THE FOREST VEGETATION OF THE LOST CREEK AREA IN THE SOUTHERN FRONT RANGE, COLORADO

by

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This study describes the forest communities of the Lost Creek Scenic Area in Colorado and discusses some of the factors which influence the current (1979) distribution of the forest cover types and the species which comprise them.

Cluster analysis, using cover values with the average linkage of pairs method (Sokal and Sneath, 1963), was used to identify forest cover types and understory groups. The forest cover types resulting from this classification coincide with the climax and successional communities that have previously been described for the Front Range with the notable absence of subalpine fir, *Abies lasiocarpa* (Hook.) Nutt. in the higher elevation forests. The majority of understory samples are found in a single group identified by the presence of common juniper, *Juniperus communis* L.

Ordination according to Bray-Curtis (1957) was used to show the sample and group relationships for both the tree cover and understory cover classification results. Environmental factors were then tested for correlation with the ordination axes, and the significant correlations were used to subjectively describe these complex gradients. The results of the tree cover ordination and environmental correlation suggest that the distribution of climax species is more closely related to a temperature gradient than to a moisture gradient. The results of

the understory cover ordination and environmental correlation were not as easily interpreted, but suggest that the environment for understory species is moderated by the tree canopy. This allows a much broader distribution of the understory species especially common juniper. An additional ordination of stands was constructed on the basis of topographic factors to demonstrate the direct relationship of forest cover types to these factors. Elevation was used as the X axis coordinate, and a synthesis of slope, aspect and slope position, which represented a moisture gradient was used as the Y axis coordinate. Stands dominated by the two most important climax species, Engelmann spruce and Douglas-fir, were clearly segregated with respect to these site characteristics. Aspen-dominated stands occurred in the widest range of site types. Stands dominated by limber pine occurred in a wide range of elevations in the drier sites.

The cover values for tree species and selected understory species were plotted for each sample in the tree cover, understory cover, and environmental ordination to demonstrate the distribution of these species with respect to the ordination axes and the cluster analysis groups. In general these figures show the centers of distribution for these species, with reduced success coinciding with increased distance from these centers. This demonstrates the continuum characteristic of vegetation distribution.

Abundant evidence indicates that fire is an important factor influencing the distribution of vegetation in the Lost Creek

area. The dry windy weather and steep slopes make this area vulnerable to large fires. A large fire is suspected to have occurred in the northern section of the study area, and an 1879 fire date is hypothesized on the basis of tree ring skeleton plots and the available weather and fire records. The frequency of drought and potentially large fires, as deduced from the 250 year record of the skeleton plots, does not demonstrate a regular periodicity but does show an increased incidence of narrow growth rings during the last 100 years.

The distributions of the tree species and forest communities in this southern segment of the Front Range differ somewhat from those described in more northern Front Range studies. Subalpine fir, which commonly occurs near tree line in the central and northern Front Range was not observed in the study area. The highest elevation forest community was a bristlecone pine stand at 3,658 m (12,000 ft). This upward shift of tree limit is expected as a function of the lower latitude of the southern Front Range. Limber pine occurred in a wide range of soil moisture conditions although stands dominated by limber pine are, as in the northern Front Range, restricted to dry windy ridges.

This abstract is approved as to form and content.

John W. Marr

Faculty member in charge of thesis.

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CHAPTER I

INTRODUCTION

Background and Objectives

The Front Range of the Southern Rocky Mountains extends approximately 320 kilometers (200 miles) northward from central Colorado into southern Wyoming. Environmental changes associated with this latitudinal gradient result in a wide range of habitat types, species, and ecological processes. The majority of Front Range forest studies have dealt with northern and especially central sections of the range. This study is concerned with the Lost Creek Scenic Area, a small segment in the southern quarter of the Front Range. The topographic complexity and forest diversity of the Lost Creek Scenic Area creates a mosaic of environmental conditions and vegetation units that can add to the existing information on the nature of the regional forest vegetation. Like most of the Front Range, this area has endured both natural and man-caused disturbances and so has lost its pristine character. The Lost Creek area is, however, an especially appropriate site for this and future studies of the processes of forest ecology by virtue of its protected status as a registered Natural Landmark, a Scenic Area, and a Wilderness Area.

This baseline vegetation study was initiated with the following objectives: (1) to identify the tree, shrub, and herbaceous species present in the study area; (2) to identify, map, classify, and describe the forest units; (3) to examine the relationships of the forest units to elevational, topographic, and soil variability; (4) to examine the successional status of these units based on their structure, age, evidence of disturbance, and known history; and (5) to compare these findings to similar studies conducted in the Front Range.

Quantitative sampling and analysis was limited to the forest vegetation types. A small percentage of the area is composed of riparian, marsh, and alpine vegetation types which have been included in the floristic list but were not quantitatively sampled or analyzed.

Location

The Lost Creek study area is situated in the Tarryall Mountains of the Front Range in Colorado, approximately 80 kilometers (50 miles) southwest of Denver and 80 kilometers (50 miles) northwest of Colorado Springs (Figure 1). There are a number of trailheads on the perimeter of the area that are accessible by graded gravel roads, but the study area is accessible only by trail. The site is located at Lat. 39°12'N., Long. 105°25'W., and includes parts of townships 9S. and 10S., Range 72W. Figure 2 shows the topography and boundaries of the 66.9 square kilometer (25.8 square mile) study area in the

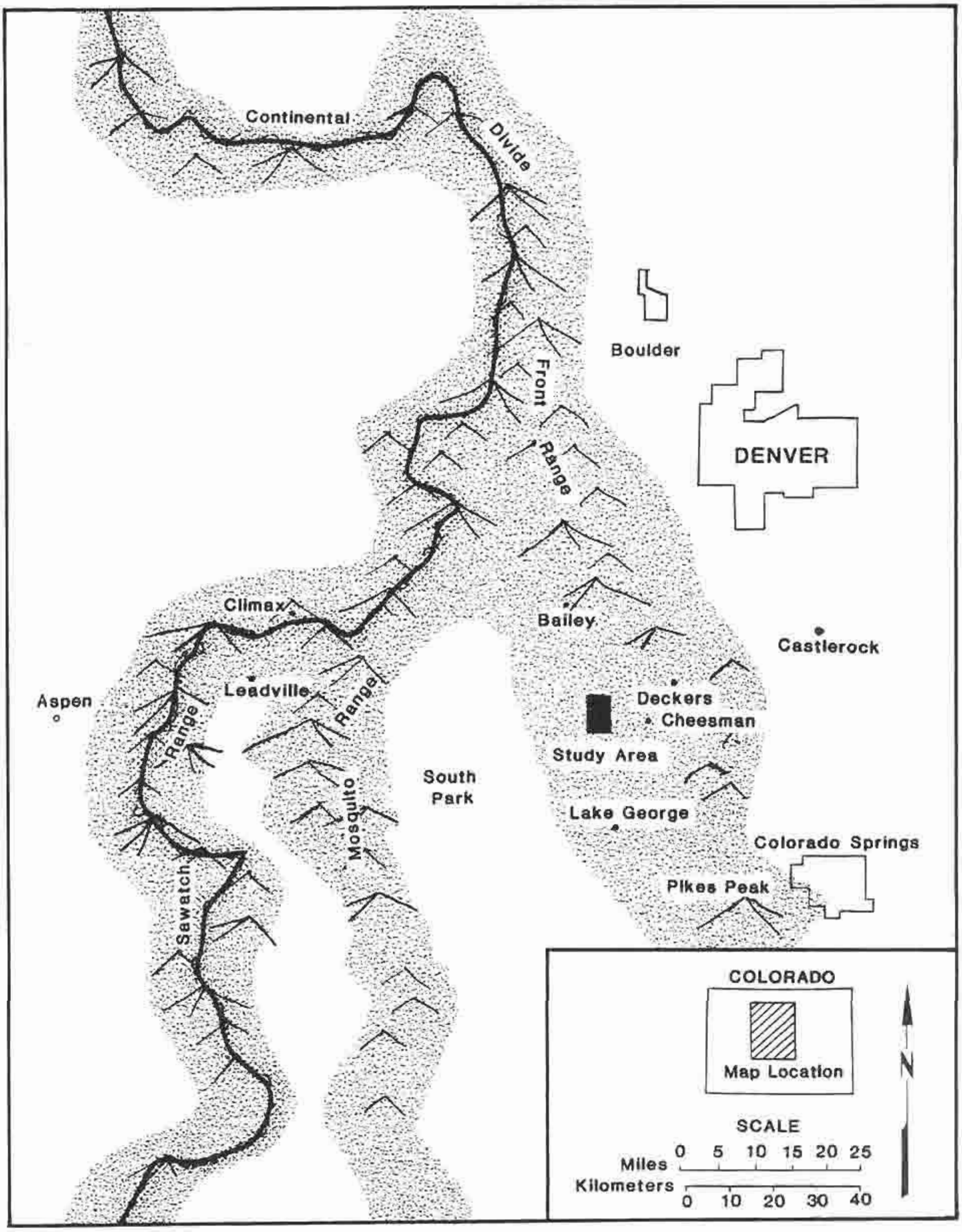

Figure 1. Regional map.

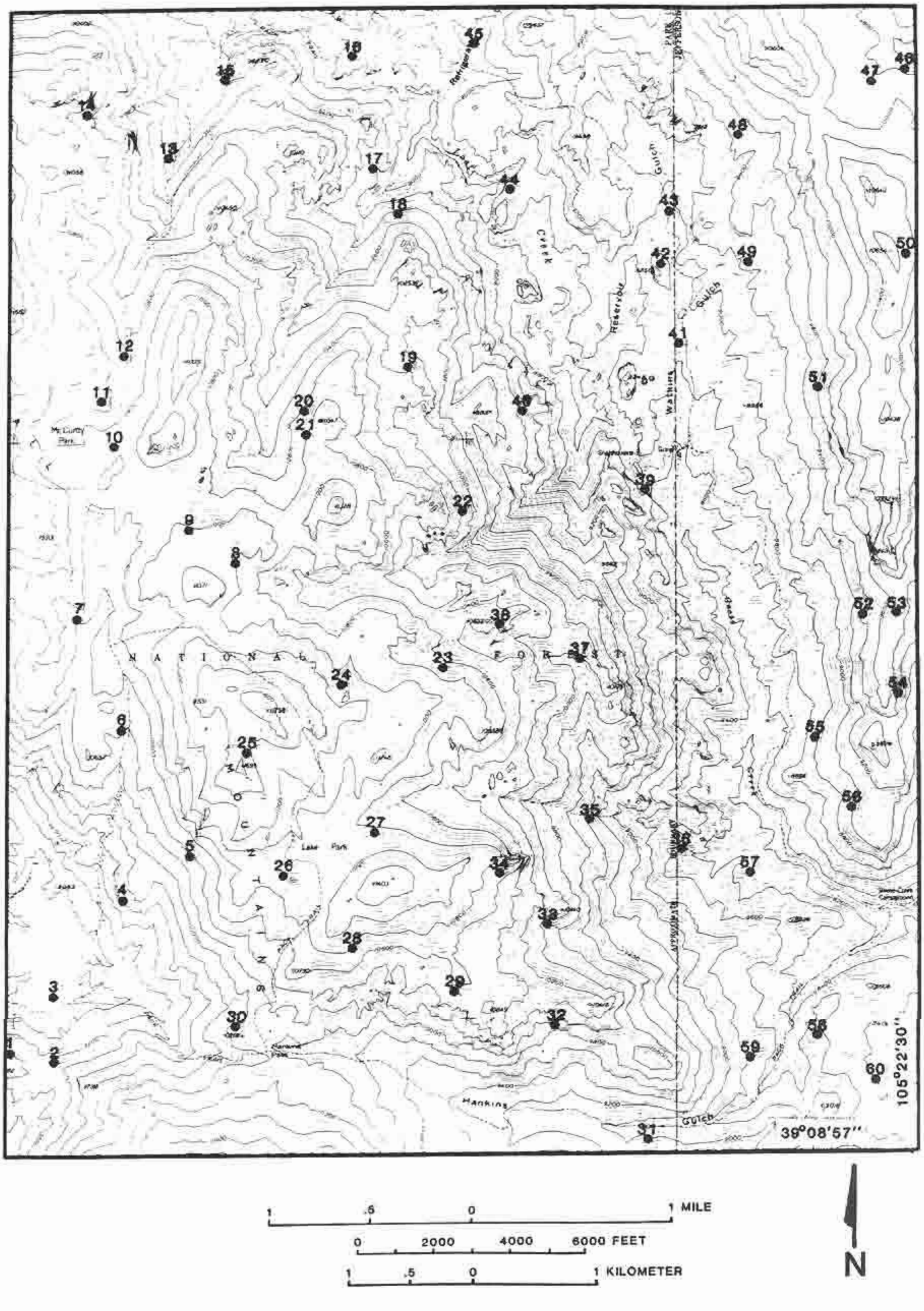

Figure 2. Topographic map with sample locations.

McCurdy Mountain quadrangle (USGS 1956). The area extends from the confluence of Lost Creek and the McCurdy Park drainage in the north to Hankins Gulch in the south, and from the Hay Creek-McCurdy Park Trail in the west to the north/south ridge east of Lost Creek.

Climate

The regional climate is typically continental with extreme variations in diurnal, seasonal, and annual atmospheric conditions. The climatic characteristics of the Front Range have been described by Marr (1961). Air masses arriving in Colorado from the southwest, west, and northwest lose their moisture-holding capacity above the Continental Divide following the compression and cooling of the air due to orographic uplift. This increases precipitation along the divide but greatly reduces the amount of precipitation to the east or lee of the continental crest. The Lost Creek site, and the southern segment of the Front Range are more distant from the Continental Divide than the northern Front Range due to the western deviation of the Continental Divide around South Park, the Mosquito Range and the Arkansas River Valley. The lower annual precipitation of the southern compared to the northern extension of the Front Range may in part be due to this greater distance from the Continental Divide, resulting in a drier position in the east slope "rain shadow". Figure 3 compares temperature and precipitation along two transects which extend from the Continental Divide to the eastern foothills and

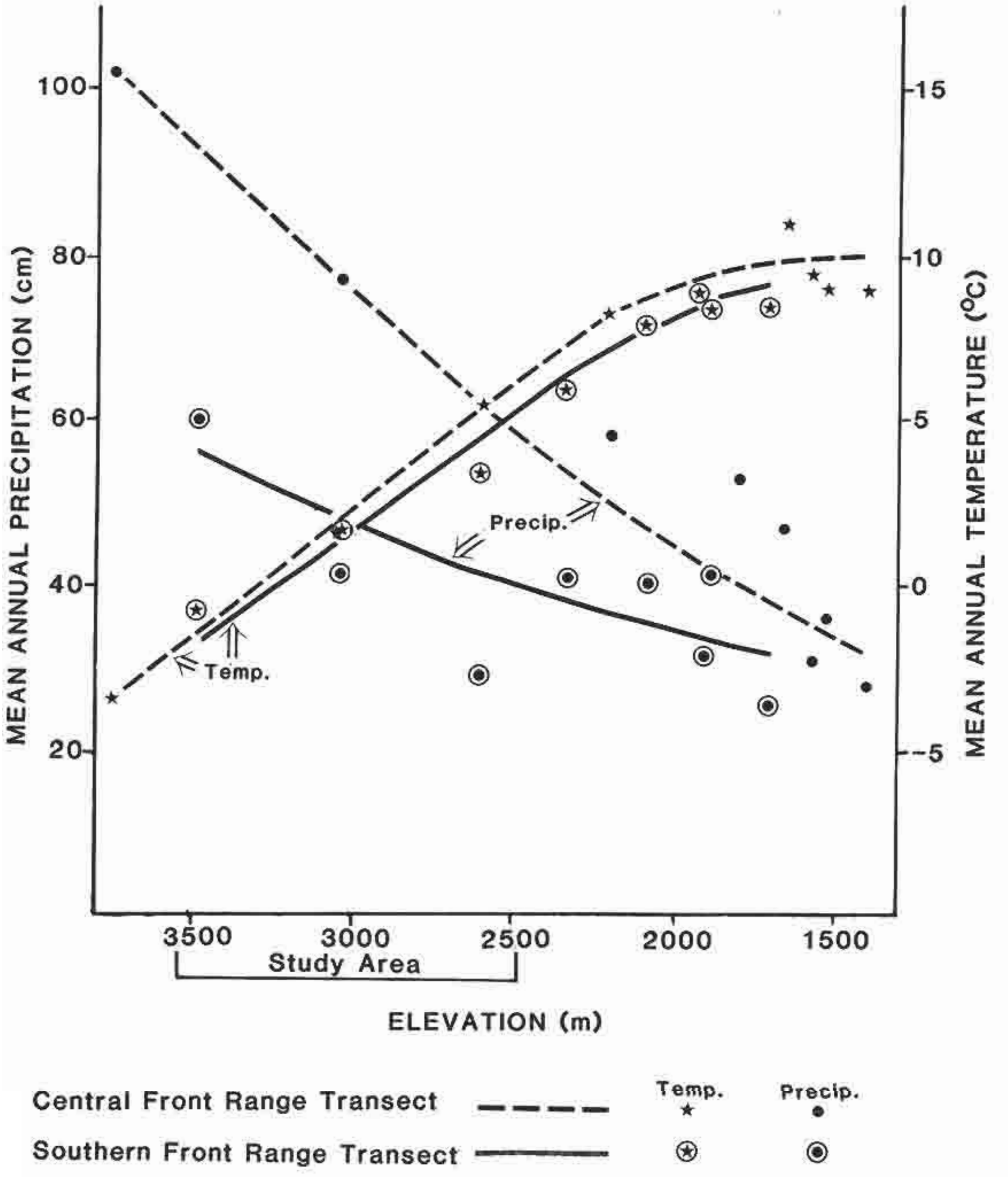

Figure 3. Two Front Range precipitation and temperature transects.

plains. The northern transect, produced by Netoff (1977), shows the variation in temperature and precipitation from Niwot Ridge (left) to the Greeley area (right). The southern transect is for the following stations: Climax, Leadville, Lake George, Bailey, Cheesman, Parker, Castle Rock, and Limon (Colorado Climatology Office, Report No. 77-1). Although temperatures are approximately the same for similar elevations along the two transects, precipitation is lower along the southern transect. The estimated annual precipitation (northern transect) for the Lost Creek study site is 60 cm to 80 cm (24 in. to 31 in.). The southern transect, which provides a better estimate for the study site, indicates an annual precipitation of 40 cm to 50 cm (15.7 in. to 19.7 in.). Although no weather data are available for the Lost Creek study area, a nearby weather station at Cheesman Reservoir shows a mean annual precipitation of 40.1 cm (15.8 in.). The orographic uplift of air masses intercepting the Tarryall Mountains results in slightly higher annual precipitation here than on the immediately surrounding lowlands. The Tarryalls are, however, exposed to strong westerly winds after they have crossed the Continental Divide and have reduced their moisture content. These desiccating winds traverse South Park unimpeded until they meet the western ridge of the Tarryalls and the higher internal ridges and peaks, resulting in severely dry conditions at these topographic positions (Figure 4) and reducing the moisture available to vegetation in the area as a whole.

FIGURE 4. Aerial photograph of McCurdy Mountain. October 25, 1980. This is a southwest facing infrared aerial photograph of the 3,709 m (12,168 ft) summit of McCurdy Mountain which is the granite tor to the right of center in the photograph. A small stand of bristlecone pine occurs below the summit at about 3,658 m (12,000 ft) and is shown to the left of the summit in the photograph. The dark band of forest below the tundra is predominantly Engelmann spruce. The lighter tone forest below the Engelmann spruce is dominated by aspen but with numerous Engelmann spruce and limber pine individuals that are taller than the canopy of the stunted aspen. This large area of aspen appears to be the result of a single large fire. The Continental Divide can be seen in the background as well as the open expanse of South Park.

Figure 5 is a climatogram for the Cheesman station located 8.5 km (5.3 miles) east of the study area at an elevation of 2,096 m (6,875 ft). The average monthly temperature and precipitation values are 20-year averages for years 1951 through 1970 (Colorado Climatology Office, Report No. 77-1). This climatogram is useful as a demonstration of trends rather than absolute values since climate may change drastically over short distances in the mountains due to elevational and topographic influences. Potential evapotranspiration (Et) was calculated according to Thornthwaite (1954; see also Dunn and Leopold, 1978). A comparison of potential evapotranspiration with precipitation shows that there is a potential for drought from about mid-April to mid-November. The potential drought is ameliorated through factors such as the water storage capacity of soil, runoff from melting snow and shading on north-facing slopes. The vegetation is of course highly adapted to these conditions and in a variety of ways ameliorates the effects of drought even on sites where moisture loss is augmented by factors such as southern exposure and dessicating winds. The climatogram shows that drought is least severe during April and May, as precipitation steadily increases. The most severe period of drought occurs near mid-June due to decreasing precipitation and increasing temperature. Monthly precipitation is highest during July and August which serves to reduce the impact of drought. During September, the precipitation drops to a level similar to June's, but decreasing temperatures maintain an almost constant

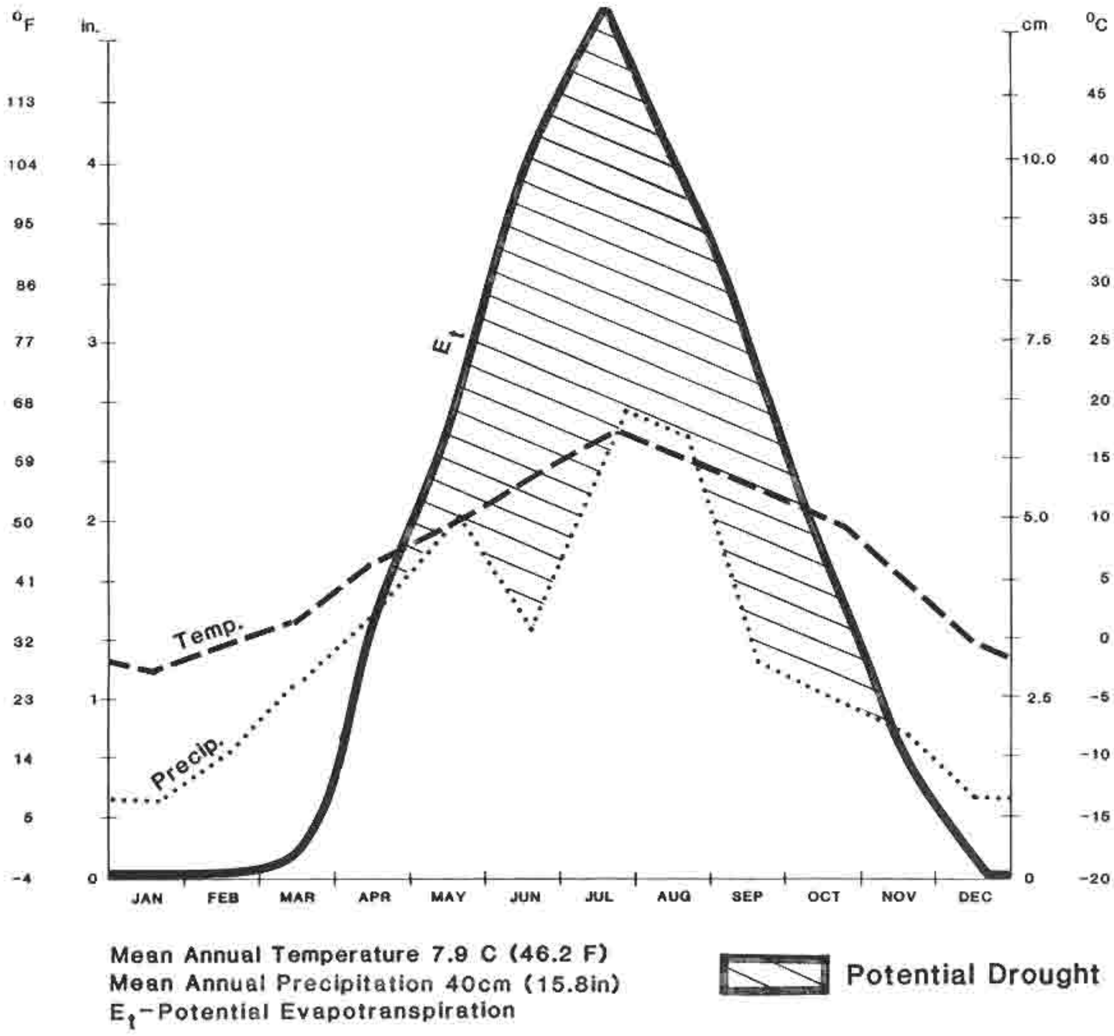

Figure 5. Local Thornthwaite climatogram.

level of drought stress from July through September. Drought stress decreases from October to mid-November as temperatures gradually decrease and the growing season comes to an end.

Because there is such a wide range of elevation in the study area, 3,535 m (11,600 ft) to 2,440 m (8,000 ft), the impact of the mid-June drought maximum on species distributions varies greatly with elevation as well as other site-specific factors. The greatest impact may be expected at sites where species are germinating during this period, while in other areas (e.g., higher elevations, north-facing slopes, drainage channels) the impact may be less. Although this climatogram is a good representation of local climatic characteristics, microsite conditions can be highly modified by both biotic and abiotic factors and may deviate significantly from even locally derived climatograms.

Geology

The Tarryall Mountains are a northwestern extension of the Pikes Peak batholith (Hutchinson, 1976). Intrusion of the main Pikes Peak batholith occurred about 1.04 billion years ago (Hedge et al., 1967), followed closely by the intrusion of the smaller Tarryall batholith along its margin (Hawley and Wobus, 1977). In Pennsylvanian time, about 300 million years ago, there was a pronounced uplift in the region that produced the Ancestral Rockies. The area of greatest uplift was slightly more northwest trending than the present Front Range but occupied about the same position. During the Late Cretaceous, about 100 million years ago, this area became part of a major marine basin as the Front Range lost its structural identity. The current Rocky Mountains are a result of the Laramide orogeny in the late Cretaceous (about 75 million years ago) and the erosional processes of the Cenozoic era. The Cenozoic geomorphic history of the Front Range has been summarized by Thornbury (1965). The early part of this period was marked by gradual uplift and truncation of the Front Range until Miocene time, about 18 million years ago, during which the regional climate changed from warm and subhumid to the present semiarid continental climate. This was followed by a period of more rapid uplift of the range, resulting in canyon-cutting through the crystalline basement rock. Regional glaciation during the Pleistocene (about 2 million years ago) was active in northern sections of the Front Range but does not seem to have directly modified the Lost Creek area, which is highlighted by an abundance of granite tors, providing a good indication of nonglaciation (Street, 1973).

Figure 6 shows the three main granite units of the Tarryall Batholith, which is a zoned pluton and forms the bedrock for the entire area. The upper shell of the batholith has been partially removed by erosion and constitutes the heterogeneous unit termed medium- to coarse-grained granite. This unit (3) forms the eastern ridge of the study area. Under this layer is a unit (2) of coarse-grained subequigranular granite which constitutes the bedrock of the Lost Creek Valley. The larger

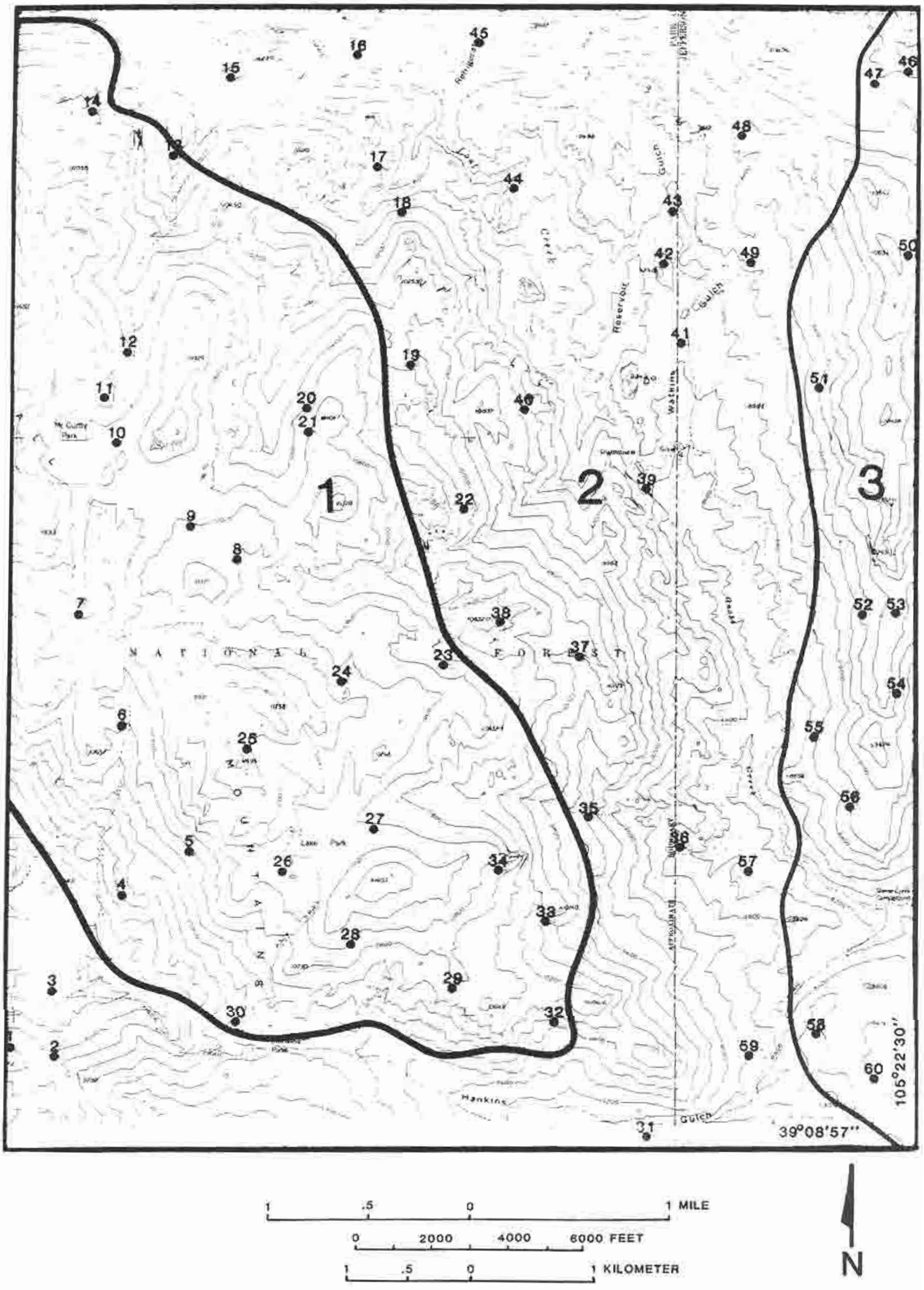

Figure 6. Geologic map.

crystals of this zone make it the most easily weathered of the three granite phases, which may account for the development of the Lost Creek channel through the middle of this unit. The spectacular tors near Lost Creek are derived from this same granite phase and appear as balanced rocks, monoliths, rounded domes, and cliffs. These complex forms are due to exfoliation and weathering along joint planes. Erosional products may accumulate as large core stones in the valley bottom which are sometimes mantled with sufficient topsoil to support vegetation. Lost Creek frequently courses underground through these boulder jams and along joint planes in the bedrock. Underground drainage of this sort, common in limestone, is almost unknown in granite, and for this reason the area has been included in the National Registry of Natural Landmarks. The lowermost zone (Unit 1) of the batholith is a more resistant coarse porphyritic granite which forms the high elevation terrain of the central and western sections of the study area. Although tors near the small streams at these higher elevations are similar to those near Lost Creek, these more isolated tors are typically cliffs and ridges with angular features.

Topography

The study site ranges in elevation from 3,535 meters (11,600 feet) on the western edge below McCurdy Mountain to 2,440 meters (8,000 feet) where Goose Creek leaves the site. The study site topography is primarily a highly dissected complex of all combinations of slope and aspect as shown in Figure 2. In contrast, the north/south ridge east of Lost Creek is a long section of relatively constant slope and aspect with continuously increasing elevation. Lost Creek/Goose Creek is the major stream draining the study area. The Lost Creek section is the upper reach of the stream characterized by several underground or "lost" segments along its length where the stream submerges beneath boulders and reappears from caves. This occurs ten times in a 6.5-km (4-mi) section and on the final reappearance the stream's name is changed to Goose Creek. In August this south-southeast flowing stream is approximately 6 m (20 ft) wide and .3 m (1 ft) deep as it leaves the study site.

Eleven tributaries feed Lost Creek, and some of these also course underground for short sections. Most drainages are narrow, with an average valley wall-slope of 23°. Three of the larger tributaries are fed by upland marshes. These marshes and some of the higher elevation saddles between peaks are the largest expanses of approximately level terrain, but they comprise only a small percentage of the study area. McCurdy Park and Lake Park are the larger marshes, and both occur at 3,290 meters (10,800 feet) elevation. A smaller marsh southeast of McCurdy Park is at the head of the third large unnamed tributary, and a small marsh south of McCurdy Park is the headwater for Hay Creek. Hay Creek drains a small section of the study site in the southwest. All of these streams are part of the South Platte River Drainage. There are a great number of tors throughout the area, the majority of which are found adjacent to drainages on the lower valley slopes. Travel through this rugged terrain is facilitated by a maintained hiking trail that encircles the area. Travel through central sections of the study site is without trails.

Soils

The study area soils are derived from weathered granite of the Tarryall batholith. This pinkish rock weathers to a coarse angular gravel called grus. Soils are predominantly unstable, well drained, sandy loams inherently low in soil nutrients (Hawley and Wobus, 1977). The forest vegetation stabilizes these soils and litterfall produces acid conditions, which are conducive to podzolization. General absence, however, of an albic horizon may be a function of the relative instability of the soils on steep valley slopes. Fire, of which there is ample evidence throughout the study area, has caused deforestation which has allowed accelerated soil erosion and prevented podzolization.

Vegetation

The vegetation of the study area occurs in the Lower Montane, Upper Montane, and Subalpine climax regions described by Marr (1961). Although the lowest elevation of the study area, 2,440 m (8,000 ft), would characteristically be the Lower Montane-Upper Montane ecotone region in the central Front Range, the approximate ecosystem boundaries are shifted to slightly higher elevations at this more southerly extent of the Front Range. The Lower Montane vegetation is incompletely represented in the study area.

The study area is forested throughout, with the exception of the numerous areas of rock outcrop and the few upland marshes. These upland marshes show little surface water but consist of water saturated mats of mosses, sedges, grasses, and forbs. Shrubs are found on the better drained sites, with a predominance of willows at Lake Park, and an additional large population of bog-birch *Betula glandulosa* at McCurdy Park. The riparian woodlands are restricted to the banks of Lost Creek/Goose Creek at the lower elevations and are characterized by alder *Alnus tenuifolia*, western river birch *Betula fontinalis*, and mountain maple *Acer glabrum*. The nonriparian forest is the primary concern of this study and is composed of Engelmann spruce *Picea engelmannii*, aspen *Populus tremuloides*, Douglas-fir *Pseudotsuga menziesii*, limber pine *Pinus flexilis*, bristlecone pine *Pinus aristata*, lodgepole pine *Pinus contorta*, ponderosa pine *Pinus ponderosa*, and blue spruce *Picea pungens*. The absence of subalpine fir *Abies lasiocarpa* is conspicuous because of its importance in central Front Range subalpine forests.

The study area exhibits two subdivisions of interest. The complex topography of the western two-thirds of the study area exhibits a mosaic of forest cover types. In contrast, the eastern third of the study area is a west-facing slope of a ridge with a relatively constant slope and aspect which rises in elevation from 2,500 m (8,200 ft) to about 3,246 m (10,650 ft). This ridge demonstrates a continuum of forest cover types as species composition changes gradually with elevation. Understory is sparse in most stands. Open stands are sunny, but understory cover is low due to the dry, often windy conditions. Dense stands are more mesic, but here reduced sunlight limits understory development. The greatest cover and richness of understory species are found in the middle to low elevation moist forest sites especially in the less acid soils beneath aspen.

Literature Review

There have been no previous vegetation studies of the Lost Creek Scenic Area, but numerous studies in the Front Range do provide a base of information on regional flora, autecology of species, and synecology of communities. Since vegetational composition and environmental factors change rapidly along the latitudinal as well as elevational gradient in the Rocky Mountains, these Front Range studies allow comparisons to be made of the smaller scale local variations of climate, topography, soil, and vegetation within the larger regional unit.

The regional flora has been described in the works of Weber (1976) and Harrington (1964). Autecological studies have described the growth requirements and tolerance limits of Rocky Mountain trees. Bates (1923, 1924) noted the critical importance of seedling sensitivity and survival on distribution patterns.

Daubenmire (1932) described adaptation of conifers to high altitude. Whitfield (1932a,b) studied the effects of environmental variables on transpiration by sunflowers at high altitude. His study at the summit of Pike's Peak provided the basis for a later study of the distribution of natural vegetation along an elevational transect from Pike's Peak eastward to the prairies (Whitfield, 1933). In this later work, Whitfield examined species distribution in terms of their morphological and functional responses to a subjectively defined temperature/moisture gradient. Sperry (1936) studied the growth rates and moisture demands of the economically important conifers at Rocky Mountain National Park. Other studies provide information on habitat requirements which affect the distribution of specific species such as aspen (Baker, 1925; Hoff, 1957), bristlecone pine (Ramaley, 1907a; Mirov, 1967; Fritts, 1969), Douglas-fir (Ramaley, 1907a; Allen, 1972), Engelmann spruce (Ramaley 1907a; Johnson, 1956; Day, 1963; Wardle, 1968; Miller, 1970; Sprackling, 1973), limber pine (Bates, 1917; Douglass, 1954, Johnson, 1956; Mirov, 1967), lodgepole pine (Clements, 1910; Mason, 1915; Gail and Long, 1935; Stahelin, 1943; Douglass, 1954; Johnson, 1956; Mirov, 1967; Moir, 1969), and ponderosa pine (Pearson, 1951; Mirov, 1967). The dynamics of the successional process in regional forests has been covered by many authors: Gardner (1905), Clements (1910), Schneider (1911), Mason (1915), Bates (1917), Baker (1925), Sperry (1936), Ives (1941), Stahelin (1943), Douglass (1954), Johnson (1956), and Marr (1961).

Dendrochonology provides an indirect look at the past climatic conditions, especially drought, which may be related to the disturbances which initiated succession. The principles of dendrochonology were described by Glock (1937), Koslowski (1962), Fritts (1966), and Stokes and Smiley (1968). Schulman (1945) studied tree ring growth in relation to spring runoff in the South Platte River Basin, near Lost Creek. Schulman (1956) also sampled Engelmann spruce at Pikes Peak and near Lost Creek for dendrochonological studies. These two studies and Kreb's (1972) study of bristlecone pine provide comparative data for estimating past climatic trends in this region.

Front Range forests have been classified in a variety of ways by different biologists. These have been reviewed by Marr (1961). His work also provides the most extensive collection of vegetational and environmental data for regional ecosystems classification, community description, and environmental correlation. The current study uses the ecosystem classification of Marr as a base and examines the variation within this scheme produced by local environmental variations.

CHAPTER II

METHODS

Floristic List

A species list for all vascular plants encountered during the 1979 field season was developed from specimens collected in the study area. Identifications were verified by Professor William Weber, Curator of the University of Colorado Herbarium.

Reconnaissance

Reconnaissance began on 3 June 1979 and continued for three weeks. This period was devoted to species collection and a familiarization with the topography, tree species distribution, and ecological processes in order to develop a sampling program appropriate for the time limitations.

Mapping

The area was mapped with respect to forest cover types (Eyre, 1980) using percent relative canopy cover as the measure of species dominance. The mapping units were defined not only by the dominant tree species but also by the subdominants if they occurred with greater than 10 percent relative cover. The mapped units were visually distinct when viewed from adjacent ridges, and their component tree species were initially identified from a distance of less than 1 mile with the aid of 10X binoculars. These mapped units were later field checked from within the stand to verify the composition and relative proportions of tree species. This procedure was not practical for the west-facing slope of the eastern-most ridge in the study area. The conifers in this area could not be differentiated into visible units. The relatively constant slope and western aspect of this segment of the study area was a contrast to the complex topography in the rest of the area. This area was mapped based on notes collected on elevational transect walks and the random samples which were located on this ridge.

Sample Site Selection

Sixty sample sites were selected using a stratified random procedure (Mueller-Dombois and Ellenberg, 1974). The study area was divided into 20 equal area square blocks on the USGS 1:24,000 McCurdy Mountain Quadrangle map. Within each of these 334.46 hectare (826.45 acre) blocks, three samples were selected using random numbers and a Cartesian coordinate grid of 20 x 20 units.

Sampling

Sample sites were located as accurately as possible in the field and adjusted only if the site fell on an unforested area. This occurred only twice; half of sample #35 fell on a large rock outcrop (a reorientation of the plot axis remedied this problem); sample #42 fell on the top of an inaccessible rock outcrop (a random direction was selected and the nearest stand was sampled). Sampling was done using the standard Daubenmire 15m x 25m plot oriented with the long axis along the slope contour.

Tree Data

Percent canopy cover was used as the measure of tree species dominance and was estimated in the standard 15 m x 25 m Daubenmire plot using fifteen 5 m x 5 m sample plots. Canopy cover was defined as the vertical projection of the canopy on the ground, excluding the gaps which may occur within the tree crowns. These values are useful only for purposes of comparison within this study due to the subjective nature of these estimates. Density for each species was measured in two categories; (1) individuals taller than 1 m and (2) individuals 1 m or less in height. The height, diameter, and age of the tallest representative of each species was also estimated. Height was visually estimated. Diameter was estimated by measuring the circumference at breast height and dividing by 3.1416 to convert this to a diameter value. Age was estimated by 5 mm (3/16 in.) increment cores taken at a height of 1 m. These cores were returned to the lab, dried and sanded. The growth increments were counted using a dissecting microscope. Skeleton plots were then constructed (Glock, 1937) for the last 250 years of growth for the 21 oldest trees sampled in this study.

Understory Data

Shrub and herbaceous data were collected using fifty 2dm x 5dm microplots located at 1 m intervals on the inner sides of the 25 m boundaries of the central 5m x 25m macroplot. Cover values were estimates of the vertical projection of each species on the soil surface. The percent cover of rock, bare soil, and litter was also estimated.

Environmental Factors

Environmental factors recorded at each site were slope, slope position, aspect, elevation, and selected characteristics of the upper soil horizons. Slope was measured in degrees with a .5 meter long level at numerous points within the plot to estimate the average slope. Slope position indicates the tendency of a site to shed or accumulate incoming moisture whether it be in the form of precipitation, surface flow, or underground drainage. Figure 7 shows the five slope position categories (after Loucks, 1962) which are defined as follows:

1. This is the driest slope position. Sites of this type are exposed, water shedding surfaces with only direct precipitation as a moisture input. These sites are typically ridges or peaks.

2. These are water shedding sites with precipitation moisture input that is augmented with surface flow and underground drainage from upslope areas.

3. These water shedding sites have an increased moisture input from a larger upslope precipitation catchment area than type 2 sites.

4. These sites are transitional between water shedding and water accumulation sites.

5. These are sites with the greatest water accumulation with soils which will achieve field capacity most frequently. Standing or running water is most frequent at these sites.

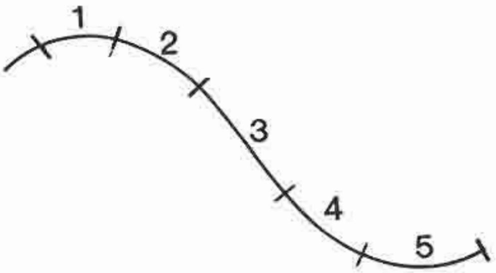

Figure 7. Slope position categories.

The aspect categories shown in Figure 8 were used to rank the combined drying influences of southerly insolation (Loucks, 1962) and the prevailing westerly to southwesterly winds. The drier sites are southwest-facing due to the combined effects of wind and sun while the moister sites are northeast-facing. Evapotranspiration losses on east-facing slopes are more attributable to insolation factors (i.e., direct insolation earlier in the day), while wind is the most influential factor on west-facing slopes. The evapotranspiration equivalence of a northwest aspect with a southeast aspect, as is indicated in Figure 8, is therefore a first approximation and requires further physiological testing and climatic information for verification. The soil pit was located in the center of each sample plot or if necessary, adjusted to a more typical site within the plot. This was sometimes necessary in plots with large boulders or steep

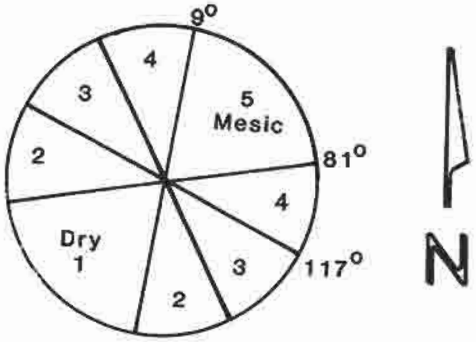

Figure 8. Aspect/moisture categories.

rocky sites where soil accumlated only on the more level terraces. Soils were analyzed for (1) depth of the organic layer, (2) depth of the A horizon, (3) pH of the A horizon, and (4) degree of clay accumulation in the B horizon. Soil depths were measured in centimeters, pH was measured in the field with a LeMotte soil test kit, and clay accumulation in the B horizon was categorized as absent, present, or abundant based on a textural determination made by hand at the site.

Dendrochronology/Climatic History

Dendrochronology provides an indirect look at the local climatic history. The annual growth ring is the integrated response of the individual tree to the environment and in some situations provides a record that correlates well with climate (Fritts, 1966). Skeleton plots were constructed for the most recent 250 years of growth for the 21 oldest trees found in the 60 samples and 2 additional bristlecone pine sites. One bristlecone pine site is below the summit of McCurdy Mountain at 3,658 m

(12,000 ft), and isolated from adjacent forests by alpine tundra. This severely windy site would probably not support the bristlecone pine if it were not for the shelter provided by the granite tor immediately to the northwest (Figures 4 and 13). The second Bristlecone site is at 3,414 m (11,200, ft) in a southwest facing drainage northwest of Lake Park. This bristlecone pine dominated stand is shown on the Forest Cover Type Map (Figure 9), is described in the map discussion p. 33, and was photographed (Figure 13). Descriptions of the environmental and vegetational characteristics of the other sample sites may be found in the appropriate summary tables.

Classification

The sample stands were classified using a modification of Sorenson's Coefficient of Community (Motyka et al., 1950) with the average linkage of pairs method (Sokal and Sneath, 1963) to produce a dendrograph. This was done separately for tree species cover values and understory species cover values. The 63 percent level of similarity was used to define sample clusters for tree cover values. Clusters at this level were found to coordinate well with the mapped units.

The groups derived from the dendrograph of understory species were not defined at a single level of similarity. The attempt to use a single level of similarity produced groups with members that were too diverse, or groups that were too similar to be properly differentiated.

A numerical classification of samples based on environmental factors was attempted, but proved unuseable. This problem arises from the different levels of measurement used for each factor and the undefined relationships between them. For example, the amount of elevational change that will compensate for a specific change in aspect is unknown. Loucks (1962) demonstrated a scalar approach that could more objectively address this problem, but the procedures do not address the factors of wind or cold air drainage which are important in the Lost Creek area. The appropriate modifications of these scalars to include these factors were not attempted in this work, but are recommended for future studies.

Ordination

Although cluster analysis is useful for differentiating groups found in a set of samples, the dendrograph is not as good at representing stand and group relationships as is ordination. The stands therefore were located in a two dimensional Bray-Curtis (1957) ordination. Separate ordinations were constructed for (1) tree species canopy cover values, (2) understory species cover values, and (3) environmental factors. The groups defined by cluster anaysis were outlined within the ordination framework in order to reveal inter-group relationships. The axes for the tree and understory ordinations were then correlated with 15 site variables. These factors were elevation, aspect, slope, slope position, depth of the A horizon, pH of the A horizon, presence of clay in the B horizon, exposed rock, bare soil, litter, fire evidence, standing dead trees, total tree canopy cover, tree diversity, and understory diversity. The factors which best correlated with the ordination axes were used in a subjective analysis of the complex gradient represented by each axis. This is the indirect gradient analysis approach of Whittaker (1967).

An alternative subjective ordination of samples based directly on environmental factors also was used to present sample and group relationships. The X axis of this ordination was defined as the sample site elevation. The elevations were arranged in decreasing rather than increasing value in order to conform with the Bray-Curtis ordination results. The Y axis was defined as a synthesis of slope, aspect, and slope position which had been scaled to the same range of values and transformed so that increasing values for each factor indicated wetter soil conditions. The average of these three values was used as the Y axis coordinate.

Species Distributions

In order to better define the distributions of each tree species and selected understory species in relation to the ordination axes and the groups defined by cluster analysis, cover values for these species have been plotted for each sample within the ordination framework.

CHAPTER III

RESULTS AND DISCUSSION

Floristic List

Results

The list of vascular plants identified in the study area and the alpine tundra of McCurdy Mountain is presented in Appendix A.

Discussion

Two hundred eighty-eight species were identified. There were 9 tree species, 28 shrubs species, 29 grass species, 11 sedge species, 1 rush species, 7 fern and fern allied species, and 203 forb species. *Mimulus gemmiparus* W.A. Weber is a rare plant of special interest that had previously been identified from only one other locality in Rocky Mountain National Park. A specimen has been deposited with the University of Colorado Herbarium.

Forest Cover Type Map

Results

The map of forest cover units is presented in Figure 9. The units are defined by a one- or two-part species code. The

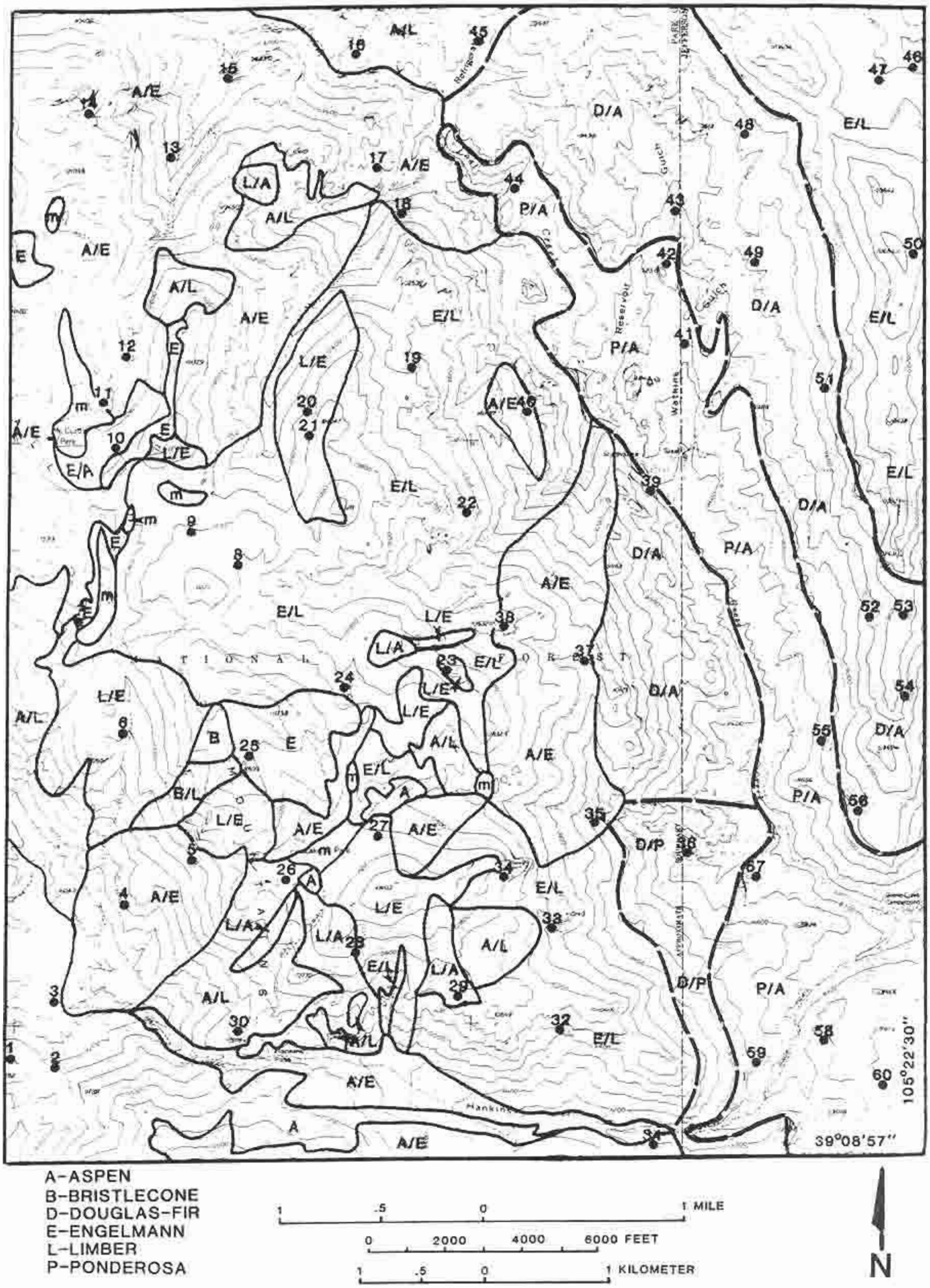

Figure 9. Forest Cover-type Map.

first species is the dominant with greater than 50 percent relative cover. The second species is the subdominant or codominant with 50 percent or less relative cover. Other tree species are usually present but not differentiated at this level of mapping. Dotted lines on the vegetation map indicate units that were determined based on the expected elevational distribution of species in areas that could not be mapped visually.

Discussion

The northwestern two-thirds of the study area is characterized by complex topography and forest cover types that are relatively easy to distinguish visually. West, southwest, and south-facing slopes in this area which are above 2,743 m (9,000 ft), are characteristically limber pine dominated stands mixed with Engelmann spruce, aspen and bristlecone pine. These slopes and ridges are sunny, well drained and wind exposed. Bristlecone pine is frequently found mixed with limber pine in sites with extremely windy conditions. These sites are typically in saddles along ridges with coarse grus soil and very little understory. Northwest of Lake Park is the only large area dominated by bristlecone pine. This site is found on a southwest facing slope between two high walled ridges and is typically dry and windy. In sites that are less severe, Engelmann spruce is mixed with the limber pine. Aspen is found on these dry windy slopes in areas which have been disturbed more recently. These stands commonly possess numerous scattered limber pine that are taller and older than the dense aspen population. At the more severe sites, aspen is stunted with Engelmann spruce established under the aspen canopy. Limber pine, however, is usually unsuccessful at establishing new seedlings under the aspen canopy due to the shade intolerance that is typical for pines. This interesting successional sequence leads to a climax of Engelmann spruce mixed with large old limber pines. The mature limber pine is competing successfully for all growth requirements yet cannot reproduce. Only factors which open up the forest canopy will allow the successful establishment of limber pine seedlings. The elimination of limber pine from these stands then becomes a function of the life span of these individuals and the frequency of the canopy clearing events. Fire is the most frequent event that would initiate the reestablishment of limber pine. The longevity of limber pine is evident in the fact that the oldest tree cored in this study was a healthy 745 year old limber pine, and other limber pine were too broad in diameter to collect a complete core. It seems reasonable to assume that few stands could avoid fire for the 800+ years required to remove limber pine by other factors such as disease, infestation, or old age. The frequency of drought, as indicated by the annual growth ring record, and the likelihood of lightning strikes support this speculation. The north, northeast, and east facing slopes of the northwestern two thirds of the study area exhibit advanced stages of this successional sequence. These mature stands have survived to this advanced stage not only due to the mesic conditions produced by a northeast facing slope but also possibly to a position in the landscape that is protected from all but the most severe forest fires. The prevailing southwesterly winds and the position of ridges as fire breaks could be factors preserving the centrally located stands of Engelmann spruce and limber pine. the current distribution of aspen is predominantly on the southern, western and northern perimeter of the study area. These areas, not surprisingly, coincide with those areas most heavily utilized by man since the 1700's. Local legend indicates a great fire for this area around 1880. No documentation has been found to positively establish this date for the Lost Creek area. Other evidence does, however, tend to support it (see tree ring discussion, p. 98). As previously described, these aspen stands are commonly stunted but may reach full growth in more mesic sites, especially along stream drainages. Not only living limber pine, but also standing dead trunks of limber pine and Engelmann spruce are interspersed through these stands, providing evidence of the predisturbance stand composition. The standing dead Engelmann spruce and limber pine may be differentiated by the relative sizes of the upper versus lower limbs. The upper limbs of limber pine may have diameters that are equal to or greater than the lower limb diameters. This is probably due to the shade intolerance of the lower limbs. The limbs of Engelmann consistently decrease in diameter toward the apex of the trunk. The presence of these standing dead trees indicate a prefire forest with varying proportions of limber pine and Engelmann spruce, the distribution of which coincides well with the distribution of current forest cover types as described above.

The remaining southern and eastern sections of the study area are not as topographically complex, and the tree species are not visually divisible. This area exhibits a typical vegetation continuum. Ponderosa pine dominates stands in the warm lower elevations. Douglas-fir occurs in the cooler mesic sites and is eventually replaced by Engelmann spruce at higher elevations. Limber pine is most abundant along the wind exposed ridges. Aspen is found in areas of disturbance and in areas with deeper moist soils, especially along drainages. These stands are sometimes small with a patchy distribution and have not been included at this level of mapping.

Sample Locations

Results

The locations of sample sites are presented in Figure 2.

Tree Analysis

Tree Data Summary

Results

The summary of tree data is presented in Table I.

Discussion

These data provide the comparative information used to describe stand composition, cover dominance, physiognomy,

TABLE I

TREE DATA SUMMARY

Sample No.	Species	% Cover	Trees/Hectare >1 m in ht.	Saplings/ Hectare ≤1 m in ht.	Height (m)	DBH (cm)	Age
1	*Populus tremuloides*	61	3,867	800	10	16	117
	Pseudotsuga menziesii	20	373	240	16	26	58
	Pinus flexilis	5	160	27	8	14	64
2	*Pseudotsuga menziesii*	42	1,200	640	15	24	76
	Populus tremuloides	30	1,973	1,547	11	12	100
	Pinus flexilis	15	320	160	11	24	78
3	*Populus tremuloides*	79	2,853	533	12	16	96
	Picea pungens	4	267	320	7	12	32
	Pinus flexilis	2	240	160	4	4	34
	Pinus ponderosa	1	160	53	5	7	44
	Pseudotsuga menziesii	1	27	27	2	1	10
	Pinus aristata	1	0	27	.4	-	-
4	*Pinus flexilis*	24	187	0	9	35	258
	Pseudotsuga menziesii	5	27	27	18	35	87
5	*Populus tremuloides*	59	5,413	1,227	10	13	74
	Pinus flexilis	15	160	80	10	23	63
	Picea engelmannii	8	160	80	14	37	99
	Pinus contorta	1	53	0	3	18	80
6	*Pinus flexilis*	24	213	27	12	53	223
	Picea engelmannii	8	107	53	14	42	238
	Pseudotsuga menziesii	6	27	0	11	39	150*
7	*Pinus aristata*	14	267	187	11	42	175*
	Pinus flexilis	13	80	53	13	60	165*
	Picea engelmannii	12	240	107	18	38	89
8	*Picea engelmannii*	36	1,733	427	16	37	570
	Pinus flexilis	3	53	0	15	72	723*
9	*Picea engelmannii*	33	853	453	17	42	241

* These samples had incomplete cores due to a radius greater than the length of the increment borer or had rotten cores that could not be counted. The age given is the minimum age derived from the countable rings.

TABLE I (cont.)

TREE DATA SUMMARY

Sample No.	Species	% Cover	Trees/Hectare >1 m in ht.	Saplings/ Hectare ≤1 m in ht.	Height (m)	DBH (cm)	Age
10	Picea engelmannii	35	5,147	773	13	29	51
	Populus tremuloides	4	827	347	11	17	75
	Pinus aristata	4	53	107	10	22	63
	Pinus flexilis	1	27	0	6	32	235
11	Pinus flexilis	9	347	133	8	32	50
	Pinus aristata	8	80	507	9	27	51
12	Populus tremuloides	81	4,080	960	12	18	85
	Pseudotsuga menziesii	3	27	27	6	10	31
	Pinus flexilis	1	0	133	.3	-	-
13	Populus tremuloides	80	8,107	3,627	14	22	112
	Pinus flexilis	1	107	107	8	10	66
	Picea engelmannii	1	0	187	.2	-	-
	Pinus aristata	1	27	0	4	5	33
14	Pinus flexilis	9	267	0	7	23	47
	Populus tremuloides	1	0	27	.9	-	-
15	Populus tremuloides	48	3,653	1,733	13	16	66
	Pinus flexilis	13	560	80	11	20	43
	Pinus aristata	5	53	27	11	23	60
	Picea engelmannii	3	80	53	7	9	35
	Pseudotsuga menziesii	2	53	0	7	9	26
16	Pinus flexilis	37	80	0	8	22	66
	Populus tremuloides	1	80	107	2	5	12
17	Populus tremuloides	31	1840	533	14	22	95
	Picea engelmannii	18	133	27	16	44	60
	Pinus flexilis	1	53	0	2	1	12
	Pseudotsuga menziesii	1	0	27	.6	-	-
18	Pinus flexilis	18	293	240	14	22	68
	Populus tremuloides	13	1,760	720	9	11	73
	Picea engelmannii	13	347	0	14	25	76
	Pseudotsuga menziesii	10	160	53	16	26	75

TABLE I (cont.)

TREE DATA SUMMARY

Sample No.	Species	% Cover	Trees/Hectare >1 m in ht.	Saplings/ Hectare <1 m in ht.	Height (m)	DBH (cm)	Age
19	*Picea engelmannii*	28	1,307	800	14	32	285
	Pinus flexilis	9	240	80	14	39	261
	Picea engelmannii	2	27	0	13	33	279
20	*Picea engelmannii*	26	533	80	17	33	409
	Pinus flexilis	15	187	53	16	50	390
21	*Picea engelmannii*	31	1,120	613	10	32	354*
	Pinus flexilis	22	187	53	11	45	745
22	*Picea engelmannii*	27	533	160	22	48	259
	Pinus flexilis	14	267	0	16	50	253
	Populus tremuloides	5	587	827	8	7	81
	Pseudotsuga menziesii	2	27	27	6	9	55
23	*Picea engelmannii*	34	2,773	1,173	12	26	295
	Pinus flexilis	10	187	133	14	40	100
24	*Picea engelmannii*	22	827	347	18	57	338*
	Pinus flexilis	1	0	27	.3	-	-
25	*Picea engelmannii*	36	800	240	18	46	212
26	*Pinus flexilis*	15	133	80	8	20	52
	Pinus aristata	10	533	240	6	13	29
	Populus tremuloides	3	347	160	4	6	25
	Picea engelmannii	1	80	133	5	7	19
27	*Picea engelmannii*	5	213	533	6	15	36
	Pinus flexilis	1	27	133	1	-	-
28	*Pinus flexilis*	31	347	27	7	19	79
	Populus tremuloides	11	1,733	880	4	5	52
	Pinus aristata	1	0	27	.2	-	-
29	*Pinus flexilis*	29	1,013	160	7	26	90
	Populus tremuloides	4	1,093	533	6	5	60
	Picea engelmannii	1	0	0	8	18	80

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* These samples had incomplete cores due to a radius greater than the length of the increment borer or had rotten cores that could not be counted. The age given is the minimum age derived from the countable rings.

TABLE I (cont.)

TREE DATA SUMMARY

Sample No.	Species	% Cover	Trees/Hectare >1 m in ht.	Saplings/ Hectare ≤1 m in ht.	Height (m)	DBH (cm)	Age
30	*Populus tremuloides*	21	1,733	827	9	14	91
	Pinus flexilis	21	640	160	8	23	72
	Picea engelmannii	4	133	613	8	20	67
	Pseudotsuga menziesii	3	160	0	9	24	87
	Pinus contorta	1	107	0	8	.6	56
31	*Populus tremuloides*	58	1,813	160	14	15	112
	Picea engelmannii	13	160	240	11	22	79
	Pseudotsuga menziesii	9	107	0	19	26	87
32	*Picea engelmannii*	18	240	0	18	49	262
	Pinus flexilis	17	267	27	16	34	208
	Pseudotsuga menziesii	15	27	0	20	63	214*
33	*Picea engelmannii*	39	1,013	213	18	48	164
	Populus tremuloides	6	693	1,120	16	19	117
	Pseudotsuga menziesii	4	107	0	17	28	107
	Pinus flexilis	2	27	0	4	10	90
34	*Pinus flexilis*	36	187	27	8	37	91
	Picea engelmannii	1	80	53	16	45	100
35	*Populus tremuloides*	34	2,080	533	14	11	115
	Pinus contorta	16	560	53	16	23	70
	Pseudotsuga menziesii	12	107	320	17	36	89
	Pinus flexilis	4	80	80	10	17	74
36	*Pinus ponderosa*	20	107	27	10	45	128
	Pseudotsuga menziesii	6	27	27	8	32	87
	Populus tremuloides	2	133	187	5	9	99
37	*Populus tremuloides*	59	5,787	4,347	8	11	97
	Pseudotsuga menziesii	3	27	0	4	8	20
	Pinus flexilis	2	80	0	4	7	21
38	*Populus tremuloides*	24	1,760	1,147	7	12	87
	Pinus flexilis	9	107	80	7	14	50
	Picea engelmannii	2	53	27	8	15	61

* These samples had incomplete cores due to a radius greater than the length of the increment borer or had rotten cores that could not be counted. The age given is the minimum age derived from the countable rings.

TABLE I (cont.)

TREE DATA SUMMARY

Sample No.	Species	% Cover	Trees/Hectare >1 m in ht.	Saplings/ Hectare ≤1 m in ht.	Height (m)	DBH (cm)	Age
39	*Pseudotsuga menziesii*	50	1,333	160	18	32	94
	Populus tremuloides	8	640	667	10	15	99
	Pinus ponderosa	1	27	0	13	22	86
	Pinus flexilis	1	27	0	10	10	80
	Picea engelmannii	1	27	0	3	5	60
40	*Pseudotsuga menziesii*	38	347	53	21	45	199
	Picea engelmannii	4	107	0	10	13	75
	Pinus flexilis	3	53	0	11	16	230
41	*Pseudotsuga menziesii*	20	267	133	17	39	130
	Pinus ponderosa	7	107	0	16	45	149
	Populus tremuloides	6	293	1,120	5	9	79
42	*Pseudotsuga menziesii*	44	1,787	133	18	27	88
	Populus tremuloides	6	267	80	12	20	91
	Pinus flexilis	5	53	53	10	21	70
43	*Populus tremuloides*	22	1,840	880	15	20	97
	Pseudotsuga menziesii	20	427	80	12	16	75
	Picea pungens	12	293	160	10	14	43
	Pinus ponderosa	11	133	0	16	37	96
	Pinus flexilis	1	80	27	3	5	34
44	*Pinus ponderosa*	19	187	53	15	55	255*
	Pseudotsuga menziesii	10	267	160	12	39	179
	Pinus flexilis	3	80	53	10	32	220
45	*Populus tremuloides*	39	1,627	747	14	31	120
	Picea engelmannii	4	53	0	8	14	35
	Pinus flexilis	1	27	0	9	15	84
46	*Picea engelmannii*	27	693	293	23	54	505
	Pseudotsuga menziesii	11	240	53	19	24	97
	Pinus flexilis	1	53	53	6	6	57
47	*Picea engelmannii*	36	880	773	27	59	450*
	Pinus flexilis	8	27	0	25	59	490*
	Populus tremuloides	3	267	1,253	14	15	150

* These samples had incomplete cores due to a radius greater than the length of the increment borer or had rotten cores that could not be counted. The age given is the minimum age derived from the countable rings.

TABLE I (cont.)

TREE DATA SUMMARY

Sample No.	Species	% Cover	Trees/Hectare >1 m in ht.	Saplings/ Hectare ≤1 m in ht.	Height (m)	DBH (cm)	Age
48	*Populus tremuloides*	29	1,893	1,067	16	16	112
	Pseudotsuga menziesii	21	347	160	18	26	58
	Pinus flexilis	15	400	53	14	25	99
	Picea engelmannii	8	133	107	12	18	62
49	*Pseudotsuga menziesii*	24	240	27	16	49	200*
	Pinus flexilis	7	107	27	14	39	213
50	*Picea engelmannii*	31	640	27	21	31	294
	Pinus flexilis	8	80	53	17	50	288*
	Pseudotsuga menziesii	3	53	0	14	6	288
	Populus tremuloides	1	187	427	8	23	82
51	*Pseudotsuga menziesii*	31	453	267	18	39	93
	Populus tremuloides	15	1,333	933	12	14	94
	Pinus flexilis	6	107	80	14	24	79
	Picea engelmannii	3	107	0	16	20	75
52	*Pseudotsuga menziesii*	42	933	160	14	32	248
	Pinus flexilis	10	533	53	13	31	259
53	*Pseudotsuga menziesii*	32	293	27	15	41	210
	Pinus flexilis	4	80	0	12	42	297
54	*Pseudotsuga menziesii*	50	1,280	267	12	27	70
	Pinus ponderosa	4	53	0	9	22	72
	Pinus flexilis	1	53	0	8	8	64
	Juniperus scopulovum	1	53	0	2	3	39
55	*Pseudotsuga menziesii*	42	613	187	15	35	100
	Pinus ponderosa	4	160	27	15	26	118
	Pinus flexilis	1	80	53	8	14	95
	Populus tremuloides	1	187	160	2	1	10
56	*Pseudotsuga menziesii*	34	1,120	107	14	25	79
	Pinus ponderosa	17	267	80	13	37	118
	Populus tremuloides	1	27	160	7	9	75
57	*Populus tremuloides*	56	2,240	827	13	21	88
	Picea engelmannii	6	27	0	11	27	105
	Pinus ponderosa	2	27	0	14	36	99
	Pseudotsuga menziesii	2	80	53	3	4	20

* These samples had incomplete cores due to a radius greater than the length of the increment borer or had rotten cores that could not be counted. The age given is the minimum age derived from the countable rings.

TABLE I (cont.)

TREE DATA SUMMARY

Sample No.	Species	% Cover	Trees/Hectare >1 m in ht.	Saplings/ Hectare ≤1 m in ht.	Height (m)	DBH (cm)	Age
58	*Pseudotsuga menziesii*	36	853	427	12	27	77
	Pinus ponderosa	15	213	27	15	49	139
	Populus tremuloides	1	53	240	6	9	70
59	*Pinus ponderosa*	17	133	53	16	48	280
	Pseudotsuga menziesii	6	80	213	7	17	75
60	*Pseudotsuga menziesii*	46	1,840	133	16	25	88
	Populus tremuloides	5	1,067	1,200	12	13	93
	Pinus contorta	1	27	0	17	24	109
	Pinus ponderosa	1	80	0	13	26	114

successional status, and estimate the time that has passed since the last major disturbance. Major disturbances are those which significantly alter the populations.

Successional status has been derived from the dominance relationship of successional (e.g., aspen, limber pine) and climax (e.g., Douglas-fir, Engelmann) species in the two height categories (i.e., trees vs. saplings). The four possible results for this type of evaluation are interpreted as follows:

1. Both height categories are dominated by climax species. In this case the stand is self-replicating and is in a later successional stage or climax condition.

2. Both height categories are dominated by successional species. This indicates an early stage of succession where climax species are just becoming estabished or have not yet been successful.

3. Successional species dominate the greater than one meter category while climax species dominate the one meter or less category. This indicates a mid-successional stage, with seedlings of climax species successfully dominating the seedlings of successional species.

4. Climax species dominate the greater than one meter category and successional species dominate the one meter or less category. This seemingly paradoxical situation arises in late successional stands that have undergone recent disturbance. Examples of disturbances which would permit the establishment of successional species without completely removing the climax species are ground fires, spot crown fires, insect infestations, grazing, and selective cutting.

There are, of course, exceptions to these interpretations. Site-specific characteristics must be included in the final analysis of a stand's successional status. Some sites may possess topographic and/or edaphic conditions that restrict succession to such a slow rate that early successional species can prolong reproductive success and dominate stands that are relatively stable for long periods of time without a replacement by climax species. For example, sample # 45 occurs at a site that has deep, fine-textured soils that were deposited in an old beaver dam. The tall, evenly-spaced aspen and grassy understory produce an inhospitable site for the establishment of climax species. An unsampled stand on a ridge southeast of Lake Park occurred in a coarse grus soil at a wind exposed site. Limber pine occurred at this site in an open stand with virtually no understory and only a few young limber pine present. Although limber pine is usually successional, at this site it appeared to be a topoedaphic climax.

A conservative estimate of the minimal time passed since the last major disturbance can be determined in early or mid-successional stands from the ages of the oldest trees in the stand. This estimate is based on the assumption that the oldest individuals were established soon after the disturbance. In the Lost Creek study area, this assumption seems to be valid for most aspen dominated stands. The character of the disturbance may, however, complicate the age distribution of the trees. Any disturbance which is incomplete will leave survivors that are relicts of the previous successional episode. In sample # 5 the stand is dominated by aspen, but an individual Engelmann spruce is over 20 years older than the oldest aspen. This steep, wind exposed site has numerous standing dead that appear to be mostly limber pine with a few Engelmann spruce. A fire at this site would tend to move through the stand rapidly due to the steep slope and frequently windy conditions. A crown fire at this site could have killed all of the mature trees but permitted the survival of seedlings and some saplings. The older Engelmann spruce individuals in the sample stands are for this reason probably relicts rather than early invaders at the post fire site. Sample # 10 is a mid-successional site that is dominated by young Engelmann spruce and has a declining aspen population. The oldest tree, however, is a limber pine that is over 150 years older than the next oldest tree. In this case, the limber pine survived the disturbance as a mature tree, which would make the 75 year old aspen a better estimate of the duration of this latest successional sequence. The age of late successional stands could not be estimated due to the absence of those early successional individuals which could provide an age estimate.

Classification

Results

The seven groups produced by cluster analysis at the 65% level of similarity are shown in the dendrograph of Figure 10.

The seven groups are distinguished by six dominant tree species as follows:

1 - Engelmann spruce
2 - Bristlecone pine
3 - Limber pine

LOST CREEK SCENIC AREA

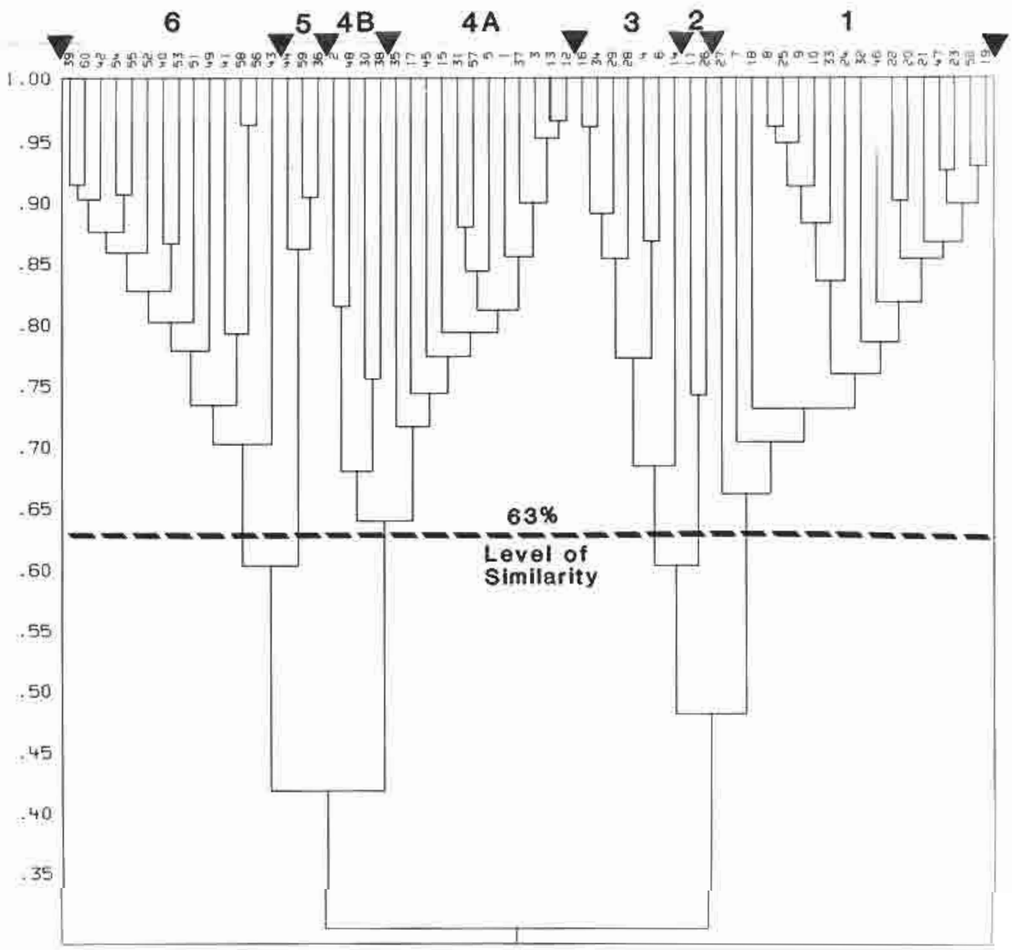

Figure 10. Dendrograph of cluster analysis results for tree cover data.

4A - Aspen

4B - Aspen

5 - Ponderosa pine

6 - Douglas-fir

Discussion

Group 1 stands have a mean Engelmann spruce cover of 27.2% (s = 9.6, n = 18) with a range of 5% to 39%. Sample #27 with 5% Engelmann spruce cover occurs at a Forest/Meadow ecotone. Sample # 18 with 13% Engelmann spruce cover also exhibits ecotonal characteristics between Engelmann and Douglas-fir dominance. The remainder of the sample stands are in various stages of succession toward an Engelmann spruce climax. The mean total tree cover for these samples is 40.5% (s = 11.5, n = 18) with a range of 6% to 54%.

Group 2 stands have a mean bristlecone pine cover of 9% (s = 1.4, n = 2) with two values of 8% and 10%. These stands are successional to Engelmann spruce. The mean total tree cover for the samples is 23% (s = 8.5, n = 2). The two values are 17% and 29%.

Group 3 stands have a mean limber pine cover of 26.2% (s = 9, n = 7) with a range of 9% to 37%. These stands are successional to limber pine or Douglas-fir. The mean total tree cover for the samples is 32.7% (s = 10.9, n = 7) with a range of 10% to 43%.

Group 4A stands have a mean aspen cover of 57.1% (s = 17.1, n = 12) with a range of 31% to 81%. Sample #45 occurs in a Forest/Meadow ecotone where the climatic climax species do not seem to be able to get established. The other samples are successional to Engelmann spruce or Douglas-fir

The mean total tree cover for these samples is 72.3% (s = 14.4, n = 12) with a range of 44% to 88%.

Group 4B stands have a mean aspen cover of 26% (s = 4.2, n = 4) with a range of 21% to 30%. These stands are successional to Engelmann spruce or Douglas-fir with a well established population of these climax species. The mean total tree cover for these samples is 61.3% (s = 23.2, n = 4) with a range of 35% to 87%.

Group 5 stands have a mean ponderosa pine cover of 18.7% (s = 1.5, n = 3) with a range of 17% to 20%. These stands are topographic and/or edaphic climaxes. The mean total tree cover for these samples is 27.7% (s = 4.5, n = 3) with a range of 23% to 32%.

Group 6 stands have a mean Douglas-fir cover of 36.5% (s = 9.9, n = 14) with a range of 20% to 50%. These stands are in various stages of succession toward a Douglas-fir climax. The mean total tree cover is 49.6% (s = 10.2, n = 14) with a range of 31% to 66%.

Ordination

Results

The two dimensional ordination of stands is shown in Figure 11. The cluster analysis groups have also been outlined on this figure. Table II is the correlation matrix of the X and Y ordination axes with environmental and biological factors.

Discussion

The usefulness of this ordination lies not only in its ability to display the relationships of stands and the groups defined by cluster analysis but also in the subjective evaluation of those factors which correlate with the ordination axes and which may influence the distribution of tree species. This indirect gradient analysis is interpretive rather than dogmatic. Although statistically significant environmental and biological correlations are used to help define the axes, only a limited number of factors have been measured, and a causal relationship between the factors and species distributions remains to be proven. The heuristic value of the ordination lies not in statistically significant tests, which it cannot provide, but rather in the *a priori* hypotheses it supports and the *a posteriori* hypotheses it may generate. The significant correlation coefficients shown in Table II indicate that as the X coordinate increases; elevation decreases, the A horizon becomes less acid, there is less clay in the B horizon, there are fewer standing dead trees, and there is an increase in tree diversity.

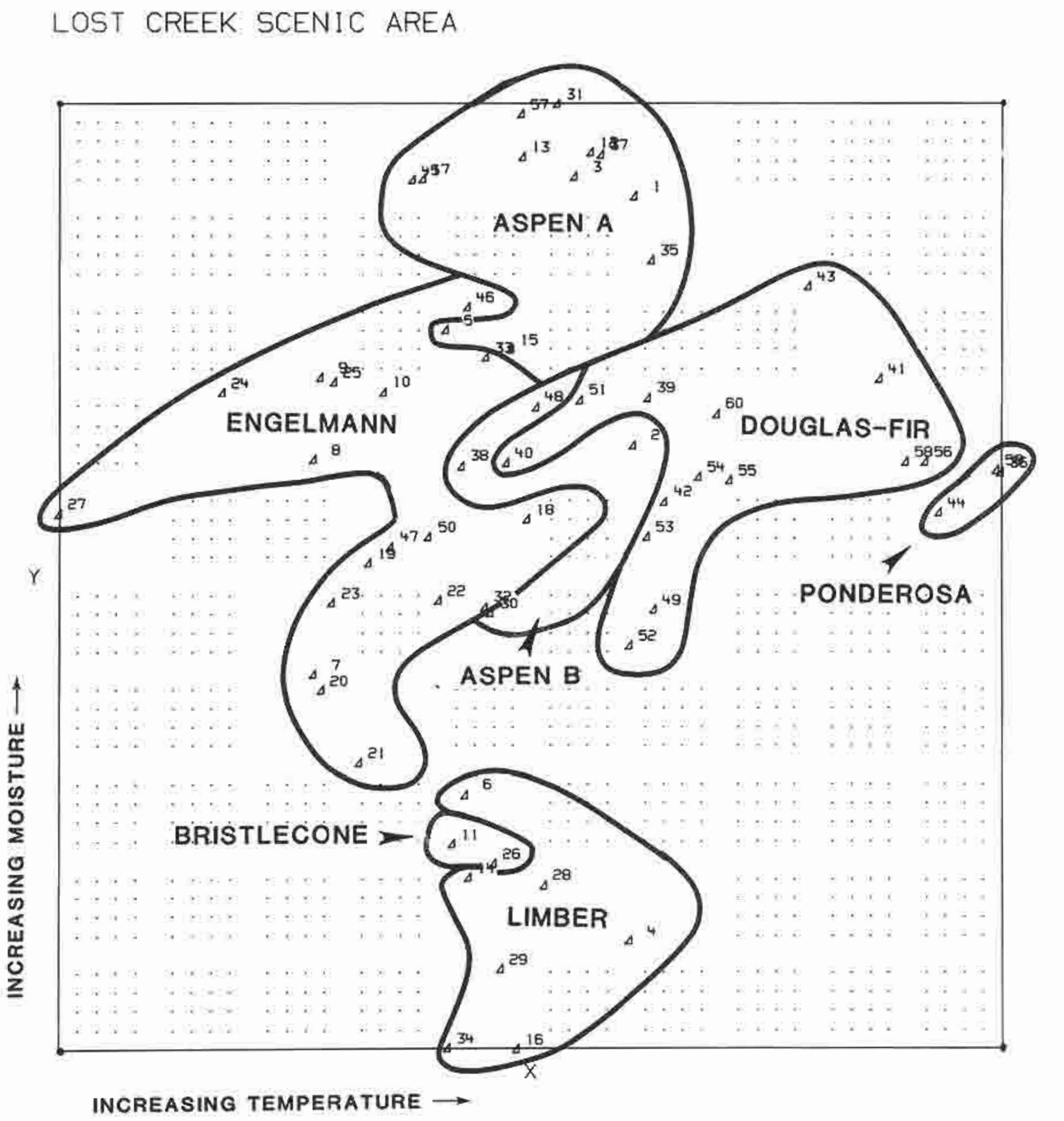

Figure 11. Ordination of samples based on tree cover data.

TABLE II

PEARSON CORRELATION COEFFICIENTS FOR TREE ORDINATION AXES WITH SELECTED FACTORS

	X Coordinate	Y Coordinate
Elevation	-.7352**	-.3824*
Aspect	-.1744	.3759*
Slope	.1852	.0414
Slope Position	-.0770	.5764**
Depth of A Horizon	-.0598	.1438
pH of A Horizon	.4086*	-.1394
Clay in B Horizon	-.2528	.2310
Rock	.0581	-.2569*
Bare Soil	.1019	-.4854**
Litter	.0059	.5190**
Fire Evidence	.1838	-.2298
Standing Dead Trees	-.3396*	-.2852*
Tree Canopy Cover	.1770	.5898**
Tree Diversity	.2195	.3926*
Understory Diversity	.1146	.1060

* $p \leq .05, |r| \geq .2546$
** $p \leq .001, |r| \geq .4221$

The correlation of elevation with the X axis is the most significant in the matrix. The location of the groups in relation to decreasing elevation coordinates well with the expected distribution of these species. Vegetation is not, however, directly affected by elevation, but instead by the complex of factors which change as the elevation changes. Some of these factors are temperature, precipitation, ultraviolet radiation, and atmospheric pressure. An interpretation of the X axis as a temperature gradient indicates that Engelmann spruce generally occur at colder sites while limber pine and bristlecone pine occur at warmer sites. This is supported by field observations and mapping which show that in the upper elevations, Engelmann spruce is more successful in the drainages while limber pine and bristlecone pine are more successful on ridges or sunny southern exposures that are not as susceptible to nocturnal cold air drainage. Daubenmire (1943a, 1943b) has demonstrated that temperature may control species distribution at high elevations since germination and seedling development of trees are at a cold tolerance limit. Further justification for this interpretation is found in the location of samples within the Engelmann group. The higher elevation plots are centrally located in the group rather than at the extreme left as would be expected if the X axis were interpreted directly as an elevational gradient. The majority of these same plots occur in mid-slope positions that would be less affected by cold air drainage than samples 27, 24, and 8 which are found near streams or drainage channels and occur at the left in the ordination.

The Y axis correlation coefficients, listed in order of their significance levels, indicate that as the Y coordinate increases; total tree cover increases, slope position becomes more mesic (e.g., sites with greater water accumulation), litter increases, bare soil decreases, tree diversity increases, elevation decreases, aspect becomes more northeasterly (aspect values have been transformed as described in methods), the number of standing dead decreases, exposed rock decreases, clay in the B horizon increases and fire evidence decreases. Not only are more factors correlated with the Y axis than the X axis, but these factors are also more balanced in their levels of significance.

Subjective evaluation of these correlations provides some insight into the complex of factors that are associated with a moisture gradient. Interpretation of the Y axis as a moisture gradient implies that stands dominated by limber pine and bristlecone pine occupy the driest sites. The severe wind desiccation at these sites may be beyond the tolerance limit for other tree species. The positions of the bristlecone pine dominated stands in the ordination, however, indicate sites that are more mesic than most limber pine sites. Although this may be an artifact of small sample size, some characteristics of these stands explain this phenomenon. All of the limber pine and bristlecone pine sites that were sampled are successional to an Engelmann spruce or Douglas-fir climax. Contrary to what might be expected, the understory in these stands is rather diverse and productive when compared to the understory of the other tree groups in Table III. What this suggests is that the growth limiting factors are different for seedlings versus saplings. The safe sites for germination and seedling development are undoubtedly dry due to the universal presence of the coarse well drained soils, but the seedlings are short and are not as severely stressed by wind desiccation as the taller saplings would be. The total number of bristlecone pine and limber pine individuals less than one meter in height is greater at the bristlecone pine dominated sites ($x = 480/H.$, $s = 226.3$, $n = 2$) than at the limber pine dominated sites ($x = 38.3$, $s = 57.3$, $n = 7$). The bristlecone pine sites seem to be supportive of greater total seedling success and at this early level of development, bristlecone pine is more successful than limber pine. The bristlecone pine dominance is maintained in later developmental stages at sites where it seems that wind desiccation stresses limber pine growth. Observations at these sites suggest that limber pine has a greater number of dead needles than the bristlecone pine while in less windy sites this difference is less apparent and a mixed stand is maintained. Succession at the windy sites seems to begin with a bristlecone pine/limber pine mixture that is initially dominated by bristlecone pine especially in the more exposed portion of the stand. The wind break provided by these trees reduces the desiccation stress sufficiently to allow an increase in the proportion of limber

TABLE III

UNDERSTORY COVER AND DIVERSITY OF TREE GROUPS

Tree Group	n	Understory Cover $\overline{x}$ (%)	Understory Cover s (%)	Understory Diversity $\overline{x}$	Understory Diversity s
Engelmann spruce (1)	18	7.6	12.5	13.7	8.0
Bristlecone pine (2)	2	15.9	2.3	24.5	.7
Limber pine (3)	7	15.0	6.6	21.9	6.5
Aspen (4A)	12	20.2	9.4	23.3	10.0
Aspen (4B)	4	10.4	3.5	21.9	9.1
Aspen combined (4A and 4B)	16	17.8	9.3	21.9	9.1
Ponderosa pine (5)	3	5.2	3.5	20.7	3.2
Douglas-fir (6)	14	12.9	7.1	17.6	7.6

n = sample size
s = standard deviation

pine, aspen, and Engelmann spruce. Sample stand #7 is an example of this process. As the canopy cover becomes more complete, only the shade tolerant Engelmann spruce is maintained. The limber pine-dominated successional stands may therefore occur at sites where soil drought reduces bristlecone pine seedling success. The predominant successional sequence in these stands is the transfer of dominance from limber pine to aspen then to Engelmann spruce or Douglas-fir. Pure stands of mature bristlecone pine or limber pine are rare in the Lost Creek study area. Pure stands of bristlecone pine are found only at those sites where the wind is not sufficiently reduced by the windbreak trees to allow limber pine and Engelmann spruce development. One such mature stand occurs as a tree island below the summit of McCurdy Mountain, Figures 4 and 12. This small stand is in a slightly protected position surrounded by the tundra. The stand is too small to develop a protected zone behind the lead trees. Engelmann spruce dominated stands occur a short distance from this stand in more protected sites. The only mature bristlecone pine dominated stand shown in the Forest Cover Type Map (Figure 9) occurs as an open stand on a steep slope below a summit on the wind exposed western front of the Tarryall Mountains (Figure 13). The understory cover and diversity in these topoedaphic climax stands is sparse in contrast to that found in the two successional stands that were sampled. Pure stands of limber pine occur in small populations along ridges, especially saddles and quite regularly as a narrow zone around large tors. A coarse

Figure 12. Photographs of bristlecone pine stand on McCurdy Mountain.

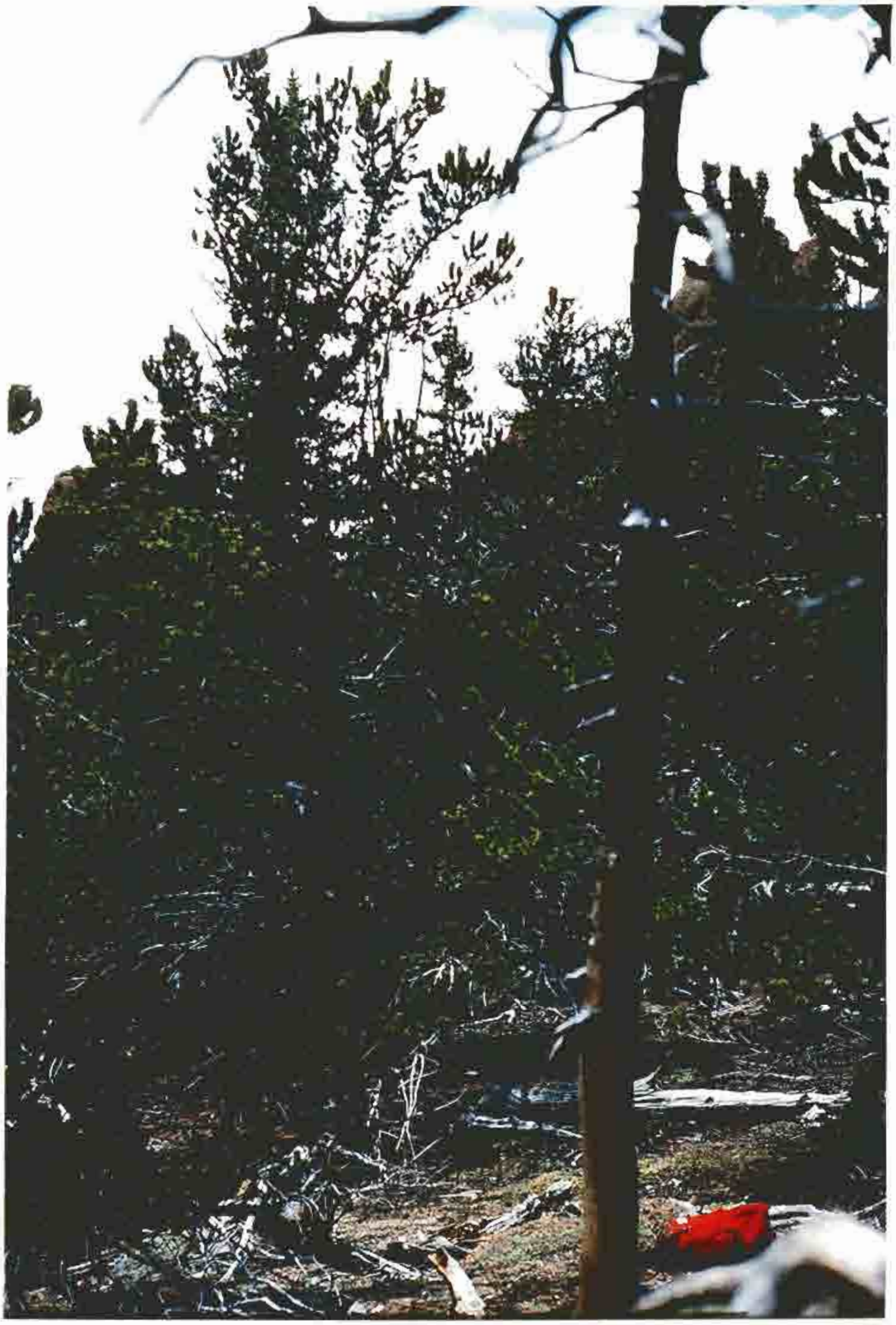

Figure 13. Photograph of mature bristlecone pine stand within study area.

grus soil with understory that is sparse or absent is common in these stands (Figure 14). If these stands had been sampled, their position in the ordination would be expected to occur below the successional stands with Y axis coordinates that would indicate drier site conditions.

It is important to consider the ordination as a momentary representation of actively changing communities. As succession proceeds, the position of a stand in the ordination changes because species composition and dominance change. As a stand's position in the ordination changes, the interpretation of site characteristics based on the subjectively defined axes, also changes. In an ecological sense, this may demonstrate the individual and community interactions with environment. That is, the individual and community not only respond to the environment but also alter it. It must be remembered, however, that site factors such as slope, slope position, aspect, elevation, and precipitation do not change. This is further justification for avoiding these terms in the definition of the ordination axes. For example, as sample # 6, which is a successional limber pine stand, becomes dominated by Engelmann spruce its position in the ordination will extend into the lower limb of the Engelmann spruce group (Figure 11). In relation to the defined axes, this would indicate a site change to slightly cooler and moister conditions. The vegetation could produce this effect with the development of a more complete canopy that would reduce insolation and transpiration at ground level. This in turn would

Figure 14. Photograph of mature limber pine stand.

affect the germination and seedling success of the vegetation and continue the successional process. With this in mind, the mobility of successional stands in the time dependent ordination can be understood as well as the relative immobility of climax stands.

The stands which approximate climatic climax conditions are found in the ordination at approximately the same Y axis moisture regime, but span a wide temperature range on the X axis (Figure 11). This implies that temperature rather than moisture is the factor which best accounts for the zonation of climatic climax forests in the Lost Creek area. A comparison of these results with other studies conducted in the Front Range can be found in Chapter IV, Synthesis.

An interesting result of the ordination is the position of the two aspen dominated groups as an interface between the Engelmann spruce and Douglas-fir groups (Figure 11). Group 4A is predominantly early successional with higher aspen cover relative to the other tree species. Group 4B is in a later successional stage at which dominance is transferring to the climax species. Samples #30 and #38 are successional to Engelmann spruce while samples #48 and #2 are successional to Douglas-fir. The interdigitation of the Engelmann and Douglas-fir groups implies an area of environmental overlap and graphically portrays an ecotonal region.

The ponderosa pine group (5) is small in this ordination due to the lower elevational limit (2,440 m or 8,000 ft) of the study area which is approximately at the upper limit of ponderosa pine distribution, and coincides with the Lower Montane/Upper Montane ecotone (Marr, 1961). The three ponderosa pine dominated sample stands occur in the Upper Montane as topographic and/or edaphic climaxes at sites that are similar to limber pine sites but without the excessive wind.

Tree Species Distribution Within the Tree Cover Ordination

Results

The distribution and cover of eight tree species with respect to the tree cover ordination are presented in Figure 15. The squares represent the cover of each species found at each of the 60 sample plots. The sides of the squares are proportional to the cover of the respective species, and the square is centered on the sample locations which are shown in Figure 11. The outlines of the classification groups shown in Figure 11 are reproduced at the bottom-center of each page.

Discussion

The purpose of these figures is to give a sense of the ecological optimum and amplitude of each species as well as to show the contribution each species makes to the tree cover classification groups. As would be expected, the dominant species demonstrate the highest cover values within their respective groups. Some species, however, are a significant component in other groups. Limber pine is a special example of this cross group success. Although limber pine is dominant only

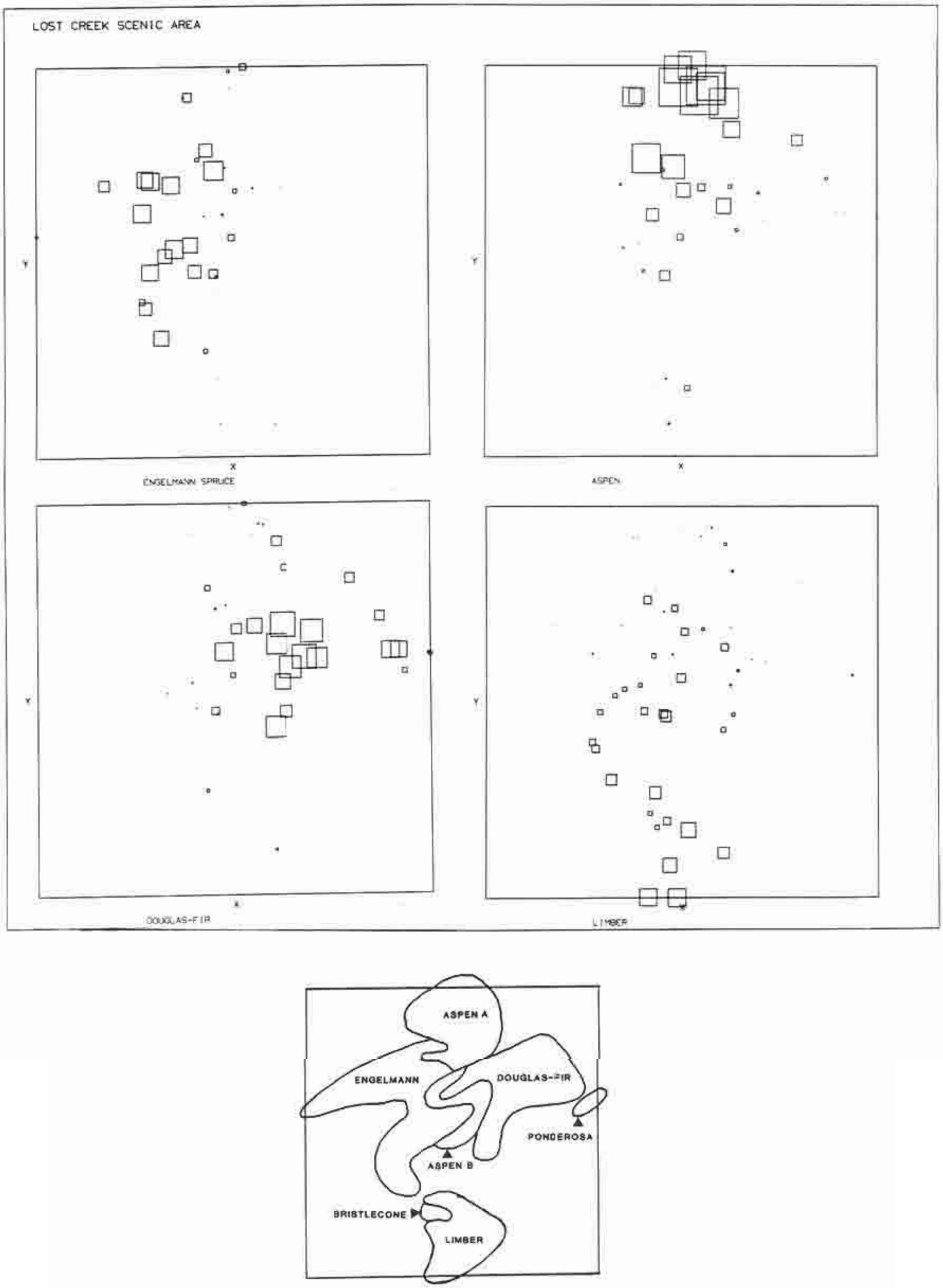

Figure 15. Distributions of tree species within the tree cover ordination.

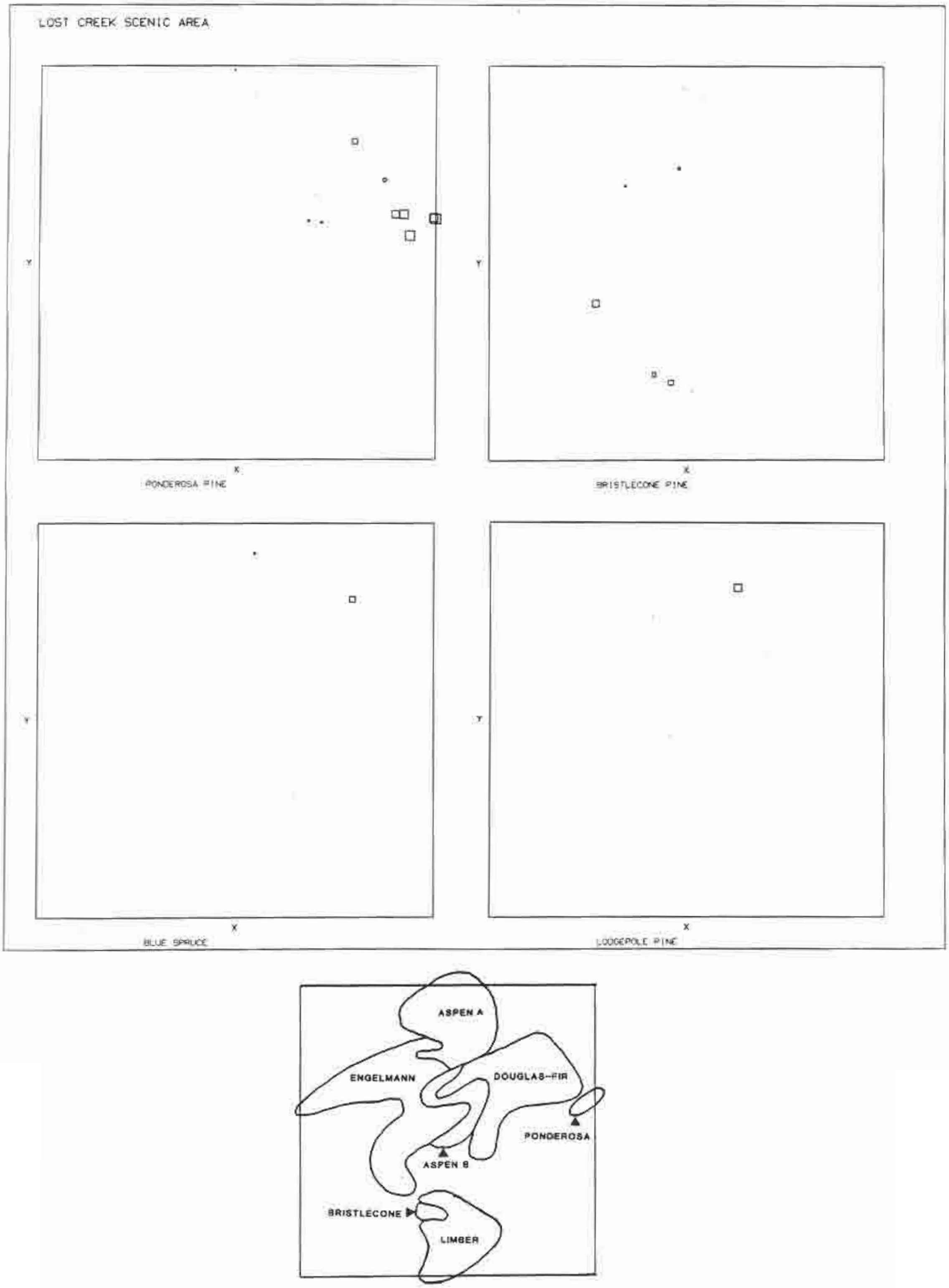

Figure 15. Distributions of tree species within the tree cover ordination. (continued)

in those sites which are dry and windy, it may occur elsewhere in sites which are more mesic.

Summary

The forest was visually divisible into tree cover units in some areas of Lost Creek and formed a continuum in others. The classification of random samples identified forest cover units that corresponded with the visual units, while the ordination shows both a separation of the centers of distribution for tree species and the reduced success of each species with greater distance from these centers. This demonstrates the acceptability of an interactive continuum and classification approach. The vegetation is distributed in a pattern that exhibits a continuum when limiting factors and tolerance limits form a continuous gradient, but if these critical factors change abruptly, distinct vegetational units may occur. The centers of distributions for species should also be expected to shift in response to competition. Zonation in vegetation should be anticipated as an expression of niche development. The degree to which vegetational zonation is evident is a function of evolutionary history, recent historical events, and environmental gradients. It is not within the scope of this work to answer why there are specific groups or communities, but rather to see if an objective procedure can define groups which can be subjectively accepted. The classification and ordination of the tree synusia in the Lost Creek study area demonstrate that this is possible.

Understory Analysis

Understory Data Summary

Results

The summary of understory cover data is presented in Appendix B. Included in this summary are: absolute cover values for the 164 sampled species, cover values for the moss and lichen categories which were not separated by species, total understory cover not including moss and lichen, and understory species diversity for each sample.

Classification

Results

The ten groups derived from the cluster analysis results are shown in the dendrograph of Figure 16. The division of the groups was done at different levels of similarity along different branches of the dendrograph. The levels of similarity range from about 68% to 25%.

Discussion

The ten groups are distinguished by the following physiognomic, floristic, and successional characteristics.

1. Herb dominated understory with *Carex* sp., *Saxifraga bronchialis*, and *Ramischia secunda*. Engelmann spruce dominated stands with low understory cover and diversity in mesic sites.

2. Shrub dominated understory with *Arctostaphylos uva-ursi*. Aspen dominated stands successional to Douglas-fir with moderate to high diversity in mesic sites.

LOST CREEK SCENIC AREA

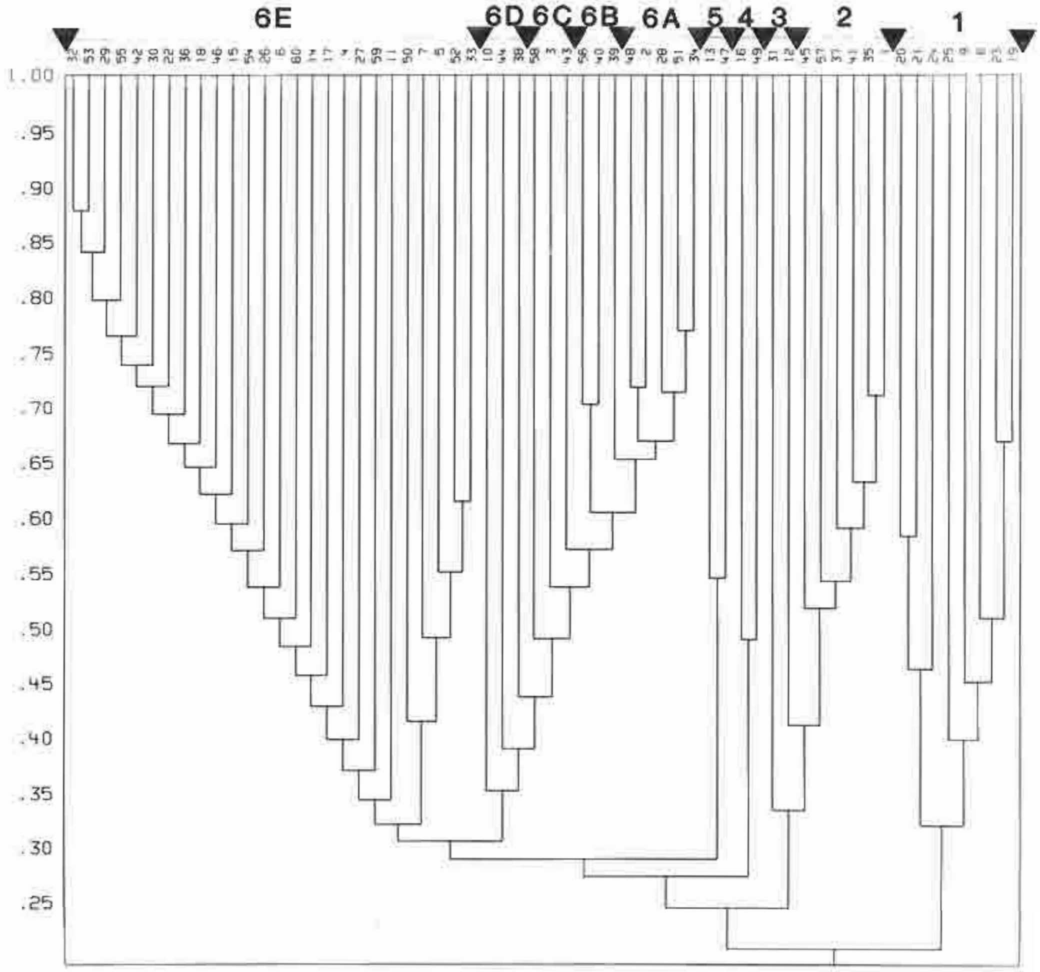

Figure 16. Dendrograph of cluster analysis results for understory cover data.

3. Herb dominated understory with tall shrubs. There are only 2 samples in this group, sample # 27 is dominated by *Senecio neomexicanus* v. *mutabilis* and sample #31 is dominated by *Vaccinium cespitosum*. *Chamerion angustifolium* has the highest cover value common to both plots and *Salix geyeriana* is the tall shrub found in both plots. Aspen dominated stands successional to Engelmann spruce with moderate to high diversity in sites that are wet and well drained.

4. Grass dominated understory with *Muhlenbergia montana*. Douglas-fir dominated or aspen/limber mixture successional to Douglas-fir, with higher diversity in sites that are dry, open stands without excessive wind.

5. Herb dominated understory dominated by *Senecio neomexicanus* v. *mutabilis* and *Erigeron eximius*. Engelmann dominated stands or aspen successional to Engelmann with low diversity in sites that are early successional, or late successional with recent ground fire (i.e., sample # 47).

6A. Shrub dominated understory, *Juniperus communis* present in all samples with *Arctostaphylos uva-usi* and/or *Jamesia americana*. These stands are dominated by aspen or limber and are successional to Engelmann or Douglas-fir with moderate diversity in mesic sites.

6B. Shrub dominated understory with *Juniperus communis* and *Jamesia americana*. Douglas-fir dominated stands with low diversity in mesic rocky sites.

6C. Shrub dominated understory with *Juniperus communis* and *Arctostaphylos uva-ursi*. Douglas-fir or aspen dominated stands successional to Douglas-fir or blue spruce with high diversity in lower elevation mesic sites with relatively deep soils. These sites commonly show signs of recent human disturbance.

6D. Herb/Grass/Sedge mixture with *Juniperus communis* present in small amounts in all samples. Although the understory composition is similar in these stands, the other stand characteristics are very distinct. Sample # 44 is at 2,722 m (8,930 ft) with a northwest facing moderate slope and coarse, well drained shallow soils. Sample # 38 is at 3,188 m (10,460 ft) with a south facing moderate slope and coarse well drained shallow soils. Sample # 10 is at 3,301 m (10,830 ft) with a west facing moderate slope with a greater soil depth and higher proportion of loam in the upper horizon. This site also shows evidence of recent human impact (circa 1950) following a greater disturbance from about 1900. Sample # 44 is a ponderosa pine/Douglas-fir mixture, Sample # 38 is dominated by aspen and is successional to Engelmann, and sample # 10 is dominated by Engelmann.

6E. These "remainder" samples all possess Juniperus communis with the exception of sample # 4. Attempts to distinguish groups that were distinct from the other Juniperus communis groups was unsuccessful. The relationships of these samples to the other classification groups can be estimated with the understory ordination in the following section.

The average cover and diversity of understory groups are presented for these ten groups in Table IV. The differentiation of groups within the understory is clearly not as successful as the classification of samples based on tree cover. Many factors related to both ecology and statistics contribute to this problem. The understory environment is greatly modified by the tree canopy which may serve to expand, contract, or divide the distribution of some of the understory species. The understory species are more responsive to short term environmental effects than are the tree species, resulting in greater variability of year to year distribution patterns. The greater total number of species increases the possibilty of species dominance occurring by chance rather than competitive superiority, thus complicating the successional pattern. The groups and patterns of understory development have not been adequately defined with this classification due to the small sample size. The more distinctive divisions occur between the shrub and nonshrub groups. The shrub groups with Juniperus communis are especially vague due to the wide range of sites in which this species occurs. A larger sample size would probably connect the "remainder" samples in Group 6E with the other Juniperus communis groups which are

TABLE IV

UNDERSTORY COVER AND DIVERSITY OF UNDERSTORY GROUPS

		Understory Cover		Understory Diversity	
Understory Group	n	$\overline{x}$(%)	s	$\overline{x}$	s
Herb dominated understory; Engelmann spruce canopy (1)	8	17.1	6.2	10.3	4.6
Shrub (*Arctostaphylos uva-ursi*) dominated understory; aspen canopy successional to Douglas-fir (2)	6	205.5	87.0	24.2	9.7
Herb dominated understory, with the tall shrub *Salix geyeriana*; aspen dominated stands successional to Engelmann spruce (3)	2	163.5	24.7	21.0	11.3
Grass dominated understory with *Muhlenbergia montana*; Douglas-fir or aspen/limber canopy successional to Douglas-fir (4)	2	162.0	9.9	27.5	3.5
Herb dominated understory; Engelmann spruce or aspen canopy, sites with relatively recent understory disturbance (5)	2	151.0	62.2	12.0	0.0
Shrub dominated understory with *Juniperus communis* (6)	2	130.1	103.5	19.0	7.8
Juniperus communis with *Arctostaphylos uva-ursi* and/or *Jamesia americana*; aspen or limber canopy successional to Engelmann or Douglas-fir (6A)	5	144.2	20.1	17.6	2.9
Juniperus communis with *Jamesia americana*; Douglas-fir canopy (6B)	3	185.3	45.1	12.3	5.5

n = sample size
s = standard deviation

TABLE IV

UNDERSTORY COVER AND DIVERSITY OF UNDERSTORY GROUPS

		Understory Cover		Understory Diversity	
Understory Group	n	$\overline{x}$(%)	s	$\overline{x}$	s
Juniperus communis with _Arctostaphylos uva-ursi_; Douglas-fir, or aspen canopy successional to Douglas-fir or blue spruce (6C)	3	247.0	153.6	29.7	3.8
Forb/Grass/Sedge mixture with _Juniperus communis_; ponderosa pine/Douglas-fir mixture successional to Douglas-fir, or aspen successional to Engelmann, or Engelmann canopy (6D)	3	58.7	16.1	24.7	2.1
Remainder samples not adequately clustered (6E)	26	115.8	108.2	18.1	8.1

n = sample size
s = standard deviation

better defined. The classfication results are of considerable value when combined with the ordination results in the next section.

Ordination

Results

The two dimensional ordination of samples is shown in Figure 17. The cluster analysis groups have also been outlined on this figure. Table V is the correlation matrix of the X and Y ordination axes with environmental and biological factors.

Discussion

The correlation coefficients in Table V indicate that as the X coordinate increases, rock cover increases, bare soil increases, slope increases, litter cover decreases, there is less clay in the B horizon, the pH of the A horizon is less acid and there is less total tree canopy cover. The steep, rocky, dry character of the study area is well represented by the fact that the majority of samples occur in the right half of the ordination. Sample # 31 is a rather isolated outlier at the left in the ordination. This sample is a dense aspen stand at 2,743 m (9,000 ft) elevation on a north facing moderately steep slope and is located in a drainage channel. This site is exceptionally moist and is the only sample in which Vaccinium cespitosum was found in abundance. Vaccinium species are much more frequent in the cool moist forests of the central and northern segments of the Front Range (Peet, 1981) in contrast to the generally drier

LOST CREEK SCENIC AREA

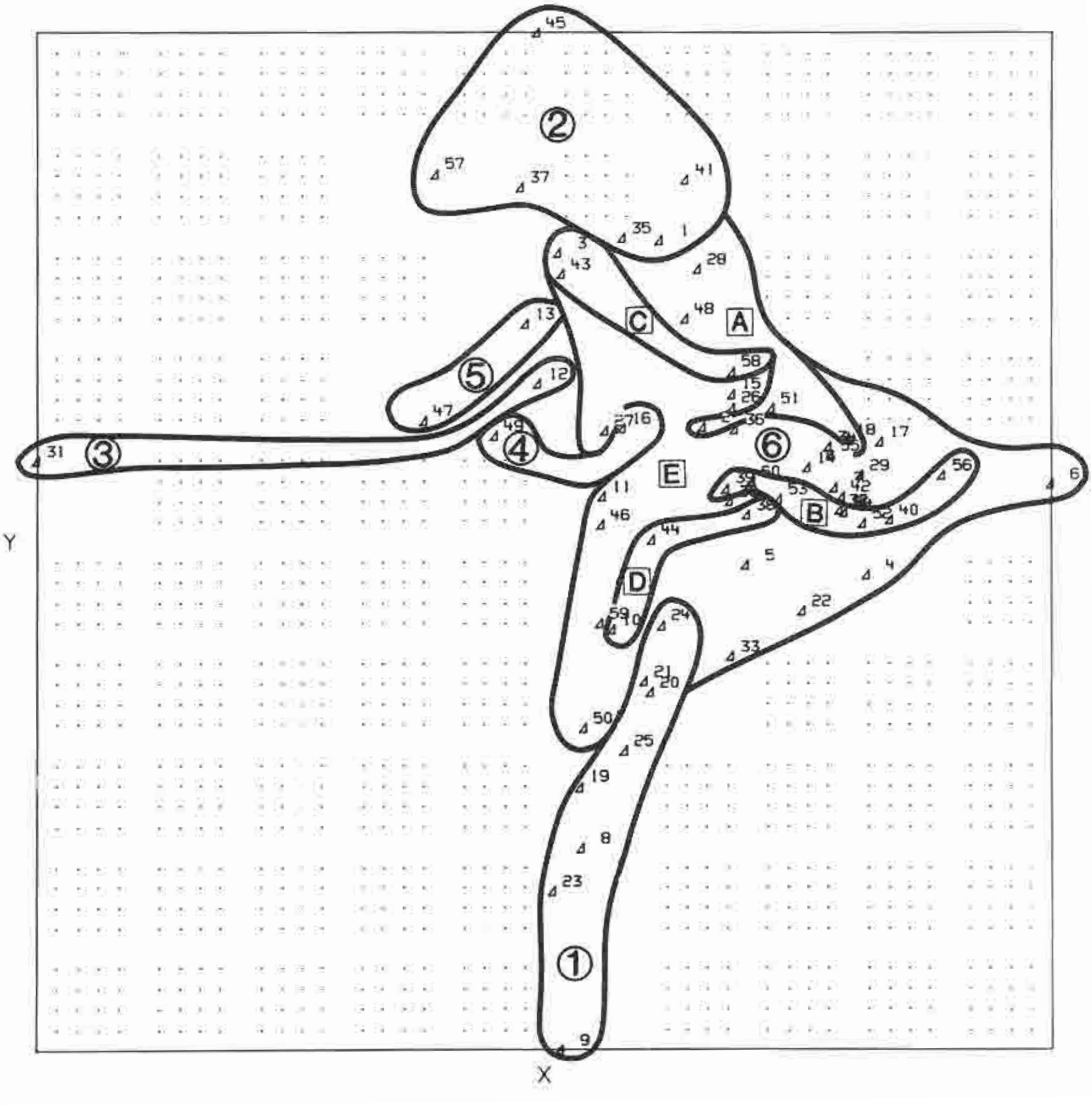

Figure 17. Ordination of samples based on understory cover data.

TABLE V

PEARSON CORRELATION COEFFICIENTS FOR UNDERSTORY ORDINATION AXES WITH SELECTED FACTORS

	X Coordinate	Y Coordinate
Elevation	.0244	-.5265**
Aspect	-.1704	-.0933
Slope	.3568*	-.1061
Slope Position	-.1525	.4425**
Depth of A Horizon	-.0788	-.0070
pH of A Horizon	.2523	.3816*
Clay in B Horizon	-.3117*	-.0959
Rock	.3949*	-.2148
Bare Soil	.3615*	-.1448
Litter	-.3426*	.2252
Fire Evidence	.1666	-.1953
Standing Dead Trees	-.0508	-.3613*
Tree Canopy Cover	-.2151	.3507*
Tree Diversity	.0585	.4245**
Understory Diversity	-.1008	.5620**

* $p \leq .05$, $|r| \geq .2546$

** $p \leq .001$, $|r| \geq .4221$

southern extension. Sample # 6 at the extreme right in the ordination is an open limber pine stand at 3,182 m (10,440 ft) elevation on a southeast facing moderately steep slope that is dry and rocky. Although this axis can be interpreted as a moisture gradient, it is a gradient that is significantly different from the moisture gradient described for the tree ordination. A comparison of the correlation coefficients shows that the tree Y axis moisture gradient is significantly correlated with elevation, aspect and slope position. In contrast, the understory X axis moisture gradient is correlated with slope. This suggests that the topographic factors which influence tree species distributions are moderated by the tree canopy and allow the understory species distributions to span a greater range of topographic positions. The environmental range of the ubiquitous Juniperus communis in the Group 6 complex, and its occurrence in virtually all tree groups is an example of the broad environmental amplitude of some understory species. The failure of this understory complex to coordinate well with the tree groups could be a result of the improved moisture conditions in the upper soil horizons which may be beneficial for understory species yet have a much smaller effect on the tree species distributions. The ordination of tree groups indicates that the early stages of succession may be moisture related, but the potential climax is more closely related to a temperature gradient. The understory ordination shows that Groups 1, 3, 4, 5, and 6D which are grass and/or herb dominated, Group 2, which is *Arctostaphylos uva-ursi* dominated, and Group 6C which is a *Juniperus communis*/*Arctostaphylos uva-ursi* mix, occur in sites with mesic moisture conditions. Group 6B which is a *Juniperus communis*/*Jamesia americana* mix, Group 6A which is a *Juniperus communis*/*Arctostaphylos uva-ursi*/*Jamesia americana* mix and the majority of 6E samples occur in the more xeric sites.

The significant Y axis correlations indicate that as the Y coordinate increases; understory diversity increases, elevation decreases, slope position becomes more mesic, tree diversity increases, soil pH becomes less acid, the number of standing dead trees decreases, tree canopy cover increases, litter cover increases, and exposed rock decreases. This gradient has features which are related to temperature, moisture, and successional status. Group 1 samples at the lower extreme of the Y axis are from late successional stands at high elevation cold dry sites. These are climax Engelmann spruce stands with herb dominated understories. Group 2 samples at the opposite end of the Y axis are early successional stands at low elevation moist sites. These are aspen dominated stands with an *Arctostaphylos uva-ursi* dominated understory. The groups between these extremes do not conform well with this simple gradient. The Group 6 subdivisions show tendencies toward one extreme or the other, but numerous exceptions occur. More precise environmental measures are required to properly define this axis.

In summary, the ordination of these samples based on understory cover values revealed ordination axes that were in some ways complementary to the temperature/moisture axes which defined tree group distributions. The environmental modification produced by the tree population presents an intuitive reason for this reduction of topographic influence on the distribution of understory species. The remaining factors which control understory distribution may include recent historical events, short term climatic extremes, and chance distribution of seed. The greater diversity of species within the understory necessitates a greater sample size than tree cover for ordination because of the increased complexity of the understory continuum and the less extreme environmental gradient.

Selected Understory Species and Tree Species Distributions Within the Understory Cover Ordination

Results

The distributions of twelve selected understory species and eight tree species within the understory ordination are presented in Figure 18.

Discussion

Those understory species which are characteristic of the groups identified by classification are found clustered in the areas of their respective groups. The distributions of *Arctostaphylos uva-ursi* and *Jamesia americana* which are tightly clustered are segregated at two loci. *Juniperus communis* is abundant at both loci indicating a broader ecological amplitude. The nonshrub understory species shown in Figure 18 exhibit lower

Figure 18. Distributions of selected understory species and tree species within the understory cover ordination. (continued)

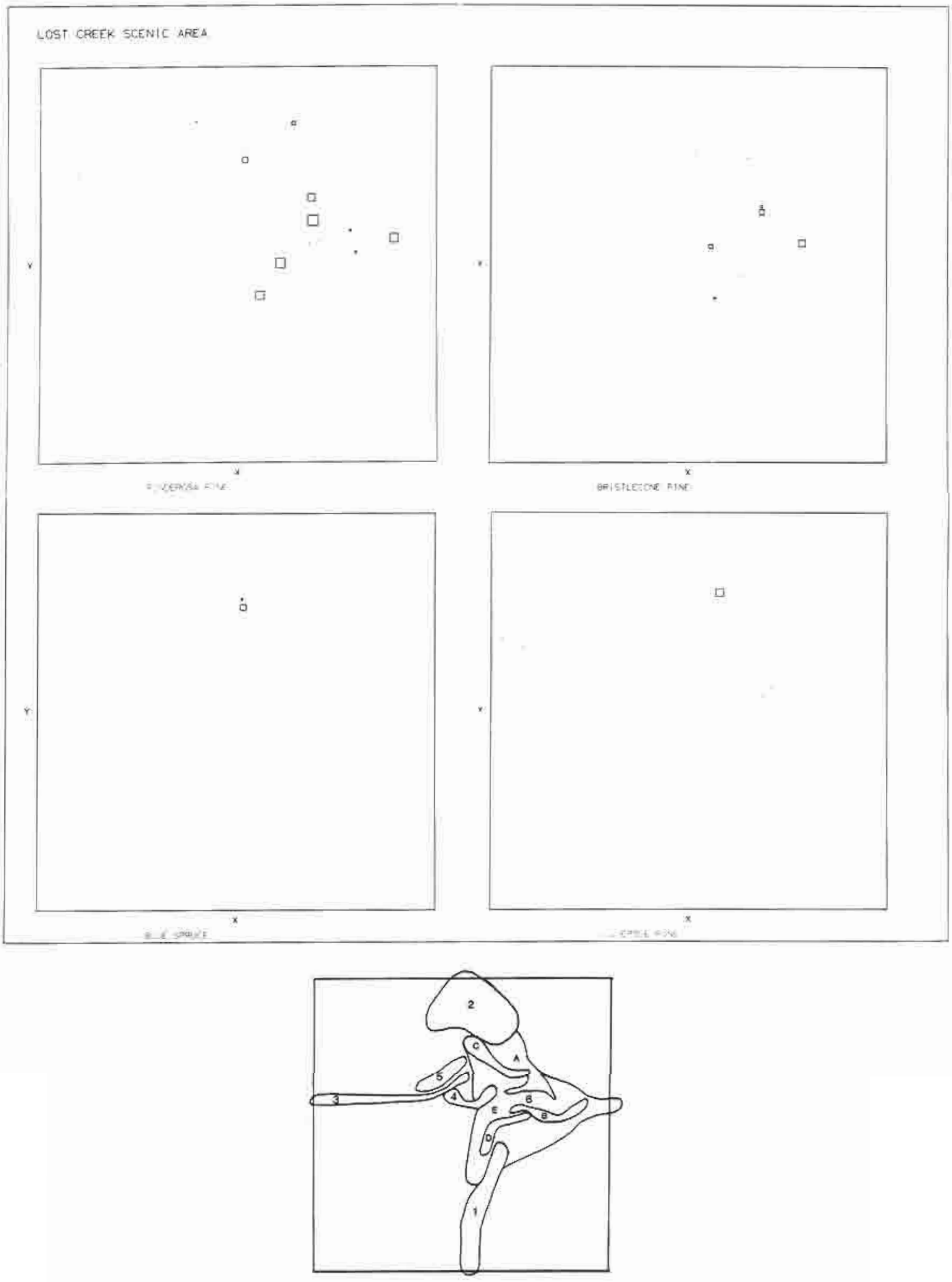

Figure 18. Distributions of selected understory species and tree species within the understory cover ordination. (continued)

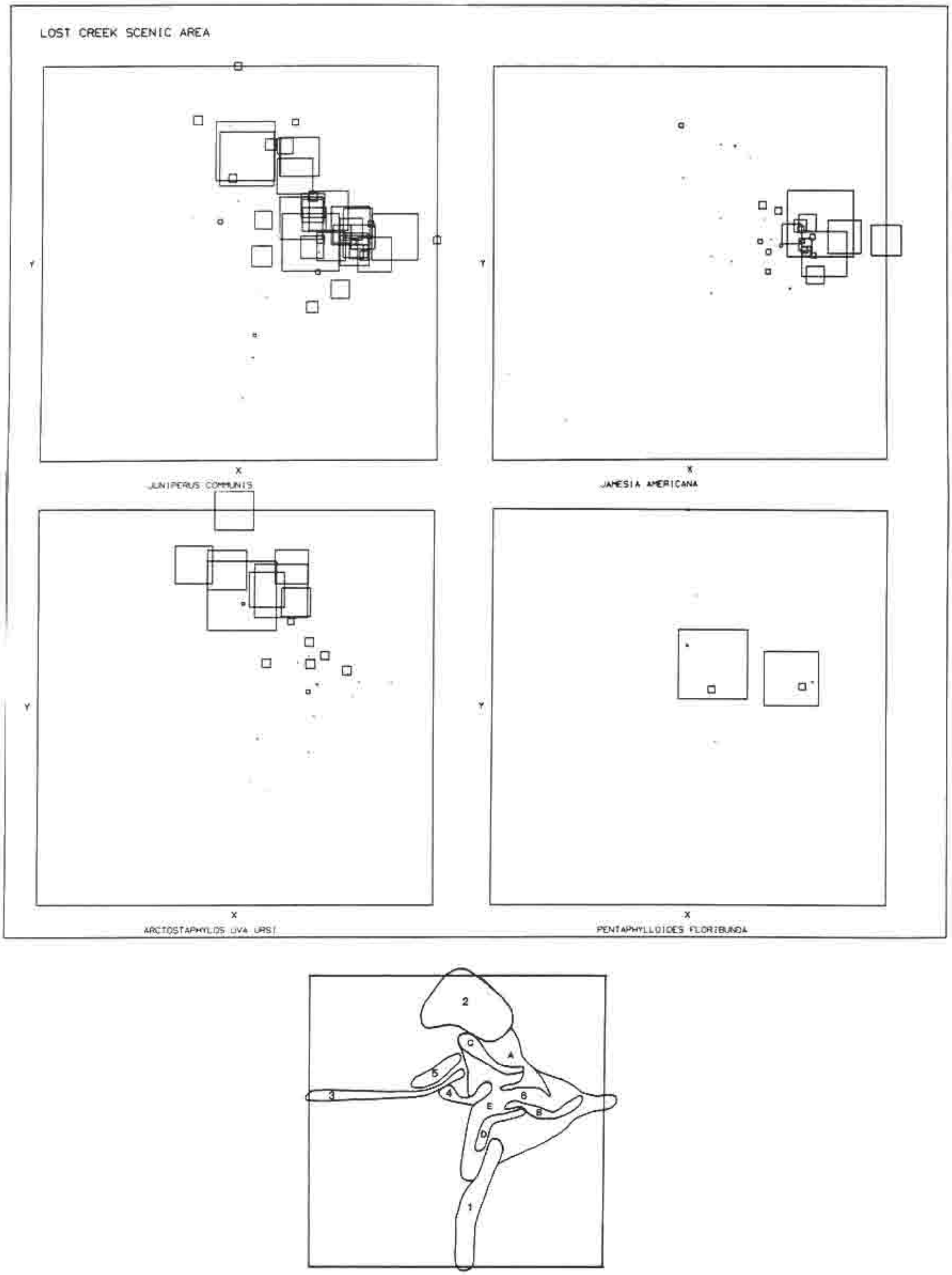

Figure 18. Distributions of selected understory species and tree species within the understory cover ordination.

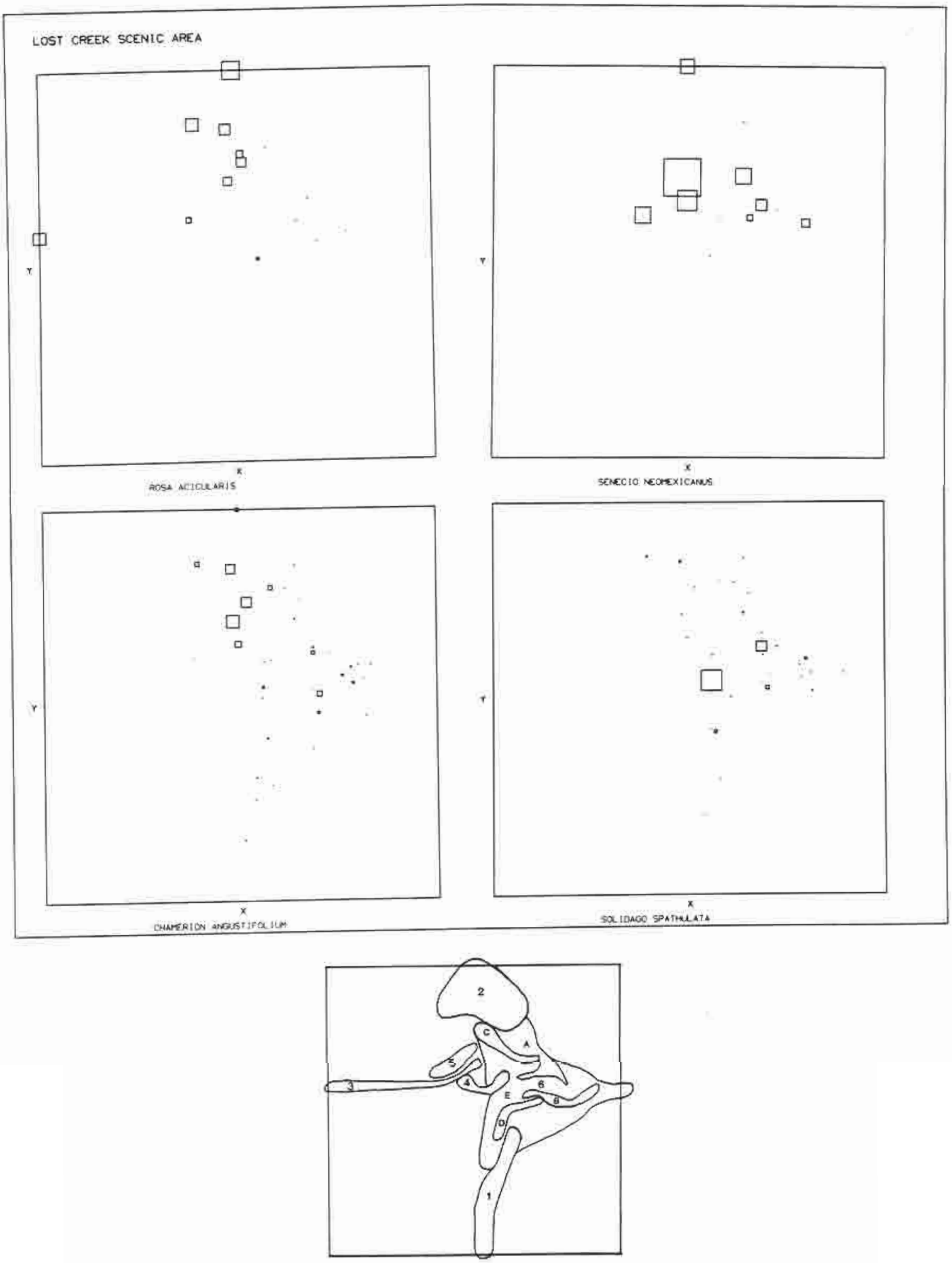

Figure 18. Distributions of selected understory species and tree species within the understory cover ordination. (continued)

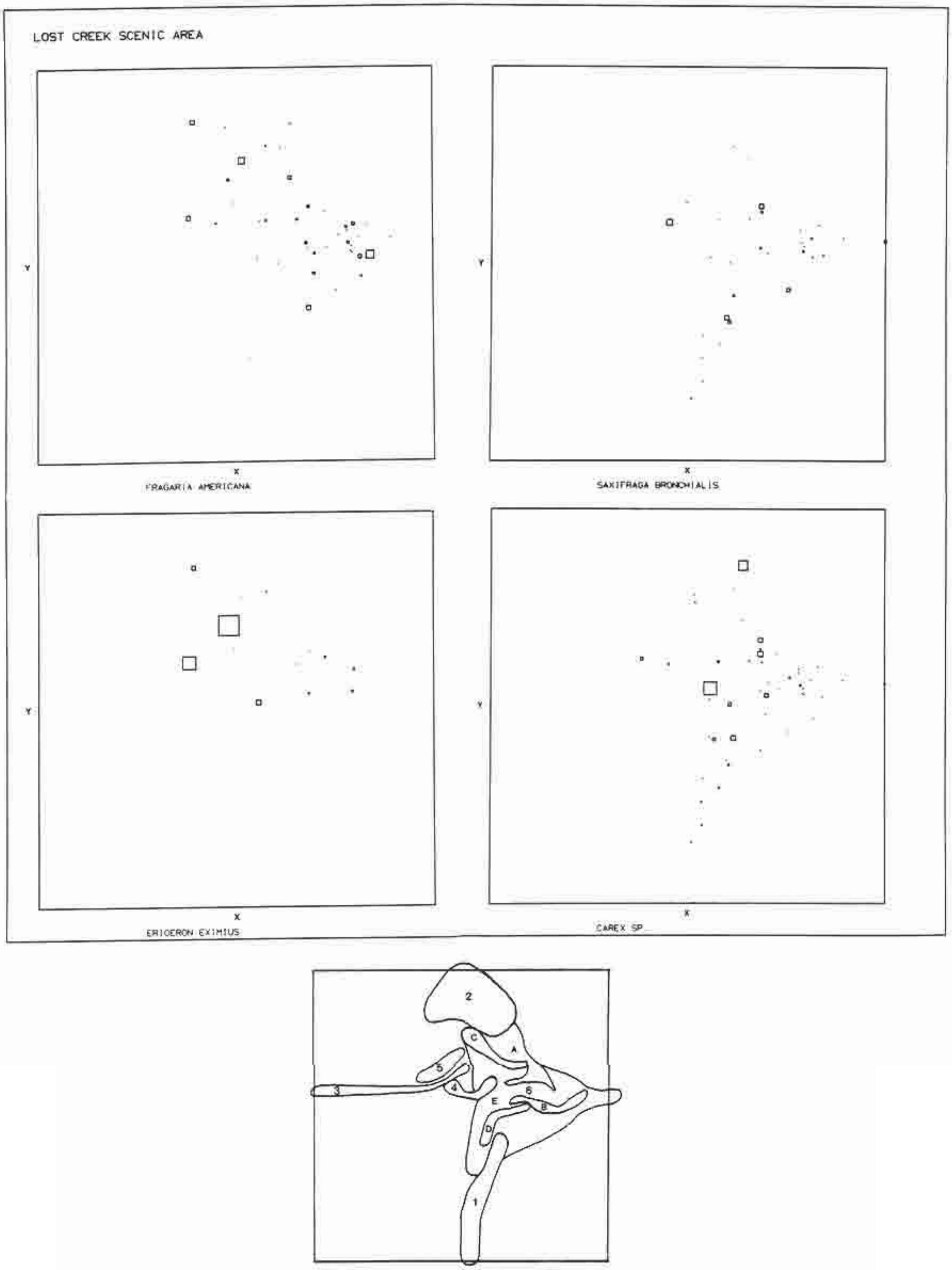

Figure 18. Distributions of selected understory species and tree species within the understory cover ordination. (continued)

cover values than the shrubs, but occur in a broader range of understory groups.

The distribution of tree species shows a clear separation of Engelmann spruce, Douglas-fir and aspen, while limber pine is more evenly distributed among the understory groups. Engelmann occurs primarily in the shrubless understory group #1, aspen is the primary tree species occurring in the *Arctostaphylos uva-ursi* group #2, Douglas-fir distribution is centered in the *Juniperus communis* groups, and limber pine is distributed in all groups.

Selected Understory Species Distributions Within the Tree Cover Ordination

Results

The distributions of twelve selected understory species within the tree ordination are presented in Figure 19.

Discussion

The distributions of understory species within the tree ordination are less clumped than the tree distributions in the previous section. The tree species distributions seem to correlate with certain proportions of understory species, but the understory species themselves may occur in numerous tree cover types. As previously discussed, the tree canopy may be modifying the environment in a manner that broadens the environmental amplitude of understory species.

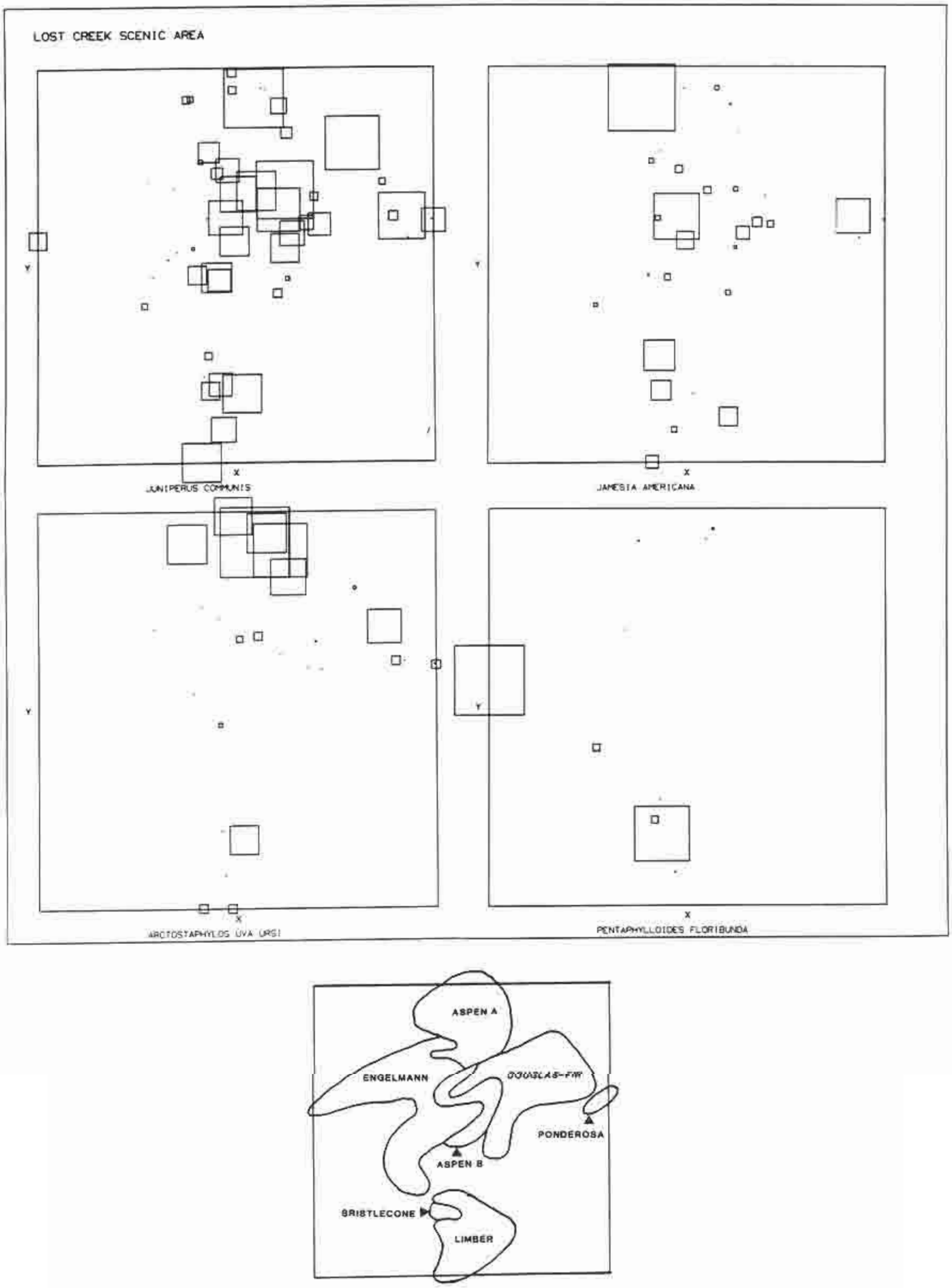

Figure 19. Distributions of selected understory species within the tree cover ordination.

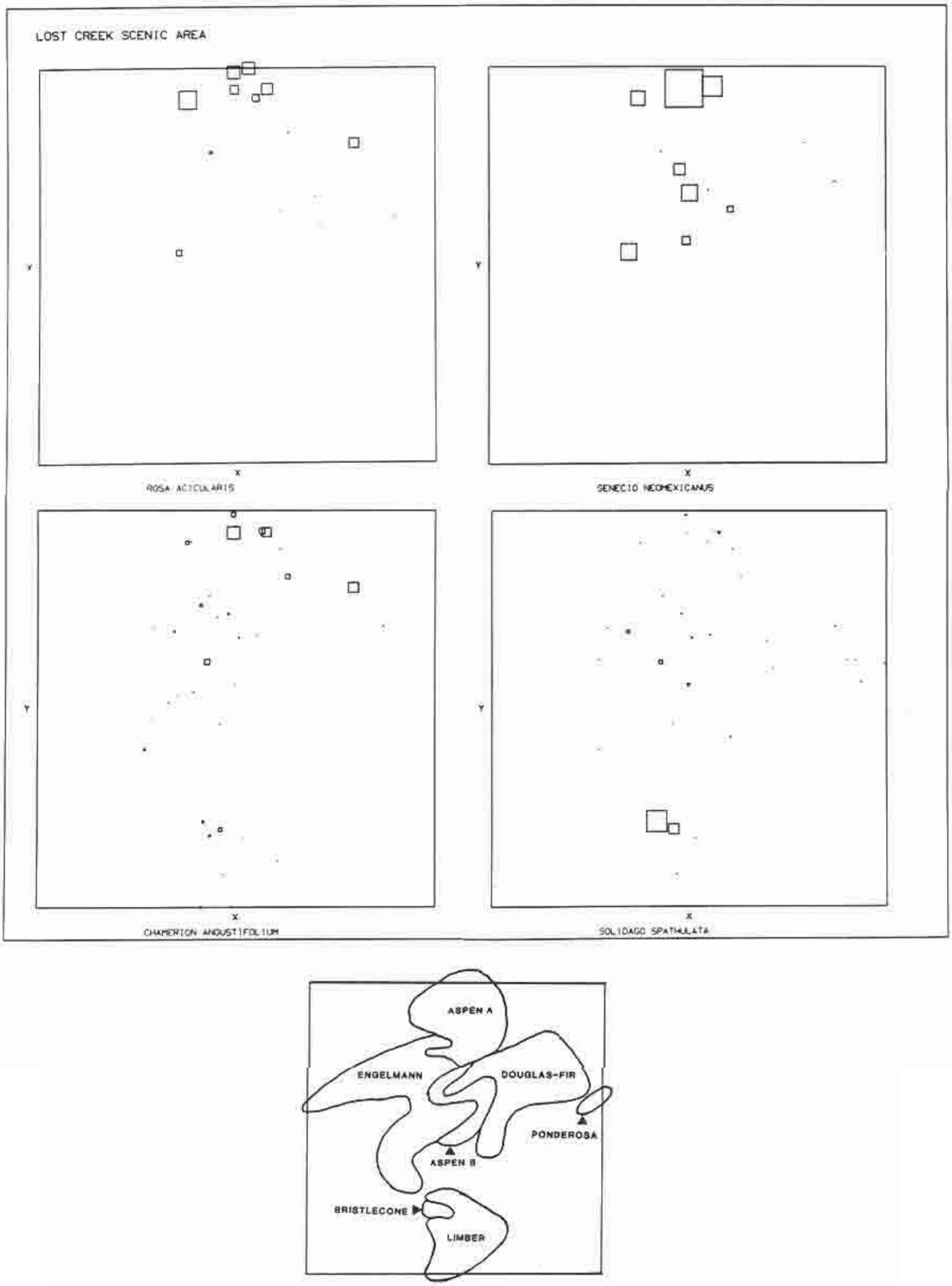

Figure 19. Distributions of selected understory species within the tree cover ordination. (continued)

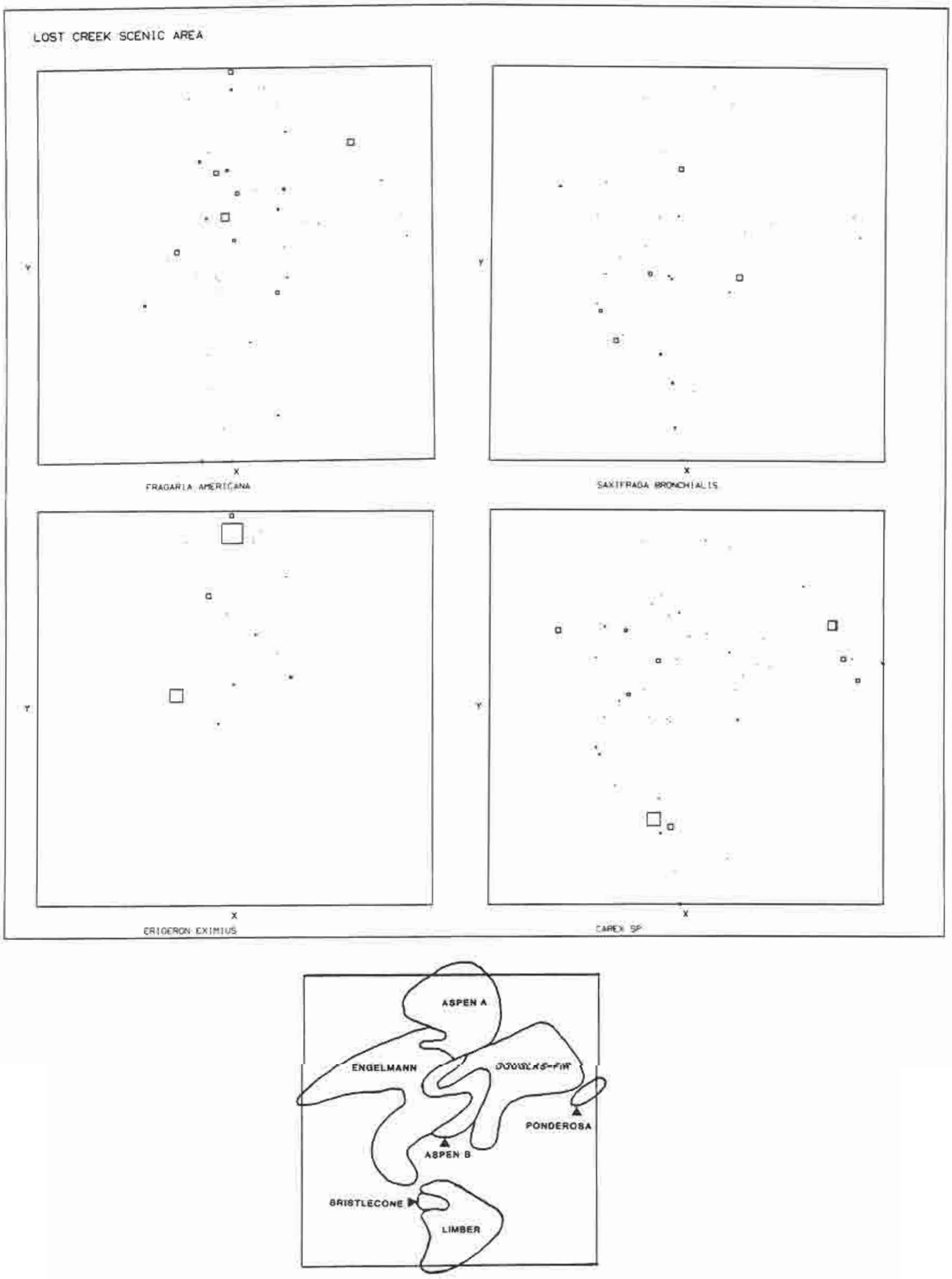

Figure 19. Distributions of selected understory species within the tree cover ordination. (continued)

Summary

The analysis of understory vegetation was more complex than the tree analysis due to both ecological and statistical problems. Although the classification results yielded some groups with a great deal of internal variability, some important understory types were identified. The understory ordination axes were not as clearly defined as the tree ordination axes which may be due to the sensitivity of the understory to factors not easily represented by the environmental factors measured in this study.

Environmental Factors

Environmental Data Summary

Results

The summary of environmental factors measured for each site is presented in Table VI.

Ordination

Results

The ordination of samples based on selected environmental factors is presented in Figure 20. The tree cover classification groups have been outlined on the ordination.

Discussion

The wide scatter of points indicates that a wide range of site types have been sampled in this study. The outlines of the forest cover groups on this ordination provide insight into the environmental amplitude of these types. Aspen and Engelmann

TABLE VI

ENVIRONMENTAL DATA SUMMARY

Sample Number	1979 Sample Date	Elevation in Meters	Elevation in Feet	Aspect°	Slope°	Slope Position	Depth of A Horizon	pH of A Horizon	Clay in B Horizon	Fire Evidence	Standing Dead Trees/375m^2	Litter*(%)	Rock*(%)	Bare Soil*(%)
1	8-31	2865	9400	353	20	5	16	5.5	0	1	1	99.5	0.0	0.5
2	8-31	2829	9280	343	25	3	8	6.0	0	1	2	98.8	0.0	1.2
3	8-15	2707	8880	343	18	5	4	7.0	1	0	0	99.9	0.0	0.0
4	8-15	2938	9640	213	25	2	6	6.0	1	1	1	61.7	39.5	0.9
5	8-06	3170	1040	253	5	3	2	5.0	1	1	1	84.3	15.5	0.1
6	8-16	3182	10440	143	30	3	3	6.5	0	0	1	49.2	38.7	12.3
7	8-16	3261	10700	193	30	3	1	5.0	2	1	7	42.3	39.4	18.6
8	8-05	3347	10980	63	20	4	26	5.0	2	1	3	90.6	2.8	0.4
9	8-05	3359	11020	1	10	3	2	4.5	1	1	1	68.8	24.2	0.6
10	7-17	3301	10830	283	10	3	2	6.0	1	0	0	79.0	2.2	5.4
11	7-16	3310	10860	223	12	2	3	5.5	0	1	3	49.9	6.5	35.1
12	8-18	3240	10630	103	15	4	3	4.0	1	0	2	76.7	23.0	0.3
13	8-19	2902	9520	68	25	4	2	5.0	1	0	0	79.0	2.2	5.4
14	8-19	3200	10500	143	25	3	5	6.0	0	1	1	34.2	15.0	49.8
15	8-19	2841	9320	323	0	3	8	6.5	1	0	1	56.6	31.0	12.2
16	8-21	2755	9040	293	6	1	3	7.0	1	1	0	51.6	0.1	9.4
17	10-14	2804	9200	113	45	4	16	4.5	0	1	0	56.6	39.1	2.1
18	8-22	2877	9440	3	35	3	1	6.0	1	1	4	61.0	33.4	3.6
19	9-23	3124	10250	353	15	2	4	4.5	1	1	9	82.0	11.5	6.4
20	8-17	3243	10640	293	30	3	2	4.5	0	0	24	65.2	22.5	12.3
21	8-17	3292	10800	307	30	2	2	6.0	1	0	20	57.5	21.8	18.1
22	9-15	3106	10190	33	30	3	14	6.0	0	1	0	86.4	13.4	0.2
23	8-01	3246	10650	19	25	3	9	4.5	0	1	6	73.5	21.5	01.5
24	8-01	3392	11130	343	5	2	7	5.5	1	1	3	63.4	7.1	12.1
25	8-06	3493	11460	79	30	3	9	4.0	2	1	9	73.0	22.4	.3
26	7-15	3310	10860	339	5	2	5	6.0	0	1	0	65.2	16.3	5.2
27	7-14	3295	10810	16	5	5	3	5.5	1	1	0	88.2	4.1	0.8
28	7-31	3292	10800	163	25	3	6	6.0	0	1	2	60.9	31.8	7.1
29	8-04	3207	10520	223	20	3	3	5.5	1	1	2	57.7	35.7	6.2
30	7-31	3048	10000	328	20	3	16	5.5	1	1	10	85.1	2.2	4.6
31	8-09	2743	9000	18	30	3	18	5.5	2	1	0	88.5	10.3	0.1
32	8-04	3018	9900	201	28	4	26	4.5	2	1	1	74.6	23.6	1.8
33	8-03	3048	10000	103	20	4	3	4.5	1	1	0	78.1	15.9	.8
34	8-03	3261	10700	177	25	3	6	5.5	0	1	5	64.4	36.7	1.3
35	8-07	2841	9320	53	20	5	2	5.5	1	1	0	76.9	20.4	0.5
36	8-09	2603	8540	163	25	3	9	6.5	1	1	0	57.2	3.4	55.9
37	8-02	3048	10000	209	35	4	5	4.5	1	1	0	59.8	37.0	3.1
38	8-02	3188	10460	193	10	2	4	5.5	1	1	1	36.3	25.0	37.6
39	9-16	2646	8680	33	20	3	2	7.0	0	1	0	85.5	14.5	0.0

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*Litter, rock, bare soil, moss lichen and vascular plant basal area were estimated separately for ground surface samples. These factors would sum to 100 percent if there were no overlap in the sample. Since most samples exhibited some overlap, the sum is usually greater than 100 percent.

TABLE VI (continued)

ENVIRONMENTAL DATA SUMMARY

Sample Number	1979 Sample Date	Elevation in Meters	Elevation in Feet	Aspect°	Slope°	Slope Position	Depth of A Horizon	pH of A Horizon	Clay in B Horizon	Fire Evidence	Standing Dead Trees/375m^2	Litter*(%)	Rock*(%)	Bare Soil*(%)
40	9-15	2853	9360	63	45	3	7	5.0	1	1	1	77.6	21.9	0.5
41	9-09	2713	8900	233	15	3	7	6.5	1	1	2	91.8	6.3	3.9
42	10-26	2768	9080	3	30	3	5	6.5	1	1	0	73.4	25.5	1.1
43	9-06	2713	8900	263	25	4	3	6.0	1	1	2	88.7	4.2	7.0
44	8-21	2722	8930	313	20	3	1	5.5	0	1	1	65.5	34.5	.1
45	8-21	2716	8910	133	2	5	16	6.5	1	0	0	88.3	10.0	1.6
46	9-08	2972	9750	33	28	3	1	6.0	1	1	3	89.9	10.1	0.1
47	9-08	2999	9840	113	15	3	5	4.0	1	1	5	99.6	0.1	0.4
48	9-07	2877	9440	283	20	4	6	6.0	1	1	1	93.9	0.1	6.1
49	9-07	2896	9500	243	23	2	9	6.0	1	1	3	67.8	0.2	32.0
50	10-13	3207	10520	103	25	2	3	5.0	1	1	2	60.3	39.0	0.1
51	10-13	2926	9600	283	30	3	1	5.5	1	1	0	78.3	21.6	0.1
52	8-12	2859	9380	303	30	3	2	6.5	0	1	4	60.8	35.6	0.1
53	8-12	2975	9760	133	30	2	7	7.5	0	1	1	50.9	48.5	0.6
54	8-11	2944	9660	103	40	2	18	7.0	0	1	0	66.2	29.1	4.3
55	8-11	2661	8730	283	30	3	7	6.5	0	1	1	73.4	17.6	7.1
56	8-10	2725	8940	293	30	3	6	7.0	0	1	1	82.1	13.2	2.9
57	8-10	2524	8280	113	10	4	6	6.5	0	0	0	93.0	0.1	6.1
58	8-08	2634	8640	48	15	3	2	6.0	1	1	1	82.9	1.9	11.8
59	8-09	2670	8760	133	30	2	6	5.5	0	1	0	36.4	57.5	4.3
60	8-08	2557	8390	23	10	3	2	4.5	1	1	0	96.0	0.3	0.6

*Litter, rock, bare soil, moss lichen and vascular plant basal area were estimated separately for ground surface samples. These factors would sum to 100 percent if there were no overlap in the sample. Since most samples exhibited some overlap, the sum is usually greater than 100 percent.

LOST CREEK SCENIC AREA

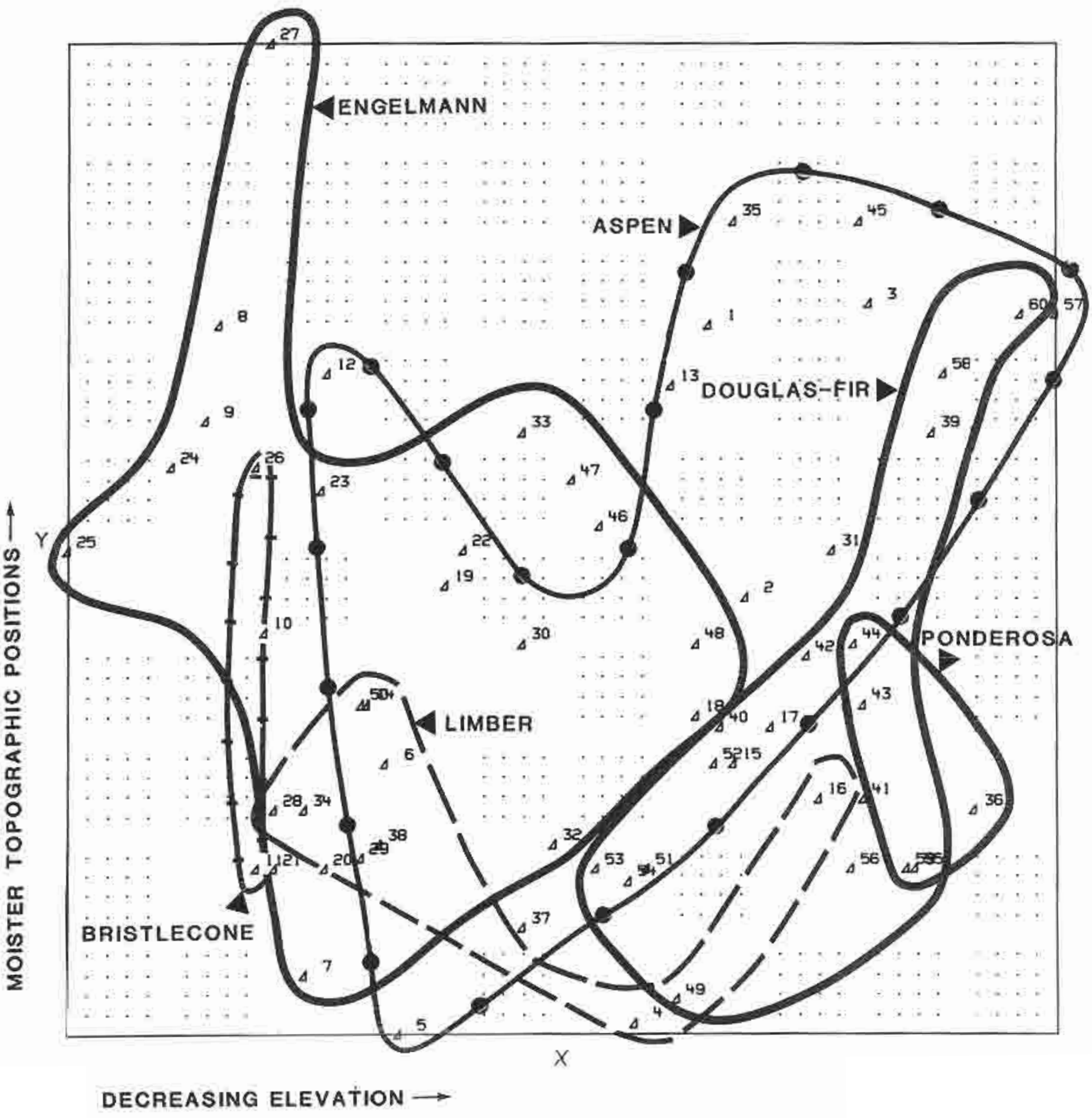

Figure 20. Ordination of samples based on selected environmental factors.

spruce span the widest elevational and topographic/moisture gradient. Limber pine spans a wide elevational gradient but is restricted to dryer topographic positions. Bristlecone pine may prefer sites that are higher in elevation and more mesic than limber pine, but Engelmann spruce is dominant in most high elevation, high moisture sites. The environmental amplitudes of Douglas-fir and Engelmann spruce may overlap on the ordination when either elevation or topographic/ moisture position are considered separately but when they are considered together, the ordination implies that Douglas-fir and Engelmann spruce are well segregated with respect to site preference. In the lowest elevations, ponderosa occupies the driest sites and overlaps with Douglas-fir at higher elevations.

Species Distributions Within the Environmental Ordination

Results

The distributions of eight tree species and twelve understory species within the environmental ordination are presented in Figure 21.

Discussion

The ecological amplitude of these species in terms of topographic factors is shown in these figures. Species distributions are more evenly dispersed in these figures than in the previous tree cover and understory cover ordinations with their complex axes. Topographic factors do not precisely control

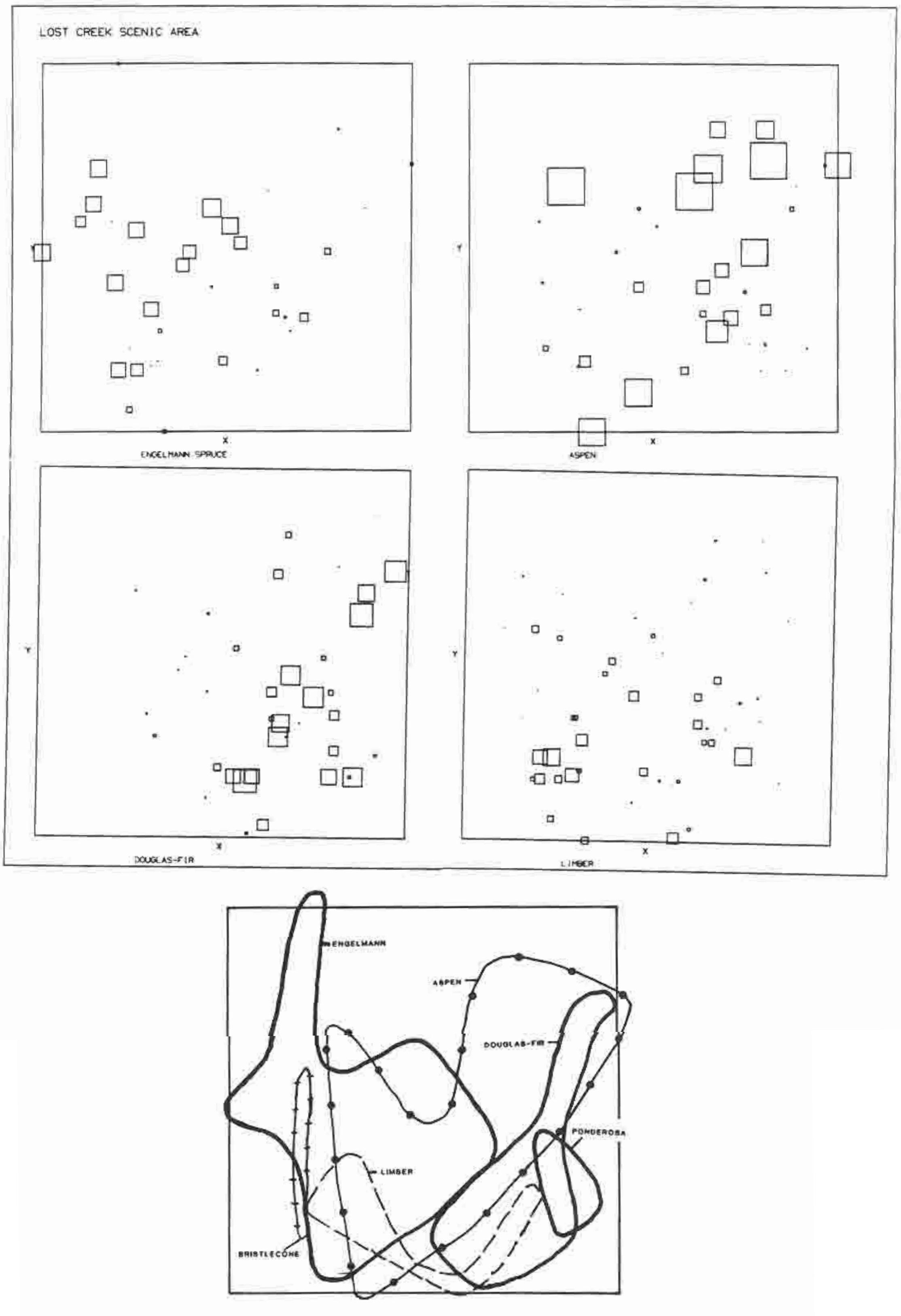

Figure 21. Distributions of selected understory species and tree species within the environmental ordination.

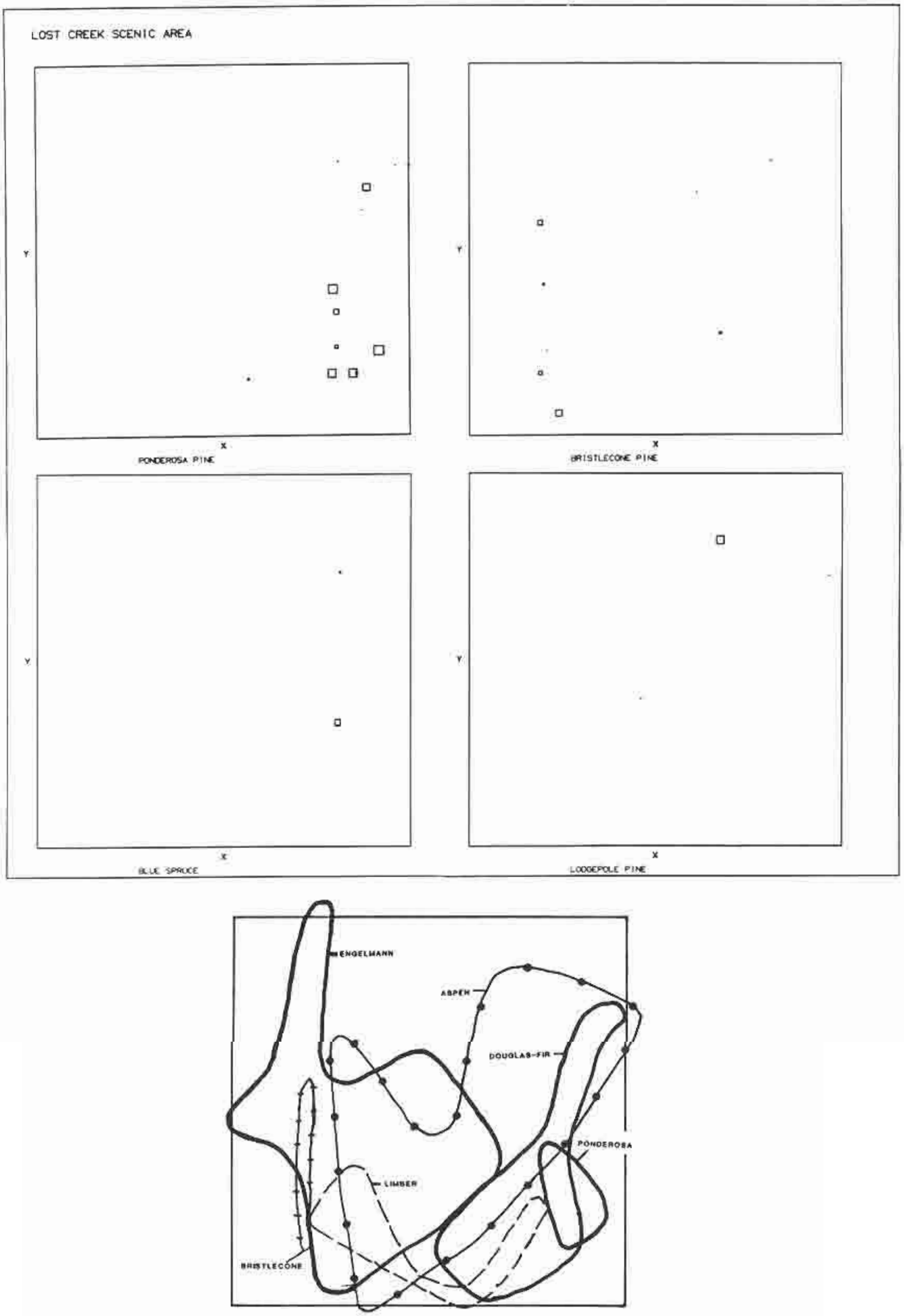

Figure 21. Distributions of selected understory species and tree species within the environmental ordination. (continued)

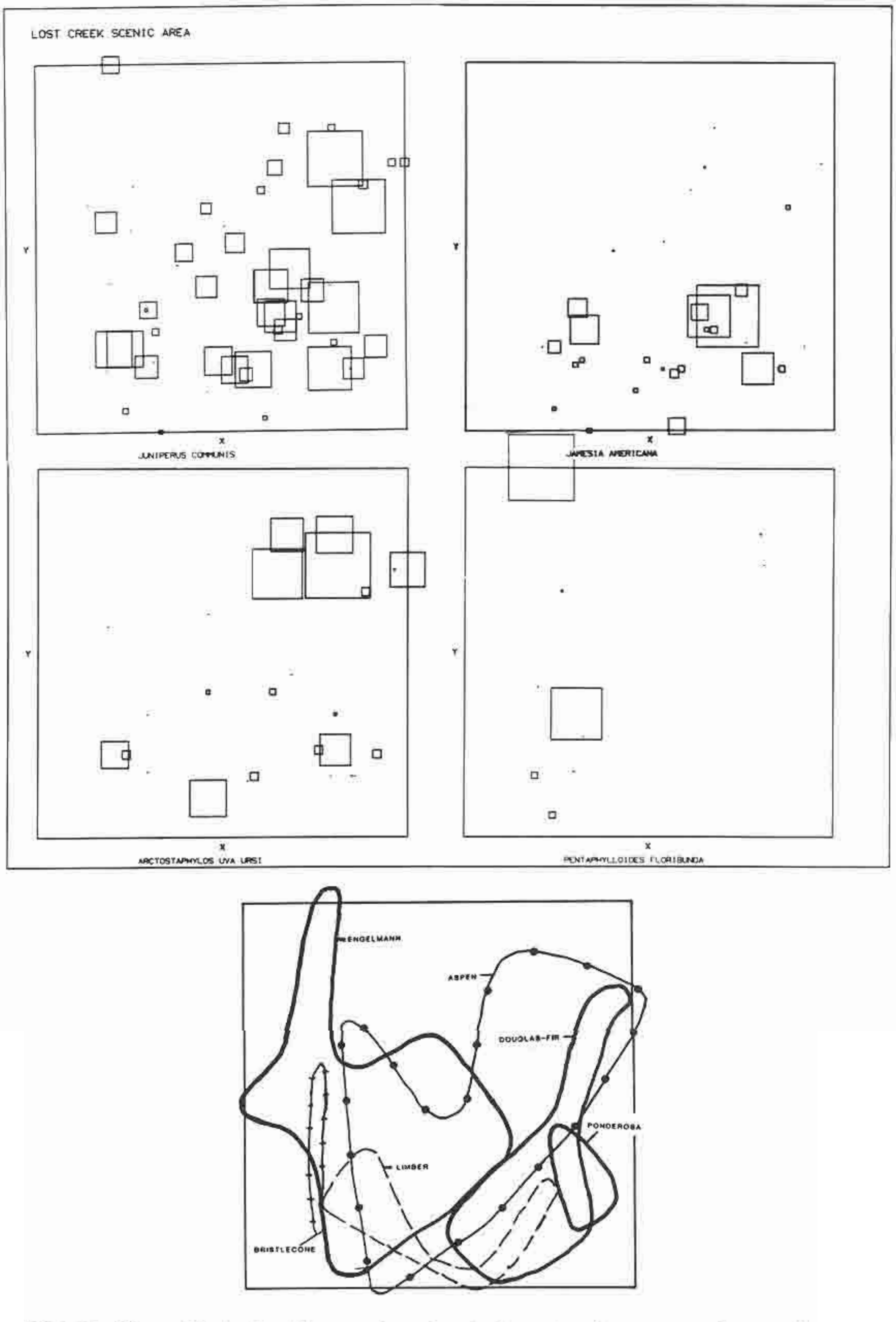

Figure 21. Distributions of selected understory species and tree species within the environmental ordination. (continued)

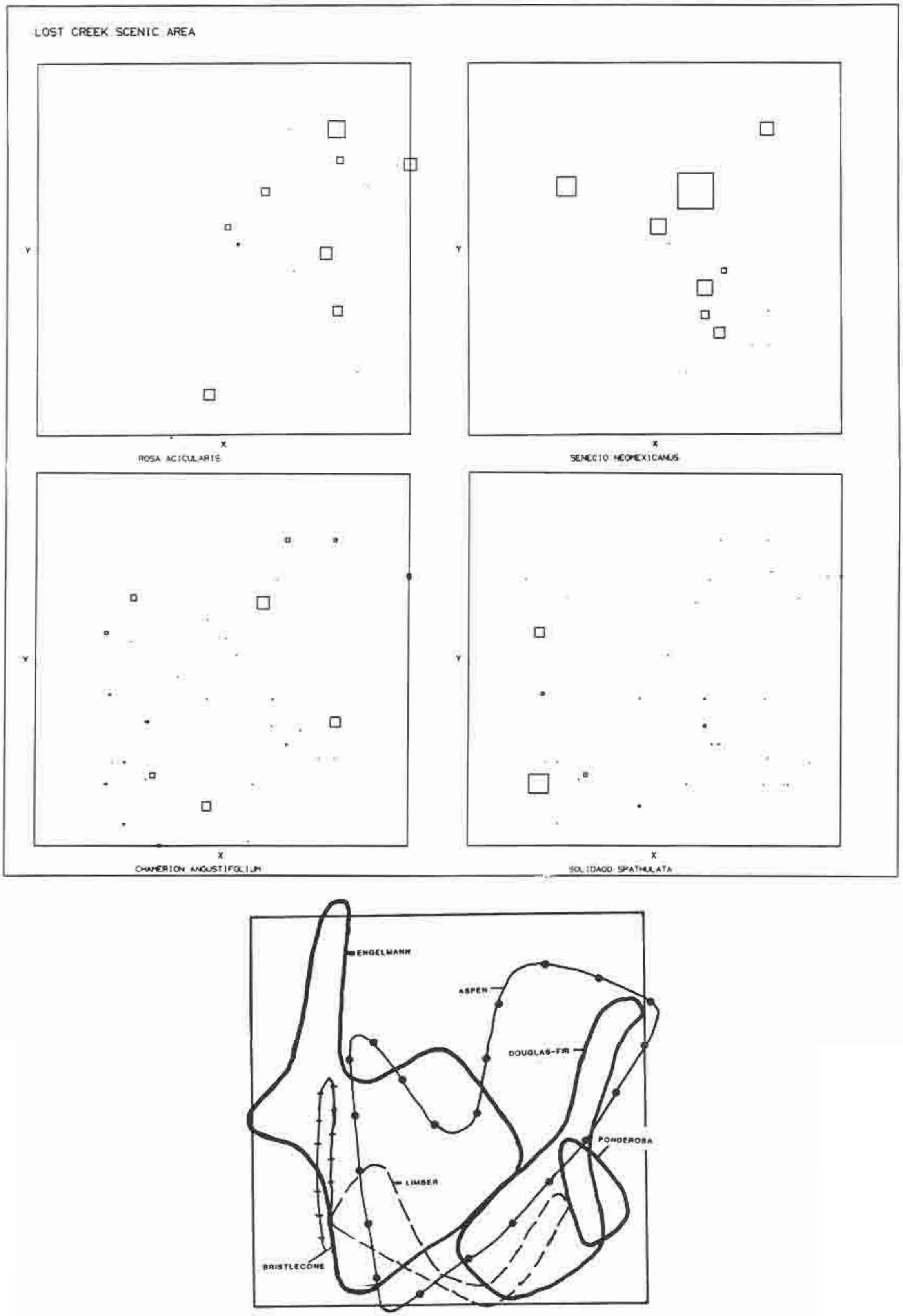

Figure 21. Distributions of selected understory species and tree species within the environmental ordination. (continued)

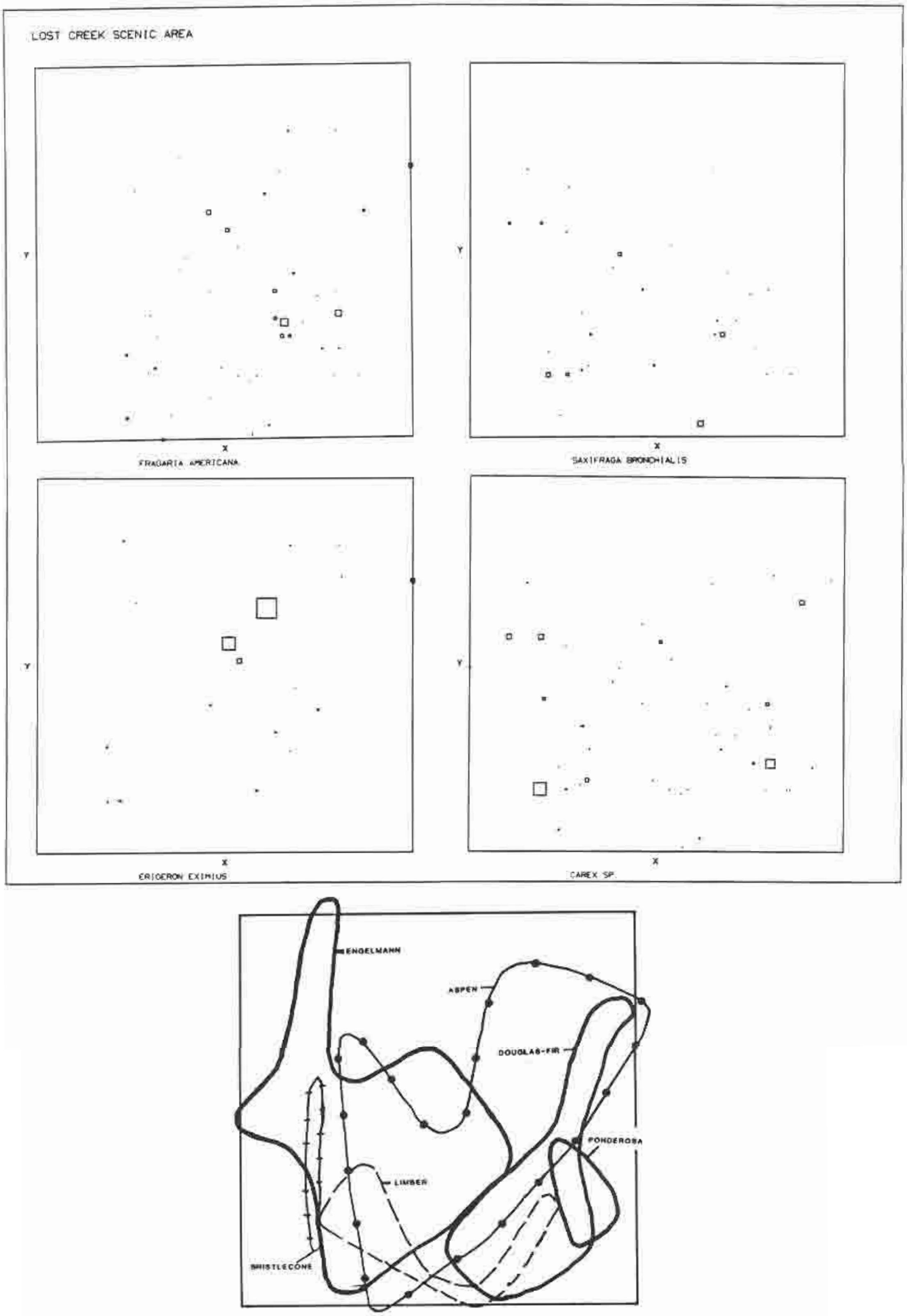

Figure 21. Distributions of selected understory species and tree species within the environmental ordination. (continued)

species distributions, but the similarities between the environmental ordination and the tree cover ordination show the considerable influence of topographic position on species distributions.

Summary

Figures 20 and 21 demonstrate the distribution of the forest classification groups and 20 species in relation to the ordination axes which are based on topographic site characteristics. This provides a representation of where the groups or species occur on the landscape. These figures have more group overlap and less distinct centers of species distributions than the previous ordination and distribution figures. Topographic factors provide only a partial explanation of the complex of factors which control vegetation distribution.

Dendrochronology Climatic History, Fire and Vegetational Distribution

Results

The skeleton plots for the 21 oldest samples are presented in Figure 22. The vertical lines indicate years of reduced radial growth in relation to adjacent years. The longer the line, the greater the reduction of annual growth.

Discussion

These skeleton plots have not undergone the statistical analysis required to correct for false or missing rings. The

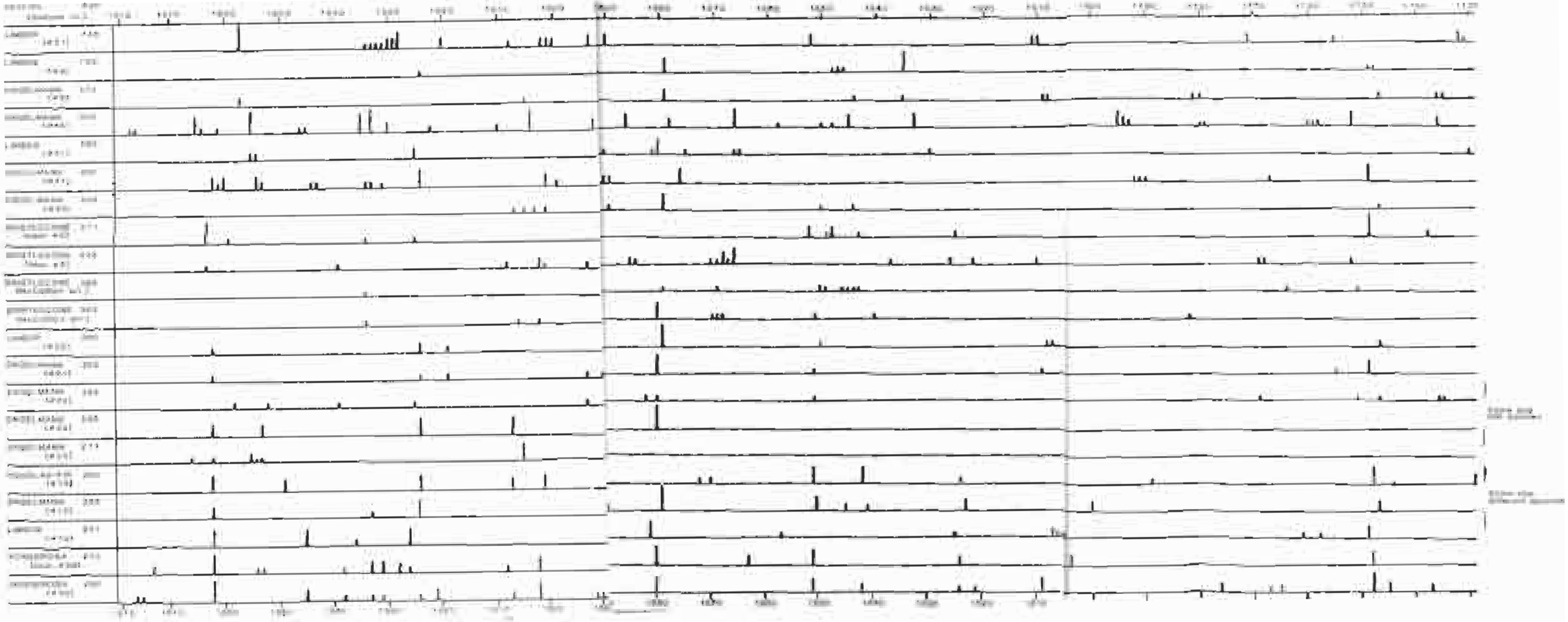

Figure 22. Skeleton plots.

inconsistencies in the skeleton plots are slight enough, however, not to obscure the climatic trend and the different responses of species and individuals to it. The interpretation of these plots is based on the assumption that severe drought years will reduce the annual growth of the majority of trees subjected to this stress. Because of the critical importance of moisture in this semi-arid environment, species distributions can be expected to fluctuate in response to highly variable annual precipitation. Not only the intensity of the maxima and minima but also the frequency of stress in relation to the response time of the vegetation are components of vegetation dynamics which greatly influence the distribution of species. The significance of drought stress on species distributions is enhanced when secondary effects such as insect infestations, disease, and fire result in catastrophic changes. The hypothesis that drought periods precede periods of high fire incidence has not yet been confirmed (Laven et al., 1980), but evidence from fires in the Lost Creek area tends to support it.

The years which show the greatest incidence of narrower than expected rings, and are likely to be years of severe drought, are approximately 1749, 1850, 1879, and 1962. Precipitation records for Cheesman Reservoir show that 1962 received the lowest annual precipitation for the years 1951 through 1970 with 25.4 cm (10 in.) versus the mean annual precipitation of 40.1 cm (15.8 in., s = 3.6). The dry year of 1962 was a local phenomenon that is not evident in the records of more distant weather stations. The response of the trees to this dry year varies from site to site, species to species, and individual to individual. The two low elevation Ponderosa pine samples were sensitive to the dry year as were some higher elevation bristlecone pine and limber pine samples. At some sites all species showed the reduced annual growth, while at other sites only certain individuals demonstrated this effect. The bristlecone pine at the severe site near the summit of McCurdy Mountain showed no effect from the dry year. Trees which are subjected to stresses other than those induced by climate will produce annual growth rings that are either too complex, or insensitive to the climatic changes. Stress due to exposed windy sites or intense competition could obscure the climatic effects on annual growth. The most useful trees for determining drought years occurred in sites that were open, well drained, and without severe exposure or competition. This small test of the correlation between low precipitation and reduced radial growth in the Lost Creek area should lend some credibility as well as caution to the interpretation of past climate based solely on tree rings. As the historical record loses continuity in the past, there is less factual climatic and historic information and greater dependence on circumstantial evidence.

The very impressive incidence of narrow rings around the year 1879 occurred at the beginning of climatic documentation in Colorado. The only source of high altitude climatic data for that period in Colorado was fortunately collected on top of Pikes

Peak, which is about 64 km (40 miles) southeast of the study area. These data were collected for the years 1874-1883 by the U.S. Army Signal Corps in the U.S. Congress, Congressional Serial Set (USC, CSS). These data indicate that 1874-1877 were four relatively dry years with an average annual precipitation of 64 cm (25.2 in.) compared to 106.8 cm (42.1 in.) for the following four years of 1878-1881. During the later period, the precipitation for May through October was:

1878	56 cm (22.1 in.)
1879	36 cm (14.0 in.)
1880	57 cm (22.5 in.)
1881	66 cm (26.0 in.)

The precipitation for the 1879 growing season was 33 percent less than the average for the four years. A record of all fires sighted from Pikes Peak was also documented by the U.S. Army Signal Corps (USC, CSS). The largest fires reported were for June 1879. A report dated June 30 stated that three large forest fires had been burning for about a month, and the direction given for these fires is in a direct line with the study area (USC, CSS, 1880). All of this evidence may only be circumstantial support for an 1879 fire date and conclusions must be made with reservation. A large fire has occurred in the Lost Creek area. This is indicated by large expanses of even-aged aspen with standing and fallen dead charred wood occurring in the aspen as well as in open areas that have not yet been reforested. The expansive aspen stands north and east of McCurdy Park are approximately 60-80 years old and may have been established following a single large fire. Reestablishment of the stand was undoubtedly delayed due to rapid soil erosion alternating with drought. If the widespread incidence of narrow rings in an area is correlated with drought that is severe enough to affect large forest populations, the tree ring record may reveal not only a climatic record but an indirect record of fire history. The skeleton plots show a 100-yr period from 1749 to 1850 that is relatively drought free, which infers reduced incidence of fire. The period from 1850 to the present shows a much higher incidence of narrow rings. Two hypotheses to explain this are that droughts are becoming more frequent, or the trees have become more sensitive to drought. One is tempted to indict atmospheric pollution in the latter case. The frequency of fires can greatly influence the distribution of species. The maintenance of limber pine in an Englemann spruce climax forest as described previously is an example of this. The skeleton plots give some indication that the frequency of the higher probability fire periods is much shorter than the maximum life expectancy of limber pine, thus maintaining this long lived successional species as a component of climax stands.

In summary, an examination of the skeleton plots from 21 increment cores indicates that the Lost Creek area has had severe droughts during which catastrophic fires are highly probable.

Although a regular periodicity of these drought events is not evident, there seems to be an increasing incidence of these events during the last 100 years of the 250 years of record. The frequency of these droughts and fires greatly influences the distribution of species, and is especially important for the maintenance of successional species such as aspen and limber pine.

CHAPTER IV

SYNTHESIS

Comparison With Other Front Range Forest Studies

Numerous Front Range forest studies have described the forest zonation and have investigated the causes. Although there has been some variation among investigators for defining the topographic limits of the forest zones, the central features of each zone have consistently been distinguished. The relationship of temperature and moisture to elevational zonation were suspected as causative factors early in the history of Front Range studies. Physiological studies (Bates 1923, Whitfield 1933, Daubenmire 1943b, and others) have tested the effects of temperature and drought. Daubenmire (1943b) presented a strong case for soil drought as a factor controlling the lower elevational limit of trees, and Wardle (1968) described physiological drought as the factor controlling the upper elevational limit of Engelmann spruce. Moisture would seem to be the critical factor controlling the distribution of tree species and this would contradict the results of the Figure 11 ordination which suggests that temperature is the controlling factor. An appropriate hypothesis (Marr, personal communication) suggests that moisture is the factor limiting the upper elevational limit of the species, but temperature controls the accessibility and utilization of moisture by the tree and so is a higher order limiting factor. For the evergreen coniferous species, this suggests that there is an upper elevational limit at which low temperatures make water unavailble, but water is still lost through transpiration resulting in permanent wilting. If, in the absence of competition, all of these conifers would have an upper and lower elevational limit that would be controlled by physiological drought and soil drought, respectively, and if the ability of these species to tolerate one form of drought is complementary to their ability to tolerate the other, it is possible that forest zonation is controlled by the different water absorbtion capabilities of the species and/or differential transpiration control capabilities.

In central and northern sections of the Front Range, subalpine fir and Engelmann spruce are two climax species which occur together rather than dominate separate elevational zones. The absence of subalpine fir in the Lost Creek area suggests that Engelmann spruce is more tolerant of soil drought which may be more severe in the southern Front Range (Figure 3). The hypothesis regarding the complementary nature of physiological drought and soil drought tolerance suggests that subalpine fir should be more successful than Engelmann spruce in moist but very cold sites. Bristlecone pine and limber pine are species which have not been studied as intensively as other tree species in the Front Range but are known to occupy sites which are generally classified as dry and windy. In this case, Figure 11 and field observations indicate that limber pine is more tolerant of soil drought and bristlecone pine is more tolerant of physiological drought. Bristlecone pine would be expected to be more successful than limber pine in dry windy sites that are slightly colder and moister. The broad distributional success of aspen in the conifer-dominated Front Range forests may be a function of soil drought tolerance and avoidance of physiological drought stress through the loss of leaves during the periods when this stress is most severe.

This classification of randomly selected samples and Bray-Curtis ordination (indirect gradient analysis) with indirect measure of the controlling environmental factors (i.e., temperature and moisture) has supported other more-or-less objective studies of the distributions of Front Range forest species and revealed differences that reflect different environments or histories. The elevational and latitudinal gradients of the Front Range create a topography that is like a canvas painted with vegetation. The average color is the theme, and the range of colors is the spice.

Diverse Approaches to Vegetation Description

The variety of sampling and analytical procedures that have been utilized in forest studies have as a common goal the more objective representation of current vegetation distribution (coenocline) in relation to the controlling environmental gradients (ecocline). Two approaches for the analysis of vegetation distribution have evolved as a result of the perception that natural vegetation may exist either as visibly distinct and functional units, described by Whittaker (1962) as the "community-unit theory," or as a composition of species that are independently distributed (Gleason, 1926, 1939), forming a vegetation continuum without objectively definable community boundaries (Curtis and McIntosh, 1951). The development of these two approaches has been reviewed by Whittaker (1962), Shimwell (1971), and Mueller-Dumbois and Ellenberg (1974). This study shows that continua and visually distinct units may exist side by side in natural vegetation. Historical factors, chance distribution of seed, competition, and the rate of change of the environmental gradient across the landscape control the distribution of vegetation and may result in a wide range of vegetational homogeneity. Lambert and Dale (1964), Greig-Smith (1964, 1971) and Anderson (1965) have noted that the ordination techniques derived from the individualistic approach can be allied with the community unit theory to provide a useful classification of the vegetation. Ordination procedures do not divide vegetation into units, but they can be powerful tools to enable the investigator to be more objective in his ultimately subjective classification of natural vegetation (Curtis, 1959). Lambert and Dale (1964) have described the synthesis of ordination and classification as a natural progression in the successive approximation (Poore, 1962) of the true nature of vegetation distribution. Whether an investigator uses a classification, ordination or combined approach depends on the objectives of the study and the nature of the vegetation within the study area. Classification by subjective analysis of the more or less objective data may be appropriate when vegetation units are easily distinguishable by inspection and appear to be functionally distinct. When the units are less well defined, ordination techniques will objectively represent the fine-grained differences and may serve as a useful tool for a finer level of classification (Greig-Smith, 1971). The development of ordination techniques has taken a predictable direction toward the differentiation and ordering of less distinct units. Interestingly, these more complex procedures have been shown to be less effective at correctly ordering samples when there is a wide range of variability among the samples (Gauch and Whittaker, 1972).

Diverse Approaches to Environmental Correlation

The fact that the vegetation samples can be classified or ordinated based on floristic similarity leads to an investigation of the factors which produce this apparent structure in natural vegetation. The correlation of the leading environmental factors (e.g., light, heat, moisture, nutrients) with vegetation distribution is the next step in the search for possible causes of the current distribution of species. This important step has been accomplished in various ways. Daubenmire (1952) subjectively described the environmental correlations based on many years of observation and quantitative soil data. Bray and Curtis (1957) tested for significant correlations between the three compositional axes of the ordination and the environmental data which was a variety of soil characteristics and percent canopy. Bakuzis (1959) subjectively defined the environmental axes of a triangular ordination and studied the combination of environmental effects on stand structure and succession. Whittaker (1960) used a composite weighted-average method in which he subjectively defined the preferred environments of individual species and defined the community position within the environmental continuum on the basis of the species which comprise it. In order to reduce complexity, the influence of some environmental factors were reduced by subjectively selecting sample locations that would emphasize only one or a few factors at a time. This was a direct gradient analysis but did not directly measure the factors which created the gradient. Loucks (1962) subjectively defined three major environmental gradients (i.e., moisture, nutrient, climate) to be used in a three dimensional ordination. Each gradient is defined by a complex of factors, and each factor is scaled into classes which reflect the relationship of the factor to the overall gradient. The synthesis of all the objectively measured factors will locate a sample within the ordination. This was an indirect gradient analysis which directly measured the factors that created the gradients. Marr (1967) used subjectively selected samples representing ecosystem units along a indirect environmental gradient and made direct environmental measurements of climatic factors. The complicating biotic, time, and historic factors were dealt with subjectively, but the establishment of permanent plots may now permit more objective assessment of these factors in the future. Extensive measurement of environmental factors although extremely time consuming is the only objective method for establishing the environmental relationship to the distribution of vegetation. Patten (1963) made extensive environmental measurements, but the final analysis of the vegetational pattern incorporated the speculative assessment of historical change.

Historical Factor

Methods exist for the objective definition of the current vegetation and its relationship to environmental factors. The historical factor, however, as an important influence on vegetation pattern cannot be overemphasized. Short-term historical factors can result in changes in the vegetation pattern represented by succession. Long-term historical factors affect not only vegetation pattern but also species composition through such mechanisms as climatic and genetic change. The mystery of current vegetation pattern is rooted in the past and flies steadily into the future.

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APPENDIX

A. Floristic List

B. Understory Cover Data

APPENDIX A

LIST OF VASCULAR SPECIES ENCOUNTERED IN THE LOST CREEK STUDY AREA AND ON McCURDY MOUNTAIN

Species	Common Name	Family
TREES		
Juniperus scopulorum Sarg.	Cedar, Red	Pinaceae
Picea engelmannii (Parry) Engelm.	Spruce, Engelmann	Pinaceae
Picea pungens Engelm.	Spruce, Colorado Blue	Pinaceae
Pinus aristata Engelm.	Pine, Bristlecone or Fox-tail	Pinaceae
Pinus contorta Dougl. var. *latifolia* Engelm.	Pine, Lodgepole	Pinaceae
Pinus flexilis James	Pine, Limber	Pinaceae
Pinus ponderosa Laws. var. *scopulorum* Engelm.	Pine, Ponderosa, Bull; Yellow	Pinaceae
Populus tremuloides Michx.	Aspen, Quaking	Salicaceae
Pseudotsuga menziesii (Mirb.) Franco	Douglas-fir	Pinaceae
SHRUBS		
Acer glabrum Torr.	Maple, Mountain	Aceraceae
Alnus tenuifolia Nutt.	Alder	Betulaceae
Arctostaphylos uva-ursi (L.) Spreng. ssp. *adenotricha* (Fern. & Macbr.) Calder & Taylor	Kinnikinnik; Bearberry	Ericaceae
Betula fontinalis Sarg.	Birch, River	Betulaceae
Betula glandulosa Michx.	Birch, Bog	Betulaceae
Ceanothus fendleri Gray	Buckbrush	Rhamnaceae
Cercocarpus montanus Raf.	Mahogany; Mountain	Rosaceae
Jamesia americana T. & G.	Waxflower	Hydrangeaceae
Juniperus communis L. ssp. *alpina* Celakovsky	Juniper, Common	Pinaceae
Pentaphylloides floribunda (Pursh) A. Love	Cinquefoil, Shrubby	Rosaceae
Prunus virginiana L. var. *melanocarpa* (Wels.) Sarg	Cherry, Choke	Rosaceae
Ribes aureum Pursh	Currant, Golden	Grossulariaceae
Ribes cereum Dougl.	Currant, Wax	Grossulariaceae
Ribes inerme Rydb.	Currant or Gooseberry	Grossulariaceae
Ribes leptanthum Gray	Currant or Gooseberry	Grossulariaceae
Ribes montigenum McClatchie	Currant, Subalpine, Prickly	Grossulariaceae
Rosa acicularis Lindl.	Rose	Rosaceae
Rubus deliciosus James	Raspberry, Boulder	Rosaceae

APPENDIX A (continued)

LIST OF VASCULAR SPECIES ENCOUNTERED IN THE LOST CREEK STUDY AREA AND ON McCURDY MOUNTAIN

Species	Common Name	Family
SHRUBS (continued)		
Rubus idaeus L. ssp. melanolasius (Dieck) Focke	Raspberry, Wild	Rosaceae
Rubus parviflorus Nutt.	Thimbleberry	Rosaceae
Sambucus racemosa L. ssp. pubens (Michx.)	Red-berried Elder	Caprifoliaceae
Salix bebbiana Sarg.	Willow	Salicaceae
Salix brachycarpa Nutt.	Willow	Salicaceae
Salix geyeriana Anderss.	Willow	Salicaceae
Salix phylicifolia L. ssp. planifolia (Pursh) Hiitonen	Willow, Planeleaf	Salicaceae
Salix scouleriana Barr.	Willow	Salicaceae
Viburnum edule (Michx.) Raf.	High-bush-Cranberry	Caprifoliaceae
Yucca glauca Nutt.	Spanish Bayonet	Agavaceae
GRASSES		
Agropyron repens (L.) Beauv.	Quack Grass	Gramineae
Agropyron trachycaulum (Link) Malte	Wheatgrass, Slender	Gramineae
Alopecurus aequalis Sobol.	Foxtail	
Blepharoneuron tricholepis (Torr.) Nash	Dropseed, Pine	Gramineae
Bouteloua curtipendula (Michx.) Torr.	Grama, Side-oats	Gramineae
Bouteloua gracilis (H.B.K.) Lag.	Grama, Blue	Gramineae
Bromopsis ciliata (L.) Holub.	Brome, Fringed	Gramineae
Bromopsis lanatipes (Shear) Holub.	Brome, Perennial	Gramineae
Calamagrostis canadensis (Michx.) P. Beauv.	Reedgrass, Canadian	Gramineae
Calamagrostis purpurascens R.Br.	Reedgrass, Purple	Gramineae
Eragrostis trichodes (Nutt.) Wood	Lovegrass	Gramineae
Festuca arizonica Vasey	Fescue, Arizona	Gramineae
Festuca brachyphylla Schult.	Fescue	Gramineae
Festuca rubra L.	Fescue, Red	Gramineae
Koeleria macrantha (Ledeb.) Smith	Junegrass	Gramineae

APPENDIX A (continued)

LIST OF VASCULAR SPECIES ENCOUNTERED IN THE LOST CREEK STUDY AREA AND ON McCURDY MOUNTAIN

Species	Common Name	Family
GRASSES (continued)		
Leucopoa kingii (Wats.) W.A. Weber	Fescue, Spike	Gramineae
Muhlenbergia filiculmis Vasey	Muhly	Gramineae
Muhlenbergia montana (Nutt.) Hitchc.	Muhly, Mountain	Gramineae
Oryzopsis asperifolia Michx.	Ricegrass, Rough-leaved	Gramineae
Oryzopsis micrantha (Trin. & Rupr.) Thurber	Ricegrass, Littleseed	Gramineae
Phleum pratense L.	Timothy	Gramineae
Poa agassizensis Boivin & D. Love	Bluegrass	Gramineae
Poa canbyi (Scribn.) Piper	Bluegrass	Gramineae
Poa fendleriana (Steud.) Vasey	Muttongrass	Gramineae
Poa glauca Vahl	Bluegrass	Gramineae
Poa nemoralis L. ssp. interior (Rydb.) Butters & Abbe	Bluegrass	Gramineae
Poa nervosa (Hook.) Vasey	Bluegrass	Gramineae
Sitanion longifolium J.G. Smith	Squirreltail	Gramineae
Trisetum spicatum (L.) Richt.	Trisetum	Gramineae
Trisetum spicatum (L.) Richt. ssp. majus Hulten	Trisetum	Gramineae
SEDGES		
Carex aquatilis Wahlenb.	Sedge	Cyperaceae
Carex aurea Nutt.	Sedge	Cyperaceae
Carex disperma Dewey	Sedge	Cyperaceae
Carex norvegica Retz. ssp. stevenii (Holm) Murray	Sedge	Cyperaceae
Carex nova Bailey	Sedge	Cyperaceae
Carex occidentalis Bailey	Sedge	Cyperaceae
Carex petasata Dewey	Sedge	Cyperaceae
Carex rossii Boott	Sedge	Cyperaceae
Carex rupestris Bell (drummondiana in Harrington)	Sedge	Cyperaceae
Carex utriculata Boott	Sedge	Cyperaceae
Eriophorum angustifolium Honck.	Cotton-grass	Cyperaceae

APPENDIX A (continued)

LIST OF VASCULAR SPECIES ENCOUNTERED IN THE LOST CREEK STUDY AREA AND ON McCURDY MOUNTAIN

Species	Common Name	Family
RUSHES		
Luzula parviflora (Ehrh.) Desv.	Wood-rush	Juncaceae
FERNS AND FERN ALLIES		
Equisetum arvense L.	Horsetail	Equisetaceae
Botrychium lunaria (L.) Sw.	Moonwort	Ophioglossaceae Pteridophyta
Asplenium septentrionale (L.) Hoffm.	Fern, Grass	Polypodiaceae Pteridophyta
Cystopteris fragilis (L.) Bernh.	Fern, Brittle	Polypodiaceae Pteridophyta
Dryopteris filix-mas (L.) Schott	Fern, Male	Polypodiaceae Pteridophyta
Pteridium aquilinum (L.) Kuhn	Bracken	Polypodiaceae Pteridophyta
FORBS		
Acetosella vulgaris (Koch) Fourr.	Sorrel, Sheep	Polygonaceae
Achillea lanulosa Nutt.	Yarrow	Compositae
Acomastylis rossii (R. Br.) Greene ssp. turbinata (Rydb.) W.A. Weber	Avens, Alpine	Rosaceae
Aconitum columbianum Nutt. f. ochroleucum St. John.	Monks Hood	Ranunculaceae
Actaea rubra (Ait.) Willd. ssp. arguta (Nutt. ex T & G.) Hulten	Baneberry	Ranunculaceae
Adoxa moschatellina L.	Moschatel	Adoxaceae
Agoseris glauca (Pursh) Raf.	Agoseris, Pale	Compositae
Aletes anisatus (Gray) Theobald & Tseng	Aletes	Umbelliferae
Allium cernuum Roth	Onion, Nodding	Alliaceae
Amaranthus retroflexus L.	Pigweed, Rough	Amaranthaceae
Androsace chamaejasme Host. ssp. carinata (Torr.) Hulten	Rock-Jasmine	Primulaceae
Androsace septentrionalis L.	Primrose, Rock	Primulaceae

APPENDIX A (continued)

LIST OF VASCULAR SPECIES ENCOUNTERED IN THE LOST CREEK STUDY AREA AND ON McCURDY MOUNTAIN

Species	Common Name	Family
FORBS (continued)		
Anemone multifida Poir. var. *globosa* (Nutt.) T. & G.	Globeflower	Ranunculaceae
Antennaria parvifolia Nutt.	Pussytoes	Compositae
Antennaria rosea Greene	Pussytoes	Compositae
Apocynum androsaemifolium L.	Dog-bane, Spreading	Apocynaceae
Aquilegia caerulea James	Columbine, Colorado Blue	Ranunculaceae
Aquilegia saximontana Rydb.	Columbine, Dwarf	Ranunculaceae
Arabis divaricarpa Nels.	Rock-cress	Cruciferae
Arabis drummondii Gray	Rock-cress	Cruciferae
Arabis hirsuta (L.) Scop.	Rock-cress, Hairy	Cruciferae
Arabis holboellii Hornem.	Rock-cress	Cruciferae
Aralia nudicaulis L.	Sarsaparilla, Wild	Araliaceae
Arenaria fendleri Gray	Sandwort	Caryophyllaceae
Arnica cordifolia Hook	Arnica	Compositae
Artemisia frigida Willd.	Sage, Pasture	Compositae
Artemisia ludoviciana Nutt.	Sage, Prairie	Compositae
Astragalus miser Dougl. ex Hook. var. *oblongifolius* (Rydb.) Cronquist	Vetch, Milk	Leguminosae
Astragalus sparsiflorus Gray	Vetch, Front Range Milk	Leguminosae
Bahia dissecta (Gray) Britt	Bahia	compositae
Besseya plantaginea (Benth.) Rydb.	Besseya, Foothills	Scrophulariaceae
Bistorta bistortoides (Pursh) Small	Bistort	Polygonaceae
Bistorta vivipara (L.) S. Gray	Bistort	Polygonaceae
Brickellia grandiflora (Hook) Nutt.	Brickellia	Compositae
Calochortus gunnisonii Wats.	Lily, Mariposa or Sego	Liliaceae
Caltha leptosepala DC.	Marsh-Marigold	Ranunculaceae
Calypso bulbosa (L.) Oakes	Fairy Slipper	Orchidaceae
Campanula rotundifolia L.	Harebell, Common	Campanulaceae
Capsella bursa-pastoris (L.) Medic	Shepherds Purse	Cruciferae
Castilleja integra Gray	Paintbrush, Orange	Scrophulariaceae
Castilleja miniata Dougl.	Paintbrush, Scarlet	Scrophulariaceae
Castilleja rhexifolix Rydb.	Paintbrush	Scrophulariaceae
Castilleja sulphurea Rydb.	Paintbrush, Yellow	Scrophulariaceae
Chamerion angustifolium (L.) Holub.	Fireweed	Onagraceae
Chenopodium atrovirens Rydb.	Goosefoot	Chenopodiaceae
Chenopodium leptophyllum Wats.	Goosefoot	Chenopodiaceae

APPENDIX A (continued)

LIST OF VASCULAR SPECIES ENCOUNTERED IN THE LOST CREEK STUDY AREA AND ON McCURDY MOUNTAIN

Species	Common Name	Family
FORBS (continued)		
Chimaphila umbellata (L.) Bart. ssp. occidentalis (Rydb.) Hulten	Pipsissewa; Princess Pine	Ericaceae
Circaea alpina L.	Nightshade, Enchanters	Onagraceae
Cirsium coloradense (Rydb.) Cockerell	Thistle	Compositae
Clematis columbiana (Nutt.) T. & G.	Clematis, Rocky Mountain	Ranunculaceae
Clementsia rhodantha (Gray) Rose	Rose Crown	Crassulaceae
Collinsia parviflora Lindl.	Baby-blue-eyes; Blue-eyed Mary	Scrophulariaceae
Collomia linearis Nutt.	Collomia	Polemoniaceae
Conioselinum scopulorum (Gray) C. & R.	Parsley, Hemlock	Umbelliferae
Corallorhiza maculata Raf.	Coral-root, Spotted	Orchidaceae
Corallorhiza trifida Chat.	Coral-root, Little Yellow	Orchidaceae
Cryptantha thyrsiflora (Greene) Payson	Cryptantha	Boraginaceae
Cryptantha virgata (Porter) Payson	Miners Candle	Boraginaceae
Delphinium ramosum Rydb.	Larkspur	Ranunculaceae
Descurainia richardsonii (Sw.) O.E. Schulz	Mustard, Western Tansy	Cruciferae
Dodecatheon pulchellum (Raf.) Merrill	Shooting-star	Primulaceae
Draba aurea Vahl	Draba, Golden	Cruciferae
Draba streptocarpa Gray	Whitlow-wort	Cruciferae
Drymocallis fissa (Nutt.) Rydb.	Drymocallis	Rosaceae
Epilobium hornemannii Hausskn.	Willow-Herb	Onagraceae
Erigeron compositus Pursh	Fleabane; Daisy	Compositae
Erigeron eximius Greene	Fleabane; Daisy	Compositae
Erigeron flagellaris Gray	Fleabane; Trailing	Compositae
Erigeron lonchophyllus Hook.	Fleabane; Daisy	Compositae
Erigeron pinnatisectus (Gray) Nels.	Fleabane; Daisy	Compositae
Erigeron subtrinervis Rydb.	Fleabane; Daisy	Compositae
Erigeron vetensis Rydb.	Daisy, LaVeta	Compositae
Eriogonum alatum Torr.	Eriogonum, Winged	Polygonaceae
Eritrichum aretioides (Cham.) DC.	Forget-me-not; Alpine	Boraginaceae
Erysimum asperum (Nutt.) DC.	Wallflower, Western	Cruciferae

APPENDIX A (continued)

LIST OF VASCULAR SPECIES ENCOUNTERED IN THE LOST CREEK STUDY AREA AND ON McCURDY MOUNTAIN

Species	Common Name	Family
FORBS (continued)		
Fragaria americana (Porter) Britt.	Strawberry	Rosaceae
Fragaria ovalis (Lehm.) Rydb.	Strawberry	Rosaceae
Fragaria virginiana Duch.	Strawberry	Rosaceae
Gaillardia aristata Pursh	Blanket-flower	Compositae
Galium boreale L. ssp. septentrionale (R. & S.) Hara	Bedstraw	Rubiaceae
Galium triflorum Michx.	Bedstraw, Fragrant	Rubiaceae
Gayophytum diffusum T. & G. ssp. parviflorum	Gayophytum	Onagraceae
Gentianella amarella (L.) Boern.	Gentian, Little	Gentianaceae
Geranium caespitosum James	Geranium, Common Wild	Geraniceae
Geranium richardsonnii F. & T.	Geranium, White	Geraniceae
Geum macrohyllum Wildenow	Avens, Large-leaved	Rosaceae
Gilia pinnatifida Nutt. var. calcarea Brand.	Gilia	Polemoniaceae
Hackelia floribunda (Lehm.) Johnston	False Forget-me-not	Boraginaceae
Heracleum sphondylium L. ssp. montanum (Schleich. ex Gaud.) Briquet	Parsnip, Cow	Umbelliferae
Heterotheca fulcrata (Pursh) Shinners	Aster, Golden	Compositae
Heterotheca horrida (Rydb.) Harms	Aster, Golden	Compositae
Heuchera parvifolia Nutt.	Alum-root, Common	Saxifragaceae
Hieracium fendleria Sch.-Bip.	Hawkweed	Compositae
Ipomopsis aggregata (Pursh) V. Grant	Gilia, Scarlet	Polemoniaceae
Iris missouriensis Nutt.	Iris, Wild	Iridaceae
Lesquerella montana (Gray) Wats.	Bladder-pod, Mountain	Cruciferae
Lewisia pygmaea (Gray) Robinson	Bitterroot, Pigmy	Portulacaceae
Liatris punctata Hook	Blazing Star	Compositae
Ligusticum porteri C. & R.	Lovage	Umbelliferae
Limnorchis hyperborea (L.) Rydb.	Bog-orchid, Northern	Orchidaceae
Linaria vulgaris Mill.	Butter-and-eggs	Scrophulariaceae

APPENDIX A (continued)

LIST OF VASCULAR SPECIES ENCOUNTERED IN THE LOST CREEK STUDY AREA AND ON McCURDY MOUNTAIN

Species	Common Name	Family
FORBS (continued)		
Linnaea borealis L. ssp. americana (Forbes) Hulten	Twin-flower	Caprifoliaceae
Lithospermum multiflorum Torr.	Puccoon, Many-flowered	Boraginaceae
Lloydia serotina (L) Sw.	Lily, Alp	Liliaceae
Lupinus argenteus Pursh	Lupine, Common	Leguminosae
Machaeranthera bigelovii (A. Gray) Greene	Machaeranthera	Compositae
Mahonia repens (Lindl.) G. Don	Oregon-Grape; Holly-Grape	Berberidaceae
Melandrium drummondii (Hook) Hulten	Campion	Caryophyllaceae
Mertensia ciliata (James) G. Don	Mertensia, Tall	Boraginaceae
Mertensia lanceolata (Pursh) A. DC.	Mertensia, Narrow-leaved	Boraginaceae
Mertensia viridis Nels.	Mertensia, Green	Boraginaceae
Mimulus gemmiparus W.A. Weber	Monkey-flower	Scrophulariaceae
Minuartia obtusiloba (Rydb.) House.	Sandwort, Alpine	Caryophyllaceae
Monarda fistulosa L. var. menthaefolia (Graham) Fern.	Bergamot, Pink	Labiatae
Moneses uniflora (L.) Gray	Wintergreen, One-flowered	Ericaceae
Oenothera caespitosa Nutt.	Evening-primrose, White Stemless	Onagraceae
Oenothera coronopifolia T. & G.	Evening-primrose, Cut-leaf	Onagraceae
Oenothera strigosa (Rydb.) Mack. & Bush	Evening-primrose, Common	Onagraceae
Oreochrysum parryi (Gray) Rydb.	Haplopappus	Compositae
Oreoxis alpina (Gray) C. & R.	Parsley, Alpine	Umbelliferae
Orthocarpus luteus Nutt.	Owl-clover, Yellow	Scrophulariaceae
Oxytropis lambertii Pursh X sericeae Nutt.	Loco, Colorado	Leguminosae
Oxytropis sericea Nutt.	Loco-weed	Leguminosae
Oxytropis splendens Dougl.	Loco, Showy	Leguminosae
Pedicularis grayi Nels.	Lousewort, Grays	Scrophulariaceae
Pedicularis groenlandica Retz	Elephantella	Scrophulariaceae
Pedicularis parryi Gray	Lousewort	Scrophulariaceae
Penstemon alpinus Torr. ssp. brandegei (Porter) Penland	Penstemon, Alpine	Scrophulariaceae
Penstemon linarioides A. Gray	Beard-tongue	Scrophulariaceae
Penstemon secundiflorus Benth.	Penstemon, One-sided	Scrophulariaceae

APPENDIX A (continued)

LIST OF VASCULAR SPECIES ENCOUNTERED IN THE LOST CREEK STUDY AREA AND ON McCURDY MOUNTAIN

Species	Common Name	Family
FORBS (continued)		
Penstemon virens Pennell	Beard-tongue	Scrophulariaceae
Phacelia hastata Lehm.	Scorpion Weed	Hydrophyllaceae
Pneumonanthe affinis (Griseb.) Greene	Gentian, Blue	Gentianaceae
Pneumonanthe calucosa (Griseb.) Greene	Gentian, Blue	Gentianaceae
Polemonium brandegei (Gray) Greene	Jacobs Ladder; Sky Pilot	Polemoniaceae
Polemonium delicatum Rydb.	Jacobs Ladder	Polemoniaceae
Polygonum engelmannii Greene	Knotweed	Polygonaceae
Polygonum sawatchense Small	Knotweed, Sawatch	Polygonaceae
Potentilla diversifolia Lehm.	Cinquefoil, Five-Finger	Rosaceae
Potentilla effusa Dougl.	Cinquefoil, Five-Finger	Rosaceae
Potentilla hippiana Lehm.	Cinquefoil, Woolly	Rosaceae
Potentilla pulcherrima Lehm.	Cinquefoil, Five-Finger	Rosaceae
Potentilla subjuga Rydb.	Cinquefoil, Five-Finger	Rosaceae
Primula angustifolia Torr.	Primrose, Alpine	Primulaceae
Pseudocymopterus montanus (Gray) C. & R.	Parsley, Yellow Mountain	Umbelliferae
Pterospora andromedea Nutt.	Pinedrops	Ericaceae
Pulsatilla patens (L.) Miller ssp. multifida (Pritzel) Zamels	Pasque Flower	Ranunculaceae
Pyrola chlorantha Swartz	Pyrola, Green-Flowered	Ericaceae
Pyrola minor L.	Wintergreen, Lesser	Ericaceae
Ramischia secunda (L.) Garcke	Wintergreen, One-sided	Ericaceae
Ranunculus inamoenus Greene	Buttercup	Ranunculaceae
Rhodiola integrifolia Raf.	Kings Crown	Crassulaceae
Rudbeckia hirta L.	Black-eyed Susan	Compositae
Rudbeckia laciniata L. var. ampla (Nels.) Cronquist	Cone-flower, Tall	Compositae
Saxifraga bronchialis L. ssp. austromontana (Weig.) Piper	Saxifrage, Spotted	Saxifragaceae
Saxifraga hyperborea R. Br. ssp. debilis (Engelm.) Love, Love & Kapoor	Saxifrage, Pygmy	Saxifragaceae
Saxifraga rhomboidea Greene	Saxifrage	Saxifragaceae
Scutellaria brittonii Porter	Skullcap	Labiatae
Sedum lanceolatum Torr.	Stonecrop	Crassulaceae
Senecio atratus Greene	Butterweed; Ragwort, Golden	Compositae

APPENDIX A (continued)

LIST OF VASCULAR SPECIES ENCOUNTERED IN THE LOST CREEK STUDY AREA AND ON McCURDY MOUNTAIN

Species	Common Name	Family
FORBS (continued)		
Senecio cernuus A. Gray	Butterweed; Ragwort, Golden	Compositae
Senecio eremophilus Rich. var. kingii (Rydb.) Greenman	Butterweed; Ragwort, Golden	Compositae
Senecio fendleri Gray	Butterweed; Ragwort, Golden	Compositae
Senecio fremontii T. & G. var. blitoides (Greene) Cronquist	Butterweed; Ragwort, Golden	Compositae
Senecio integerrimus Nutt.	Butterweed; Ragwort, Golden	Compositae
Senecio neomexicanus Gray var. mutabilis Greene	Butterweed; Ragwort, Golden	Compositae
Senecio werneriaefolius Gray	Butterweed; Ragwort, Golden	Compositae
Senecio wootonii Greene	Butterweed; Ragwort, Golden	Compositae
Sibbalia procumbens L.	Sibbaldia	Rosaceae
Silene acaulis L.	Moss-pink	Caryophyllaceae
Sisyrinchium montanum Greene	Blue-eyed Grass	Iridaceae
Smilacina stellata (L.) Desf.	False Solomon's Seal, Few Flowered	Liliaceae
Solidago canadensis L.	Goldenrod, Canada	Compositae
Solidago sparsiflora Gray	Goldenrod	Compositae
Solidago spathulata DC.	Goldenrod	Compositae
Stellaria calycantha (Ledeb.) Bong.	Chickweed	Caryophyllaceae
Stellaria laeta Rich.	Chickweed	Caryophyllaceae
Stellaria longifolia Muehl. ex. Willd.	Chickweed	Caryophyllaceae
Stellaria umbellata Turcz.	Chickweed	Caryophyllaceae
Streptopus amplexifolius (L.) DC.	Twisted-Stalk	Liliaceae
Swertia perennis L.	Gentian, Star	Gentianaceae
Taraxacum officinale Wiggers	Dandelion, Common	Compositae
Telesonix jamesii (Torr.) Raf.	Telesonix	Saxifragaceae
Thalictrum fendleri Engelm.	Meadow-Rue	Ranunculaceae
Thermopsis divaricarpa Nels.	Golden Banner	Leguminosae
Thlaspi arvense L.	Fanweed; Penny-Cress	Cruciferae
Thlaspi montanum L.	Wild Candytuft	Cruciferae
Tonestus pygmaeus (T.& G.) Nels.	Hapolpappus	Compositae
Tragopogon dubius Scop.	Salsify; Oyster-Plant	Compositae
Trifolium dasyphyllum T.& G.	Clover, Whiproot	Leguminosae
Trifolium nanum Torr.	Clover	Leguminosae
Trifolium pratense L.	Clover, Red	Leguminosae

APPENDIX A (continued)

LIST OF VASCULAR SPECIES ENCOUNTERED IN THE LOST CREEK STUDY AREA AND ON McCURDY MOUNTAIN

Species	Common Name	Family
FORBS (continued)		
Urtica dioica L. ssp. *gracilis* Ait.) Selander	Nettle, Stinging	Urticaceae
Vaccinium cespitosum Michx.	Bilberry, Dwarf	Ericaceae
Valeriana capitata Pallas *ex* Link ssp. *acutiloba* (Rydb.) F.G. Meyer	Valerian	Valerianaceae
Veratrum tenuipetalum Heller	Lily, Corn Husk	Liliaceae
Veronica wormskjoldii R.& S.	Speedwell, Alpine	Scrophulariaceae
Viola adunca Smith	Violet, Mountain Blue	Violaceae
Viola renifolia Gray var. *brainerdii* (Greene) Fernald.	Violet	Violaceae
Viola biflora L.	Violet, Twin-Flower	Violaceae
Zigadenus elegans Pursh	Death Camas	Liliaceae

APPENDIX B

Understory Cover Data

Key to species numbers found in data table.

1. Pyrola chlorantha
2. Pyrola minor
3. Ramischia secunda
4. Vaccinium cespitosum
5. Pneumonanthe calycosa
6. Geranium caespitosum
7. Scutellaria brittonii
8. Astragalus miser
9. Astratalus sparsiflorus
10. Acer glabrum
11. Oxytropis lambertii x sericea
12. Oxytropis splendens
13. Thermopsis divaricarpa
14. Betula glandulosa
15. Sambucus racemosa
16. Smilacina stellata
17. Arctostaphylos uva-ursi
18. Ribes aureum
19. Ribes cereum
20 Zigadenus elegans
21. Ribes leptanthum
22. Ribes montigenum
23. Jamesia americana
24. Juniperus communis
25. Oenothera caespitosa
26 Cercocarpus montanus
27. Pentaphylloides floribunda
28. Prunus virginiana var. melanocarpa
29. Rosa acicularis
30. Rubus deliciosus
31. Rubus parviflorus
32. Gilia pinnatifida
33. Salix bebbiana
34. Salix brachycarpa
35. Salix geyeriana
36. Salix phylicifolia

37. Salix scouleriana
38. Carex aquatilis
39. Polemonium delicatum
40. Bistorta bistortoides
41. Eriogonum alatum
42. Carex nova
43. Carex occidentalis
44. Carex petasata
45. Carex rossii
46. Polygonum engelmannii
47. Polygonum sawatchense
48. Androsace septentrionalis
49. Agropyron repens
50. Agropyron trachycaulum
51. Anemone multifida var. globosa
52. Aquilegia caerulea
53. Bouteloua curtipendula
54. Aquilegia saximontana
55. Bromopsis ciliata
56. Bromopsis lanatipes
57. Calamagrostis canadensis
58. Clematis columbiana
59. Delphinium ramosum
60. Festuca arizonica
61. Festuca brachyphylla
62. Festuca rubra
63. Koeleria macrantha
64. Leucopoa kingii
65. Muhlenbergia montana
66. Pulsatilla patens
67. Oryzopsis micrantha
68. Thalictrum fendleri
69. Poa agassizensis
70. Poa canbyi
71. Poa fendleriana
72. Poa glauca
73. Poa nemoralis ssp. interior
74. Sitanion longifolium
75. Acomastylis rossii ssp. turbinata
76. Trisetum spicatum ssp. majus
77. Drymocallis fissa
78. Equisetum arvense
79. Botrychium lunaria
80. Fragaria americana
81. Fragaria virginiana
82. Cystopteris fragilis
83. Potentilla diversifolia
84. Potentilla effusa

85. Potentilla hippiana
86. Muhlenbergia filiculmis
87. Adoxa moschatellina
88. Allium cernuum
89. Potentilla subjuga
90. Apocynum androsaemifolium
91. Sibbaldia procumbens
92. Mahonia repens
93. Galium boreale ssp. septentrionale
94. Cryptantha virgata
95. Galium triflorum
96. Heuchera parvifolia
97. Saxifraga bronchialis
98. Mertensia ciliata
99. Saxifraga rhomboidea
100. Campanula rotundifolia
101. Linnaea borealis ssp. americana
102. Arenaria fendleri
103. Melandrium drummondii
104. Minuartia obtusiloba
105. Silene acaulis
106. Telesonix jamesii
107. Stellaria laeta
108. Stellaria longifolia
109. Castillega miniata
110. Chenopodium atrovirens
111. Castilleja sulphurea
112. Achillea lanulosa
113. Agoseris glauca
114. Pedicularis parryi
115. Antennaria rosea
116. Arnica cordifolia
117. Artemisia frigida
118. Artemisia ludoviciana
119. Penstemon linarioides
120. Brickellia grandiflora
121. Cirsium coloradense
122. Erigeron compositus
123. Erigeron eximius
124. Erigeron flagellaris
125. Erigeron lonchophyllus
126. Penstemon secundiflorus
127. Erigeron subtrinervis
128. Erigeron vetensis
129. Gaillardia aristata
130. Heterotheca fulcrata
131. Heterotheca horrida
132. Hieracium fendleri
133. Penstemon virens

134. Machaeranthera bigelovii
135. Oreochrysum parryi
136. Aletes anisatus
137. Conioselinum scopulorum
138. Ligusticum porteri
139. Senecio cernuus
140. Senecio eremophilus var. kingii
141. Senecio fendleri
142. Pseudocymopterus montanus
143. Rubus idaeus ssp. melanolasius
144. Senecio neomexicanus var. mutabilis
145. Senecio werneriaefolius
146. Senecio wootonii
147. Chamerion angustifolium
148. Solidago sparsiflora
149. Solidago spathulata
150. Taraxacum officinale
151. Tonestus pygmaeus
152. Unknown Graminoid
153. Moss
154. Lichen
155. Arabis divaricarpa
156. Poa nervosa
157. Chimaphila umbellata ssp. occidentalis
158. Arabis drummondii
159. Arabis hirsuta
160. Arabis holboellii
161. Moneses uniflora
162. Carex sp.
163. Draba aurea
164. Draba streptocarpa
165. Erysimum asperum
166. Mertensia viridis

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SPECIES NUMBER

NUM	SUM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
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31	141	0	1	10	51	0	0	0	0	0	39	0	0	12	0	1	0	0	0	0	0	0	0	0	4	0	0	0	0

[illegible]

PAGE 2

SPECIES NUMBER

QUAD	TOT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
32	41	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	21	0	1	0	0
33	47	1	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	1	0	0	0	0	1	0	33	0	0	0	0
34	172	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	1	0	0	0	0	21	30	0	20	0	0
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60	57	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	3	0	0	0	0	0	1	16	0	0	0	0
		1	0	45	52	1	42	2	40	2	119	1	5	38	17	1	19	217	1	21	4	12	[illegible]	[illegible]	677	1	41	205	4

[illegible]

[illegible]

DAY	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	40	41	42	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	108	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	52	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	173	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	173	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	71	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	150	[illegible]	74	[illegible]	11	[illegible]	[illegible]	[illegible]	13	[illegible]	24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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NUM	[illegible]	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
32	41	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
33	67	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	177	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	1	0	0
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36	93	1	0	0	0	4	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
37	167	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
38	77	2	0	0	0	1	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	2	0	4	0	0	0	0
39	147	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	336	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0
41	157	0	0	0	0	0	0	1	0	0	0	0	0	0	0	4	0	0	0	0	0	3	0	0	2	0	0	0	0
42	101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	1	0	0	0	0
43	285	43	5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	4	0	0	17	0	0	0	0
44	47	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0	0	0	0
45	832	0	0	1	0	0	0	1	0	2	0	0	7	0	0	0	0	1	7	0	0	9	1	0	1	0	0	0	0
46	91	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
47	137	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	[illegible]	0	0	0	0
48	147	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	7	0	0	0	0
49	154	0	0	0	0	0	0	0	0	91	0	0	0	0	0	0	0	0	0	0	0	27	0	0	7	0	0	0	0
50	81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
52	53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	7	0	0	0	0
53	72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
54	43	0	0	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0
55	87	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	5	0	0	1	0	0	0	0
56	113	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
57	298	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
58	74	2	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	7	0	0	0	0	0	0	0
59	23	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
60	67	0	1	0	1	0	0	0	0	0	0	0	1	1	0	2	0	0	1	0	0	1	0	0	0	0	0	0	0
		[illegible]	6	1	37	13	1	4	2	152	1	2	2	1	1	1	-	6	3	2	6	72	1	1	146	1	2	2	[illegible]

[illegible]

PAGE 7

SPECIES NUMBER

NUM	SIZE	[illegible]	44	27	[illegible]	[illegible]	47	41	42	18	[illegible]	35	36	37	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112
32	87	[illegible]	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
33	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	139	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	128	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	[illegible]	0	0	0	0	0	0	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	168	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
38	77	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
39	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	132	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	601	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	[illegible]	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
44	47	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	338	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	1	1	0	0	0	0	0	0	4	0	11
46	731	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0
47	1017	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	147	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	159	0	0	0	0	0	0	0	0	0	1	0	0	17	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
50	71	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	128	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
52	41	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
53	78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
55	47	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
56	582	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
57	[illegible]	0	0	0	0	0	14	0	14	0	0	24	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	7
58	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	1
59	270	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
60	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		25	2	1	[illegible]	53	13	1	14	11	[illegible]	24	1	47	3	11	10	13	55	5	5	1	7	4	1	7	6	14	45

[illegible]

[illegible]

SPECIES NUMBER

[illegible]	SUM	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
1	[illegible]	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	125	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	474	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
4	115	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1
5	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	103	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	73	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
8	35	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	52	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
11	179	0	0	11	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	146	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
13	135	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	279	0	0	1	0	1	1	1	1	0	2	0	0	0	0	0	1	0	0	7	0	0	0	0	0	0	0	0	0
15	173	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	155	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	11	0	0	1	0	1	4	0	0	0	0	0	0
17	274	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
18	141	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	53	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
25	81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
26	147	0	0	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
27	525	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	1356	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
29	75	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	77	0	0	0	1	0	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	181	0	0	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

[illegible]

PAGE 10

SUM	[illegible]	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
32	91	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	172	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	174	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	93	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	162	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	142	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	218	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	152	0	0	0	0	1	4	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	101	0	0	0	0	0	0	0	0	0	0	4	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	99	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	47	0	0	1	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
45	332	0	*1	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	31	0	0	0	1	0	0	0	0	0	0	10	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
47	107	0	0	0	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
4	142	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
49	149	0	0	1	0	1	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
50	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	135	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	77	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	93	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
55	87	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
56	152	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
57	292	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
58	73	0	0	4	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	0	0	0	0	0
59	23	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	42	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
		1	27	52	21	5	21	5	4	12	18	107	1	1	3	9	31	1	2	15	1	11	1	4	3	1	1	1	1

[illegible]

[illegible] 13

SPECIES SUMMARY

ROW	SUM	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166
1	344	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	9	0	0	0	0	0	1	0	1	0	0
2	139	0	1	0	17	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	5	0
3	171	0	1	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
4	114	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
5	63	0	5	0	0	2	6	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
6	109	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1
7	77	1	0	0	0	0	0	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	7
8	34	0	8	0	0	1	0	0	0	4	0	0	0	0	0	1	0	0	1	0	0	0	2	0	1	0	0
9	9	0	5	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0
10	28	1	4	0	0	1	1	3	0	5	0	0	0	0	0	1	0	0	0	0	0	0	6	0	0	0	0
11	176	0	9	0	0	1	0	4	4	42	0	0	0	0	0	1	0	0	0	0	0	0	27	0	1	0	0
12	164	0	0	1	61	0	0	12	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
13	339	0	0	0	77	0	0	25	0	1	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	776	1	0	1	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	0	0	0
15	173	0	0	0	33	0	0	1	4	2	0	0	0	0	0	1	0	0	0	0	1	0	7	0	0	0	0
16	159	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	4	0	0	0	0
17	776	0	0	1	0	0	0	1	0	0	0	0	4	0	0	0	0	0	0	0	0	0	1	0	1	0	0
18	141	0	0	0	17	1	0	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	17	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0
20	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0	1	0	0
21	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0
22	54	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
23	13	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
24	34	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	10	0	1	0	0
25	74	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	3	1	1	0	0
26	147	0	0	0	0	1	0	7	0	21	0	0	0	0	0	4	0	0	0	0	0	0	13	1	1	0	1
27	536	0	0	0	0	0	0	1	0	7	1	0	15	0	0	1	0	0	1	0	0	0	0	0	1	0	0
28	155	1	0	0	0	0	0	1	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
29	79	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
30	77	0	0	0	0	1	0	1	0	1	0	0	1	0	0	1	0	0	0	0	0	0	1	0	1	0	0
31	131	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0

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EAST CREEK [illegible]

                                              PAGE 12

                                SPECIES NUMBER
NUM   SUM  141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166
 32    41    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   0   0   0   0
 33    52    0   0   0   0   0   0   1   0   0   0   0   0   0   0   0   0   0   0   0   0   1   1   0   0   0   0
 34   12?    1   0   0   0   0   0   3   0   1   0   0   0   0   0   0   0   0   0   0   0   0   1   0   0   0   0
 35   134    0   0   0   0   1   0   0   0   1   0   0   0   0   0   0   0   4   0   0   0   0   0   0   0   0   0
 36    32    1   0   0   0   0   1   0   0   1   0   0   0   0   0   0   0   0   0   0   0   0   2   4   1   0   0
 37   152    1   0   0   0   0   0  13   0   1   0   0   0   0   0   0   0   0   0   0   0   0   0   1   0   0   1
 38    77    4   0   1   0   0   1  13   0   1   1   0   0   0   0   1   0   0   1   1   0   0   0   0   1   0   3
 39   142    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
 40   132    0   0   1   0   1   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   3   0   0   0   1
 41   152    2   0   0   1   0   0   1   0   1   0   0   0   0   0   1   0   0   0   0   0   0  14   0   0   0   0
 42   101    0   0   0   0   0   0   0   0   0   0   0   1   0   0   0   0   0   0   0   0   0   1   0   0   0   0
 43   2[illegible]    0   2   0   1   0   0  21   0   0   0   0   0   0   0   1   0   0   0   0   0   0   2   0   0   0   0
 44    47    0   0   0   0   0   0   0   0   1   0   0   0   0   0   1   0   0   0   0   0   0   7   0   1   0   0
 45   132    1   0   0  20   0   0   7   0   1   0   0   0   0   0   1   0   0   0   0   0   0   0   0   0   1   1
 46    91    0   0   0   1   0   0   1   0   1   0   0   0   0   0   0   0   0   0   0   0   0   1   0   0   0   0
 47   107    0   0   0  13   0   0   1   0   0   0   0   4   0   0   0   0   0   0   0   0   0   6   0   1   0   1
 48   141    0   0   0  13   0   0   2   0   1   0   0   1   0   0   1   0   0   0   0   0   0   1   0   1   0   0
 49   161    1   0   0   0   0   0   0   0   0   0   0   0   0   0   1   0   0   0   0   0   0   8   0   1   0   1
 50    71    0   0   0   0   0   0   2   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   0   0   0   0
 51   126    0   0   0   1   0   0   1   0   2   0   0   1   0   0   0   0   0   0   0   0   0   1   0   0   0   0
 52    43    0   0   0   0   0   0   0   0   2   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
 53    72    0   0   0   0   0   0   0   0   0   0   0   1   0   0   0   0   0   0   0   0   0   1   0   0   0   0
 54    91    0   0   0   0   0   0   0   7   0   0   0   0   0   0   0   0   0   0   0   0   0   1   0   0   0   0
 55    87    1   0   0   0   0   0   0   1   1   0   0   0   0   0   1   0   0   0   0   0   0   1   0   1   0   0
 56   1?2    0   0   0   0   0   0   0   0   1   0   0   0   0   0   0   0   0   0   0   0   0   1   0   0   0   0
 57   29?    0   0   1   0   0   0   0   0   1   1   0   7   0   0   1   0   0   0   0   0   0   0   0   0   0   0
 58    78    4   0   0   0   0   0   0   0   1   0   0   1   0   0   1   0   0   0   0   0   0   9   0   1   0   0
 59    23    1   0   0   0   0   0   0   0   1   0   0   0   0   0   0   0   0   0   0   0   0   1   0   0   0   0
 60    42    0   1   0   0   0   1   0   0   1   0   0   0   0   0   1   0   0   0   1   0   0   1   0   0   0   0

            21   6   7 270  12   5 168   8 122   5   2  37   0   0  27   1  20   3   1   2   2 162   2  22   1  12
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