7.0	39.35	0.6793	24.0	46.4	29.7	5.88
34	7.8	34.87	1.3839	20.6	65.3	14.2	2.81
35	7.4	19.19	1.3027	30.5	57.4	12.2	3.30
36	7.6	21.78	1.0121	24.0	52.9	23.2	7.09
37	7.3	32.46	0.6865	33.1	38.2	28.8	5.38
38	7.1	33.99	0.8280	22.6	56.5	20.9	3.57
39	7.4	25.47	1.2345	24.4	67.8	7.8	2.66
40	7.3	24.08	1.3072	30.4	50.8	18.9	4.11
41	7.4	69.04	0.8593	23.3	56.3	20.4	2.09
44	7.6	19.35	1.1800	18.1	75.3	6.8	3.31
45	7.0	35.25	0.7987	11.3	70.8	18.0	6.28
46	7.5	26.89	1.7367	10.0	84.1	6.0	1.81
47	6.9	13.05	1.3183	10.6	80.7	8.8	3.43

48	7.3	30.16	0.9229	22.5	49.8	27.7	7.15
49	7.9	27.39	1.2902	13.7	76.0	10.4	5.74
50	7.0	34.29	0.9303	22.0	66.8	11.3	4.22
51	7.2	29.51	1.0285	20.4	67.7	12.0	3.02
52	7.0	15.54	0.9946	28.9	49.1	22.0	5.26
53	7.2	17.83	0.7193	16.1	65.1	18.9	12.89
54	7.0	16.41	0.8693	15.2	28.2	56.7	37.22
55	7.3	27.16	1.1626	16.4	68.5	15.2	7.85
56	6.7	32.74	0.6965	26.1	48.3	25.6	9.07
57	7.8	22.29	1.1124	25.3	46.5	28.3	6.31
58	7.3	24.48	0.8082	15.7	50.4	33.9	7.85
59	6.9	20.55	1.1651	30.0	41.0	29.1	6.67
60	7.4	29.70	0.8291	16.8	73.2	10.1	2.63
62	7.1	20.16	0.9821	22.3	58.3	19.4	5.73
63	7.1	39.60	0.6023	12.7	76.5	10.9	5.02
64	7.1	32.63	0.9642	21.8	59.3	19.0	4.02
65	7.2	34.60	1.0260	9.2	82.9	8.0	1.82
66	7.6	35.58	0.7109	19.4	55.2	25.5	5.24
67	7.0	37.18	0.8545	23.5	56.1	20.5	5.90
68	7.4	32.73	0.8917	18.3	62.2	19.6	3.65
69	7.2	31.14	0.6486	20.5	53.4	26.2	9.67
70	7.3	33.44	0.8336	20.4	59.8	19.9	4.35
71	6.8	22.55	1.2647	21.2	53.2	25.6	7.00
72	7.5	41.09	0.7342	22.3	48.0	29.7	5.72
74	7.2	39.38	0.8832	7.1	81.4	11.6	2.95
75	7.1	13.74	1.0836	6.4	82.2	11.5	1.98
76	7.0	19.83	1.3330	18.1	70.9	11.1	3.09
77	6.8	16.55	1.1126	19.4	58.8	21.9	6.49
78	7.8	25.57	0.6313	10.5	86.0	3.6	3.86
79	7.3	43.67	0.8520	1.4	93.5	5.3	2.32
80 A	7.4	26.81	0.7980	23.7	50.5	25.9	6.08
80 B	7.2	37.63	0.8823	23.3	50.5	26.3	7.27
81	7.8	21.44	1.0832	22.9	27.1	50.0	6.14
82	7.4	24.64	0.9282	9.7	84.0	6.5	2.37
83	7.0	18.88	1.1259	7.5	85.8	6.7	1.27
85	7.2	24.88	0.8764	23.1	39.9	37.1	10.06
86	6.9	25.19	1.0296	12.5	63.0	24.6	4.87
87	8.0	21.24	1.0436	16.8	59.2	24.0	2.39
88	7.3	33.28	1.0763	15.3	59.7	25.0	6.79
89	6.6	20.12	1.0057	28.8	20.5	50.8	7.28
91	7.1	29.48	0.9290	30.4	28.8	40.9	5.64
92	7.4	30.71	0.8074	12.1	71.9	16.1	3.91
93	7.1	21.57	0.5481	17.2	70.5	12.4	6.02
94	6.7	25.89	0.9570	16.7	56.8	26.6	5.10
95	7.0	33.75	0.2981	25.0	41.1	34.0	2.43
96	7.1	32.43	0.8522	12.5	75.7	11.9	3.76
97	7.4	18.70	0.6022	34.4	18.1	47.7	6.16
98	7.2	34.16	0.6761	31.4	27.6	41.1	8.59
99	7.7	30.96	0.7727	40.0	34.8	25.3	6.55
100	7.8	14.72	0.7612	26.1	59.3	14.6	3.00
101	7.3	30.38	0.5951	32.1	13.2	54.7	12.08
102	6.8	19.32	0.8886	42.3	29.3	28.4	8.26

103	7.4	25.73	1.0713	16.6	65.3	18.1	4.79
104	7.5	15.45	1.0966	31.9	11.3	56.9	9.38
105	7.6	21.30	1.2284	10.3	82.9	6.8	3.77
106	9.1	13.93	0.7995	19.5	44.9	35.7	9.11
107	8.9	21.72	0.8843	10.3	48.7	41.1	8.59
108	8.0	24.19	1.0343	19.4	59.2	21.4	3.55
109	7.7	32.60	0.7297	13.5	75.7	11.0	1.74
110	6.9	32.88	1.0519	15.4	58.9	25.8	5.66
112	6.9	25.25	0.8454	24.1	2.9	73.1	4.63
115	7.3	25.93	0.9849	21.4	34.8	43.9	3.01
116	7.0	22.93	0.8888	20.5	21.9	57.7	3.18
117	7.7	22.96	0.8853	24.1	20.1	55.9	7.58
118	8.3	24.61	0.9071	13.2	58.2	28.7	1.84
119	8.2	8.46	1.1765	15.9	60.0	24.2	2.17
120	7.7	34.50	0.6234	20.1	42.0	38.1	7.25
121	7.2	29.78	0.2400	31.2	40.8	289.0	7.16
123	7.5	27.97	0.8195	23.8	30.5	45.9	3.22
124	6.9	34.63	1.0215	13.8	64.3	22.0	2.77
125	7.0	30.53	0.8377	14.5	71.6	13.9	2.46
127	8.1	25.16	0.8788	17.1	45.7	37.3	12.13
128	7.3	11.72	0.8631	17.3	57.9	24.8	5.45
129	6.6	13.28	0.9137	16.1	29.1	55.0	4.32
130	6.5	29.70	0.8154	19.1	32.6	48.3	4.36
131	7.5	34.37	1.1033	12.1	79.3	8.7	2.95
132	7.8	28.79	1.0732	7.5	83.9	8.6	1.98
133	7.7	29.25	0.9507	6.3	93.5	0.2	0.56
134	7.5	33.12	0.7550	21.8	24.6	33.6	6.57

stand	diameter widest base (cm)	height (m)	stand area length (m)	stand area width (m)	crown cover (m2)
1	52.20	10.00	10.35	9.50	77.37
2	39.47	7.62	5.80	9.60	46.57
93	1.04	0.60	11.87	0.68	30.93
95	1.04	0.95	10.00	24.20	229.66
30	12.86	3.66	5.00	5.10	20.03
31 A	0.32	3.05	9.50	4.00	35.78
31 B	47.11	4.27	11.90	6.35	65.48
3	1.50	3.96	6.10	6.95	33.44
32	2.57	6.31	9.29	9.91	72.38
96	0.86	0.75	1.40	1.49	1.64
4	30.00	2.13	2.00	4.06	7.21
74	1.47	0.54	3.80	3.22	9.68
75	1.50	1.09	2.20	0.95	1.95
76	11.00	1.00	2.30	1.20	2.41
77	20.37	7.31	10.82	9.61	81.95
78	1.33	1.57	10.33	5.03	46.32
79	7.80	3.39	4.31	2.40	8.84
5	2.95	1.83	1.06	0.90	0.75
6	2.12	1.68	0.78	1.90	1.41
80 A	3.02	17.37	11.07	12.10	105.41
80 B	4.38	2.02	9.50	2.35	27.57
7	5.99	5.49	4.55	5.10	18.28
8	2.90	25.50	6.00	5.80	27.34
9	3.79	7.77	11.70	4.00	48.40
10	6.77	3.05	19.20	7.40	138.93
11	2.04	1.07	2.67	1.85	4.01
12	5.73	3.96	8.65	6.20	43.30
13	6.62	2.44	5.41	4.75	20.27
14	32.47	30.48	2.19	1.22	2.28
15	5.42	1.22	4.40	4.67	16.15
16	8.20	2.74	2.40	2.50	4.71
100	1.02	0.90	0.77	0.39	0.26
17	5.19	3.05	2.60	2.79	5.70
20	35.01	5.62	16.00	12.35	157.81
21	3.80	3.02	24.22	6.60	186.51
22	6.99	3.33	3.04	2.32	5.64
23	5.47	5.17	10.55	8.49	71.18
24	2.77	2.02	4.08	5.46	17.87
25	4.79	1.99	5.22	3.51	14.96
26 A	39.79	7.08	6.81	9.28	50.83
26 B	1.60	2.20	0.89	1.43	1.06
27	50.29	8.18	6.32	6.67	33.13
28	40.74	5.67	7.32	9.50	55.55
29	1.38	1.58	3.02	2.09	5.13
33	8.66	2.75	6.07	5.40	25.83
34	0.81	0.50	0.24	0.46	0.10
35	28.97	9.08	11.02	7.97	70.81

36	41.06	10.11	5.77	4.58	21.03
37	15.28	2.90	2.90	3.00	6.83
38	14.64	4.38	4.91	4.36	16.87
39	19.74	5.28	5.49	6.24	27.02
40	29.29	4.44	5.08	6.04	24.28
41	10.25	4.34	5.08	8.34	35.36
44	31.51	7.25	4.14	6.72	23.16
45	17.19	4.72	7.77	9.86	61.03
46	46.16	10.98	7.83	6.74	41.68
48	4.60	2.71	3.22	4.81	12.66
50	2.95	1.99	2.47	3.43	6.83
47	1.21	1.09	1.15	1.06	0.96
49	5.29	6.78	9.04	9.01	63.97
51	4.18	2.87	5.06	4.75	18.90
52	2.11	2.08	1.11	1.02	0.89
53	7.51	3.35	3.92	3.38	10.46
54	13.32	4.13	7.13	7.66	42.95
55	1.86	1.21	0.49	0.52	0.20
56	3.74	2.92	2.55	3.43	7.02
57	2.63	3.32	1.08	2.29	2.23
58	9.72	7.19	25.32	10.05	245.64
59	39.79	16.11	8.49	11.48	78.30
60	2.90	2.17	2.71	2.00	4.36
62	6.28	3.09	5.81	4.99	22.90
63	1.21	2.01	2.22	2.47	4.32
64	4.03	3.81	3.79	3.21	9.62
65	2.06	1.17	1.11	1.07	0.93
66	53.79	33.84	29.06	21.30	497.97
67	3.52	3.99	3.20	2.77	7.00
68	36.29	6.40	8.02	11.58	75.43
69	1.05	1.33	0.98	1.01	0.78
70	32.47	8.53	13.63	11.81	127.08
71	0.95	0.98	0.61	0.57	0.27
72	1.97	1.94	1.86	1.67	2.45
81	79.90	14.72	9.81	9.33	71.93
117	5.97	1.69	2.50	2.83	5.58
82	4.93	2.73	22.11	34.28	624.36
83	3.84	2.97	44.78	36.16	1286.34
85	0.16	5.93	7.74	7.44	45.25
87	6.10	5.21	20.74	21.29	346.86
88	23.87	12.57	9.88	14.68	118.44
89	2.40	2.03	5.94	5.98	27.90
91	2.40	3.63	41.96	24.67	871.70
94	21.96	10.61	9.03	6.05	44.65
97	2.74	3.15	25.82	26.28	532.97
98	1.33	1.53	2.76	2.88	6.25
99	2.27	1.28	3.34	2.32	6.29
101	2.11	2.56	6.65	7.25	37.94
104	3.08	2.01	4.26	5.34	18.10
108	3.02	1.97	2.96	3.55	8.32
110	20.37	7.64	6.48	6.80	34.63
86	21.60	2.13	7.58	6.52	39.04

112	4.89	3.06	4.70	4.74	17.50
115	42.97	21.42	22.34	24.30	427.12
116	22.28	13.04	8.34	7.79	51.09
92	78.94	19.57	13.77	10.75	118.05
103	48.51	14.73	43.28	18.82	757.20
18	12.73	9.70	31.20	13.90	399.38
102	9.42	3.74	4.39	3.92	13.56
105	36.29	9.08	5.19	5.12	20.87
106	53.16	9.26	6.02	5.91	27.95
107	49.02	9.34	7.38	6.03	35.31
109	52.20	13.42	5.48	10.13	47.84
118	2.55	3.31	2.60	2.87	5.87
119	3.08	2.91	3.44	2.95	8.02
120	2.00	2.64	3.28	3.45	8.89
123	25.40	10.47	8.71	6.61	46.08
121	4.25	3.81	4.98	4.51	17.68
124	1.67	2.08	3.10	3.10	7.55
125	3.98	2.44	2.07	2.65	4.37
127	41.38	7.09	5.42	5.34	22.73
128	1.16	1.17	1.06	0.74	0.64
129	1.24	1.70	1.58	1.93	2.42
130	43.93	10.90	4.88	4.80	18.40
131	32.15	9.51	5.19	7.38	31.02
132	27.38	8.90	5.17	4.00	16.51
133	3.00	3.05	4.18	4.59	15.10
134	13.69	7.78	15.34	15.81	190.52

stand	depth of O horizon (cm)	depth to impenetr. layer (m)	depth to gleying (m)
1	2.39	0.15	**
2	0.64	0.18	**
93	0.56	0.30	**
95	1.42	0.24	**
30	0.33	0.85	0.30
31 A	0.18	0.07	**
31 B	0.79	0.09	**
3	1.35	0.15	**
32	0.64	0.77	**
96	1.27	1.01	**
4	0.79	0.31	**
74	0.00	0.38	**
75	2.62	0.19	**
76	0.79	0.40	**
77	0.00	1.01	0.46
78	1.68	0.30	**
79	0.00	1.01	**
5	0.00	0.22	**
6	0.00	0.20	**
80 A	0.00	1.01	**
80 B	0.00	1.01	**
7	0.00	0.87	**
8	0.00	0.61	**
9	0.48	0.17	**
10	0.79	0.26	**
11	0.00	0.14	**
12	0.00	1.01	**
13	0.00	0.03	**
14	0.00	1.01	**
15	0.33	0.21	**
16	0.00	0.71	**
100	1.60	0.27	**
17	0.00	0.26	**
20	0.00	0.24	**
21	0.00	0.21	**
22	2.69	0.92	0.46
23	2.06	0.41	0.46
24	1.27	0.49	0.47
25	0.15	0.60	**
26 A	0.33	0.89	**
26 B	0.00	1.01	0.36
27	0.00	0.74	**
28	0.00	0.70	**
29	0.00	0.83	0.02
33	0.00	0.09	**
34	0.00	0.16	**
35	0.33	0.32	**

36	0.00	0.17	**
37	0.15	0.20	**
38	0.00	0.00	**
39	0.00	0.02	**
40	0.00	0.04	**
41	0.00	0.04	**
44	0.00	0.32	**
45	0.00	0.92	**
46	0.00	1.01	**
48	0.00	0.20	**
50	0.00	0.38	0.33
47	0.33	0.12	0.08
49	0.33	0.10	**
51	0.00	0.10	**
52	0.00	0.46	0.23
53	0.97	0.16	0.11
54	2.06	0.32	**
55	0.00	0.14	0.08
56	1.75	0.12	**
57	0.00	0.08	**
58	1.75	0.43	0.18
59	0.56	0.16	**
60	0.00	0.08	**
62	1.60	0.16	0.13
63	0.00	0.00	**
64	0.79	0.13	**
65	0.00	0.00	**
66	0.25	**	0.08
67	0.00	0.51	**
68	0.48	0.80	**
69	0.97	0.47	**
70	0.00	**	**
71	0.64	0.13	**
72	0.15	0.29	**
81	1.52	1.01	**
117	0.00	0.30	**
82	0.02	0.25	**
83	0.00	1.01	**
85	1.27	1.01	**
87	1.68	1.01	**
88	1.60	1.01	**
89	1.04	1.01	**
91	0.48	1.01	**
94	0.00	1.01	**
97	0.56	1.01	**
98	0.08	1.01	**
99	0.33	1.01	**
101	0.89	1.01	**
104	0.00	1.01	**
108	0.64	0.47	0.30
110	1.27	1.01	**
86	1.52	1.01	**

112	0.48	0.62	**
115	0.48	0.73	**
116	1.27	1.01	**
92	0.56	0.56	**
103	0.00	1.01	**
18	0.00	1.01	**
102	2.08	0.65	**
105	0.00	1.01	**
106	2.69	0.13	**
107	1.83	1.01	**
109	0.00	1.01	**
118	0.00	1.01	**
119	0.48	1.01	**
120	1.19	0.67	**
123	0.15	1.01	**
121	3.18	0.38	**
124	1.12	1.01	**
125	0.00	1.01	0.08
127	0.00	1.01	**
128	0.41	1.01	0.04
129	1.04	1.01	0.02
130	1.52	1.01	**
131	0.15	1.01	**
132	0.15	1.01	**
133	0.00	1.01	**
134	2.06	1.01	**

stand	wetted channel width (m)	rip zone width (m)	distance from wetted channel (m)
1	1.09	9.60	0.48
2	1.16	3.95	1.83
93	12.50	23.00	in channel
95	1.56	7.96	in channel
30	2.74	5.80	8.77
31 A	1.52	21.00	1.22
31 B	1.52	21.00	1.22
3	0.89	8.93	1.97
32	1.10	22.75	in channel
96	1.16	5.65	0.98
4	7.75	30.00	in channel
74	1.12	10.89	0.64
75	0.51	10.00	0.78
76	0.98	7.02	1.94
77	2.39	14.97	in channel
78	0.45	9.87	1.44
79	2.52	9.03	2.85
5	0.70	3.00	in channel
6	0.40	2.60	in channel
80 A	0.70	5.50	3.15
80 B	0.70	5.50	2.85
7	1.00	3.75	1.24
8	0.70	3.65	1.40
9	0.75	4.00	1.50
10	0.45	12.00	4.50
11	0.85	1.85	0.03
12	0.55	4.47	3.00
13	0.50	3.18	3.50
14	1.05	4.20	1.52
15	1.59	3.40	1.37
16	0.60	2.20	1.73
100	0.38	3.25	0.09
17	0.50	2.27	0.05
20	2.01	4.55	1.52
21	0.66	6.58	in channel
22	1.92	7.18	0.65
23	5.43	7.64	1.02
24	2.25	5.20	in channel
25	0.82	2.47	0.55
26 A	2.09	5.79	0.54
26 B	1.24	6.10	in channel
27	0.24	6.93	1.35
28	0.69	5.96	1.00
29	1.42	2.64	0.16
33	2.91	3.69	0.79
34	2.55	2.41	in channel
35	0.51	2.44	1.96
36	0.88	3.48	0.60

37	0.71	1.32	0.29
38	0.83	2.82	0.55
39	1.20	1.75	0.66
40	1.06	12.83	0.95
41	1.00	12.83	4.38
44	0.84	8.88	5.71
45	0.44	13.41	0.21
46	0.69	13.41	1.77
48	1.46	1.27	1.88
50	0.61	5.78	0.99
47	0.33	3.57	0.82
49	0.68	5.48	2.09
51	0.54	4.61	3.01
52	0.89	9.15	0.11
53	0.60	6.03	1.31
54	1.46	6.09	1.17
55	0.60	0.99	0.19
56	0.74	7.12	13.12
57	0.90	5.69	15.22
58	0.85	4.06	0.46
59	0.91	89.00	85.00
60	0.85	3.24	0.10
62	0.96	2.68	2.09
63	0.66	10.98	in channel
64	0.53	6.79	0.58
65	0.43	6.79	in channel
66	0.55	7.55	1.38
67	2.01	2.23	1.81
68	1.08	6.59	1.87
69	5.46	5.46	1.89
70	0.71	5.38	1.21
71	1.02	2.91	0.52
72	0.41	1.67	0.78
81	1.82	10.46	12.04
117	0.47	16.01	0.11
82	547.62	34.28	14.21
83	547.62	44.78	5.33
85	547.62	152.40	45.72
87	547.62	152.40	68.58
88	547.62	152.40	73.15
89	547.62	152.40	82.30
91	547.62	152.40	91.44
94	547.62	152.40	100.58
97	547.62	152.40	109.73
98	547.62	152.40	118.87
99	**	152.40	118.87
101	**	152.40	73.15
104	**	152.40	109.73
108	**	152.40	36.58
110	**	152.40	68.58
86	**	152.40	73.15
112	**	152.40	64.01

115	**	152.40	54.86
116	**	152.40	64.01
92	2.31	14.33	1.21
103	1.83	7.01	2.57
18	**	**	**
102	**	**	**
105	7.53	13.32	1.10
106	10.14	26.10	0.43
107	2.09	23.00	2.20
109	2.41	4.11	2.04
118	3.23	7.67	0.47
119	7.50	8.99	0.15
120	5.65	10.60	2.21
123	3.81	6.96	2.26
121	22.82	36.47	8.42
124	1.44	9.35	1.90
125	7.14	9.33	in channel
127	12.00	15.00	1.04
128	5.56	10.11	0.67
129	6.75	8.93	in channel
130	7.00	12.00	in channel
131	5.52	12.02	in channel
132	1.49	9.81	in channel
133	2.53	9.96	in channel
134	**	**	**

stand	gradient (%)	aspect ( )	elevation (m)	exclosure age (yrs)
1	25	315	1207	0
2	25	315	1188	9
93	25	315	1188	9
95	25	315	1207	9
30	25	315	1204	9
31 A	25	315	1204	9
31 B	25	315	1204	9
3	25	315	1173	9
32	25	315	1181	9
96	29	315	1204	9
4	16	270	1158	5
74	20	270	1173	5
75	27	270	1170	5
76	27	270	1164	5
77	27	270	1164	5
78	27	270	1151	5
79	27	270	1149	5
5	15	180	1006	10
6	15	180	1009	10
80 A	15	180	1009	10
80 B	13	180	1009	10
7	13	180	1018	10
8	13	180	1024	10
9	13	180	1024	10
10	13	180	1029	10
11	13	225	1029	10
12	13	180	1029	10
13	13	180	1036	10
14	13	180	1039	10
15	13	180	1039	10
16	13	180	1055	10
100	13	180	1055	10
17	13	180	1059	10
20	6	180	1059	10
21	6	180	1067	10
22	6	180	1067	10
23	6	180	1082	10
24	6	180	1082	10
25	6	180	1090	10
26 A	6	180	1097	10
26 B	6	180	1097	10
27	6	180	1097	10
28	6	180	1116	10
29	6	180	1120	10
33	8	90	1189	4
34	8	90	1176	4
35	8	90	1173	4
36	8	90	1173	4

37	8	90	1164	4
38	8	90	1164	4
39	8	90	1158	4
40	8	90	1152	4
41	8	90	1152	4
44	8	90	1146	4
45	8	90	1143	4
46	8	90	1134	4
48	8	90	1134	4
50	8	90	1131	4
47	5	90	1116	10
49	5	0	1074	10
51	5	90	1116	10
52	5	90	1116	10
53	5	90	1112	10
54	5	45	1112	10
55	5	45	1112	10
56	5	0	1112	10
57	5	45	1112	10
58	5	0	1112	10
59	5	0	1109	10
60	5	0	1079	10
62	5	0	1074	10
63	5	45	1082	10
64	5	45	1082	10
65	5	45	1082	10
66	5	0	1067	10
67	5	0	1091	10
68	5	0	1082	10
69	5	0	1082	10
70	5	0	1082	10
71	5	0	1070	10
72	5	45	1070	10
81	<5	315	899	9
117	<5	315	905	9
82	<5	270	866	29
83	<5	270	866	29
85	<5	315	866	29
87	<5	315	866	29
88	<5	315	866	29
89	<5	0	866	29
91	<5	0	866	29
94	<5	0	866	29
97	<5	0	866	29
98	<5	0	866	29
99	<5	0	866	29
101	<5	0	866	29
104	<5	0	866	29
108	<5	0	866	29
110	<5	0	866	29
86	<5	0	866	29
112	<5	45	866	29

115	<5	45	866	29
116	<5	45	866	29
92	3	315	872	4
103	5	270	777	
18	20	0	1097	9
102	20	0	1109	9
105	5	0	823	1
106	6	0	811	1
107	6	0	811	1
109	6	0	805	2
118	6	0	805	2
119	5	0	805	2
120	5	0	805	2
123	5	0	798	2
121	5	270	960	9
124	2	225	926	10
125	2	225	926	10
127	2	225	922	10
128	2	225	917	10
129	2	225	917	10
130	2	225	922	10
131	2	225	922	10
132	2	225	926	10
133	2	225	926	10
134	17	0	1029	9