SOME ASPECTS OF THE ECOLOGY OF THE BRYOPHYTES IN THE THREE SISTERS PRIMITIVE AREA

by

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SOME ASPECTS OF THE ECOLOGY OF THE BRYOPHYTES IN THE THREE SISTERS PRIMITIVE AREA

INTRODUCTION

The Three Sisters Primitive Area, 247,000 acres including the western section, was established in 1939. It was situated in a region bounded on the north by the McKenzie River, on the west and south by the South Fork of the same river, and it extended eastward some 25 miles from the three peaks for which the area was named. The western or Olallie section, 53,000 acres, was reclassified in 1955 for multiple use and the remainder of the Primitive Area was designated as the Three Sisters Wilderness Area. Since the study concerns portions of the original Primitive Area, the term, "Three Sisters Primitive Area", has been retained in this paper.

Most of the area covered by the study lies in the Willamette National Forest; the portion east of the peaks is in the Deschutes National Forest. The parts of this large area are accessible only by trails because its primary purpose is for wilderness recreation. The principal trails are: the Oregon Skyline extending north and south on the west side of the peaks; the Green Lakes on the east side which parallels the Skyline; Horse Creek and Park, traversing the Horse Lakes-Horse Creek section; Foley Ridge, entering the high country from the west; and Olallie, coming into the western section from Foley Springs Road and leaving at Frissell Crossing on the South Fork. There are also a number of trails from the South Fork, most of which

extend into Olallie Trail.

Topographically, there are three different regions in the Primitive Area. One is the western section (Olallie) of the original Three Sisters Primitive Area, now designated as Horse Creek Timber Management Area. It is characterized by steep ridges with Olallie Trail zig-zagging up to the crest, then proceeding along the hillsides and over the saddles between ridges and peaks. Horse Pasture Mountain, 5668 feet, and Olallie Mountain, 5708 feet, are in this part. The soil is of rather heavy texture and subject to erosion. The constant shift in slope and exposure complicate vegetation analysis. The Horse Lakes-Horse Creek area, bounded by Horse Creek Trail on the northeast and by Park Trail on the south, is characterized by much more gradual slopes. The 5000-5500 foot, plateau-like section, traversed by Park Trail, is poorly drained and is covered by a forest including spruce. Horse Mountain, 6223 feet, is near the eastern end of this section. The third area is the high country, ranging from 5500 to 7000 feet. It includes the stands of the upper part of Foley Ridge Trail, Husband Lake and Skyline Trail, Sisters Mirror Lakes and Green Lakes. This is relatively level country and there is much pumice-covered ground.

Annual rainfall in the section west of Horse Creek, the Olallie area, is 60 inches. It increases to 80 inches in the Horse Creek and Horse Lakes area, to 90 inches along Skyline Trail and to 100 inches on the Three Sisters. The rainfall decreases to the south of Horse Creek and, much more markedly, to the east of the Sisters.

In the Horse Creek drainage area, the timber surveys for the Willamette National Forest show 58,000 acres of D3 site timber, which is between 100 and 200 years old, only 8,000 acres of D2 site timber or pole stands, and 100 acres of D1, young trees. This indicates that there have been no serious fires in recent times. The massive, fire-scarred Douglas firs, seen in many parts of the area, are vestiges of the forest preceding this old fire. 37,000 acres of D4 and D5 site classes, 300 years old, include the old Douglas fir, the mature mountain hemlock and the silver fir.

Before 1957, the only formal biological work carried on in the Three Sisters Primitive Area was that of Hopson (1946) on the valley of the McKenzie River. She studied the geomorphology, the higher plants and the vertebrates, except fish. The purpose of her study was to compile information that would be useful to various educational interests (43, p. 5-10). In 1957, National Science Foundation grants to Oregon State College provided funds for biological studies in the Three Sisters Area. The field work in the botanical studies was under the direction of Dean H. P. Hansen of the Graduate School with Dr. John Merkle as research associate and George Van Vechten as research fellow. Under this NSF grant, Van Vechten studied the ecology of the vegetation of timberline and alpine regions of the Three Sisters and wrote his doctoral thesis on this research (87).

Bryophytes have not been included in any of the studies in the Three Sisters Primitive Area. Lack of information about this interesting plant group in such a large and undisturbed area was one

of the primary factors that led to the choice of this research. Correlating the bryophyte species with particular habitats, identified both by topographic data and by the vegetation, especially the tree species, has developed the ecological aspects of this study. This has resulted in a much more significant type of investigation than a check list of the species would be. An added incentive to work in this area was the reclassification of the western section, which opened it to logging. Since bryophytes are especially sensitive to microclimatic changes, it was desirable to make some records of their distribution before the habitats had been disturbed.

REVIEW OF THE LITERATURE

The scarcity of research in the northwest on the ecology of bryophytes, in contrast to the rich bryophyte flora of the area, favors a rather extensive review of the literature. The areas covered by this review are: studies of correlation of bryophyte growth with particular plant communities; forest community studies in which bryophytes are included; forest studies of practical value, such as those on forest site classification, forest management and tree regeneration; studies of corticolous bryophytes; bryophyte community studies; studies of succession in forests, on sand, on rock, and on tree trunks; and autoecological studies.

Correlation studies. The paper most pertinent to the research in the Three Sisters Primitive Area is that of Higinbotham and Higinbotham, who worked in the relatively favorable bryophyte habitats of the eastern portion of Mt. Rainier National Park. They concluded that each tree community, tentatively considered as climax, appears to have a characteristic bryophyte layer with one or two moss species predominant. Thus, the *Pseudotsuga menziesii* community is characterized by *Eurhynchium oreganum*, *Rhytidiadelphus triquetrus* and *Hylocomium splendens* and the *Abies amabilis-Tsuga mertensiana* community by *Dicranum fuscescens* (41, p. 158-159). Two other studies, with much less emphasis on bryophytes, are those of Cooke in northern Idaho and eastern Washington and of Tisdale and McLean in British Columbia. In the former, the correlation of fungi, lichens and mosses

with grassland, shrub and forest communities was determined. The bryophyte communities were indicated and the species listed separately for different habitats in each association (22, p. 176-177). In southern interior British Columbia, a poorly developed layer of species of Brachythecium, Cladonia and Peltigera occurs in the Pseudotsuga/Calamagrostis association (86, p. 265).

Forest community studies in which bryophyte species are included. Harshberger found a heavy cover of Polytrichum and Hypnum spp. on the trees and the ground in Picea mariana and Abies fraseri forests of North Carolina, with abundant Polytrichum commune about old stumps on grassy balds (36, p. 376-378). Dirks-Edmunds, comparing the biotic communities of western cedar-hemlock and eastern oak-hickory, noted the six centimeter thick mats of Hylocomium splendens and Rhytidiadelphus loreus on the logs and the ground in the western forests (28, p. 238).

Three papers by Oosting and Billings include studies of Ravenel"s woods, of Sierra Nevada red fir, and of virgin spruce-fir forests of the north and south Appalachians. Bryophytes in the eastern oak, birch, chestnut and hemlock forests show a 70% frequency (59, p. 342) but mosses are rare, except in very damp places, on rotting wood or at tree bases, in the western red fir forest (60, p. 273). Seven species of bryophytes are common to both the north and south Appalachians, fifteen are found only in the south, and nine only in the north. These differences with respect to

bryophytes reflect the differences in humidity, snow cover and soil characteristics of the two areas (61, p. 101-102).

Oosting and Reed reported that mosses occur regularly in the virgin spruce-fir forests in the Medicine Bow Mountains in Wyoming but less abundantly than in the Appalachian spruce forests (62, p. 88). Brown mentioned Polytrichum commune as the dominant species in some stands on Roan Mountain in the southern Appalachians (12, p. 84). In the spruce-fir-birch forests of northern Minnesota, Buell and Niering found a well-developed layer of Calliergon schreberi (14, p. 609).

Bryophytes in forest studies of practical value. The work on forest site type classification in Europe centered around that of Cajander in Finland in the early part of the twentieth century. His classification scheme was based on the concept that exploitable stands of normal density are made up of site species that reflect the primary site factors (17, p. 24-26). Five forest classes were listed with types given under each. The Hylocomium-Myrtillus or HMT, one of the types in the moist land class, is characterized by Norway spruce, Scots pine and birch, dry peat humus, abundant shrubs and a fairly abundant, continuous moss cover (17, p. 35-38). This system has been the basis of silvicultural practices in Finland.

Brinkman based his work in Alberta, Canada on that of the Finnish School of Forestry. He observed that the lowest hepatic content marks a readily-drained gravel, an intermediate hepatic content is on sandy loam, and the highest hepatic content indicates clay loam soil, holding more moisture. Thus the hepatic flora, he concluded,

directly indicates humidity and indirectly the nature of the soil (10, p. 29-30). Rowe, in a study in 1956, also decided that soil moisture is the most important determinant of growth. He constructed a vegetation table, classifying the forests into groups from very dry to wet. The extent of each layer, trees, shrubs, herbs, mosses and lichens, across this moisture gradient was shown. The VMI or vegetation moisture index was determined for each group of forests. Until more is known about the comparative responses to moisture of different forest species, these indexes cannot be used as indicators of site types (78, p. 463-466).

Heimburger found too few mosses in the Adirondack forests, except in the subalpine area, to use them to indicate site quality. He designated three types, one of which, the Hylocomium-Cornus with balsam fir, black spruce and dense mats of feather mosses, is comparable to the HMT in Finland (37, p. 23-26).

There are three forest site classification studies covering extensive areas of the northwest which include bryophytes among the plant indicators. Spilsbury and Smith (1947) described the Polystichum site type, for example, by saying that it includes: any three of the Liliaceae; any three of these ferns, sword, deer, lady and maiden hair; any three of these mosses, Eurhynchium oreganum, Hylocomium proliferum, Rhytidiadelphus triquetrus and Mnium spp.; and 40% frequency of Mnium spp. on the ground and logs (83, p. 22-25). At the other extreme in forest sites is the Gaultheria-Usnea type with few, depauperate Polystichum; no lilies; Hypnum circinale

and Polytrichum on the ground and Dicranum, rather than Mnium, on the logs (83, p. 31).

Becking (1954) was interested in second growth management of Douglas fir in small woodlots. He considered the wild ginger-sword fern-Douglas fir, with moss sparingly present, as the highest Douglas fir site type. In lowland salal-Douglas fir, considered as fair to poor Douglas fir site, Eurhynchium oreganum covers the soil and rotten logs but is missing under the salal (1, p. 50-70). Site was not classified on the basis of plant indicators alone in the University of British Columbia forest survey (1959). The Douglas fir-moss forest association of the east coast of Vancouver Island was described in this way: soil fairly fertile because of lateral flow of ground water; topography marked by steep slopes and gullies; hemlock, red cedar, grand fir, broad-leaf maple, and red alder as the tree species; scant herbs with many saprophytic species; and a moss cover of Hylocomium splendens and Eurhynchium oreganum (11, p.583).

There have been four recent forest management studies in which bryophytes were involved. Two of these concerned the New Jersey pine region. Buell and Cantlon (1955) reported that winter burning favors the more economically valuable pine over oak. But moss is also favored by this practice and an abundant cover of this plant intercepts rainfall (13, p. 523-524). Moul and Buell emphasized this by saying that, if the moss mats under pine dried out between showers, they could prevent 50% of the water from reaching mineral soil (55, p. 161).

Paulsell (1957) also found that periodic burning increases the moss cover in the Ozark hardwoods. This hinders oak seedling regeneration and the accumulation of hardwood litter (67, p. 22). Johnsen (1959) said that removal of litter by burning should result in an increase in bryophytes. Actually, however, this practice accelerates erosion, increases soil water evaporation and causes temperature variation -- all conditions that are harmful to bryophytes. Raking, on the other hand, offers fresh substrate for moss because the soil is disturbed (45, p. 39-40).

Mosses are both favorable and unfavorable for conifer regeneration depending upon tree species, bryophyte species and environmental factors. Germination of conifer seeds and survival of the seedlings may be affected. Engelmann spruce in British Columbia germinates and grows best on mineral soils and rotten wood and most poorly on moss and litter (64). In southeastern Alaska, one-fifth as many seeds of hemlock, spruce and cedar germinate on moss as on mineral soil and survival value is 28% lower (32, p. 1). Seeds of Abies alba germinate in Hylocomium triquetrum but seedlings die back after one year, if the moss layer is more than ten centimeters deep (72). Moss serves as a mechanical barrier, preventing seeds of hemlock, spruce and cedar in southeastern Alaska forests from reaching the moist seed bed. Or, if seeds get down to the soil, the germinating seedlings may be prevented, by the moss layer, from reaching the surface (32, p.1).

The ability of seedlings to survive may be a matter of

whether the roots can get to the soil. Abies lasiocarpa is able to establish itself on moss and litter because of greater initial root penetration and hypocotyl growth (82). The falling seeds of eastern white pine filter among the vertical Polytrichum commune plants, then germinate and grow rapidly because their roots get to the mineral soil readily (81, p. 48). Spruce seed, on the other hand, if shed on snow, lodges on the moss when the snow melts so that, as germination occurs, the radicle seldom reaches the soil (56).

Competition, especially for moisture, between the bryophytes and the seedlings may be involved. In Norway so few spruce seedlings are found on moss that its removal in patches, to reduce the unfavorable effect on moisture, is recommended (53). Seedlings of spruce may be protected from physical agencies in drier sites by the moss but competition may occur between the seedlings and the moss (56). Since the Polytrichum commune gets its moisture from air, there is no root competition with the eastern white pine seedlings (81, p. 48).

Moisture content in the moss around seeds and seedlings may be lowered by climatic factors, thereby affecting germination and seedling survival. In southeastern Alaska, the 100-117° F. temperature in the moss results in a reduction to 31% moisture content around the exposed seed or seedling roots, even shortly after rains (32, p. 1). Feather moss and Dicranum, which are shade mosses that dry badly after logging, form critically dry seed beds

for black spruce in Minnesota in drouth periods. Sphagnum, on the other hand, is very good for regeneration because of its water-retaining capacity (38, p. 1-2). In eastern white pine, however, the rapid drying out of moss in direct sunlight is considered as beneficial. The irregular surface thus formed loses heat so quickly that lethal temperatures do not occur (81, p. 48).

Moss may help in the establishment of seedlings. This occurs in Indiana deciduous forests, where hemlock seedlings can grow on steeper slopes having sufficient moss or other floor covering to provide them with lodgment (29, p. 143).

Studies on corticolous bryophytes. Epiphytic mosses are recognized as sensitive microclimatic indicators. Since, however, the microclimate is more sensitively balanced than the macroclimate, the controlling factor determining the distribution of the epiphytes cannot always be isolated (70, p. 54-58). The presence of a particular species of epiphyte on a given host depends upon both the micro- and macroclimatic conditions. The former are determined largely by the surface conditions on the host and the latter by rainfall. More important than annual precipitation in the Olympics, as a factor in the distribution of epiphytes, is the time that the rain appears with respect to spore and gamete distribution (20, p. 75-76).

To study variation in pine-inhabiting cryptogams, especially with respect to altitude, Culberson used a belt transect 435 miles long and ten miles wide across North Carolina from east

to west. He found that the number of species increases from the ocean to the upper coastal plain. The species count drops in the sandhills but increases again throughout the piedmont and into the mountains, where as many as ten species per quadrat may occur. Substrate factors are also involved because two trees of different pine species, growing closely together, support greatly different average numbers of species per quadrat (27, p. 24-28).

There is some disagreement as to conclusions concerning correlation of bark-inhabiting bryophytes and forest tree climaxes. Phillips said that the bryophyte climaxes are more widely distributed than are the tree species. This is true because certain combinations of habitat conditions that can be tolerated by a given bryophyte community, occur in forests of different species (68, p. 313-314). Culberson arranged the environmental conditions, which determine the succession from pioneer to climax forest communities in northern Wisconsin, on a gradient. When the distribution of bark communities in the same region was also arranged on a gradient, gross correlation between the two gradients was evident (25, p. 230).

Both Phillips and Culberson emphasized that chance or the historical factor may be involved in distribution of corticolous bryophytes. In the case of two trees, side by side in the same habitat, one may lack bryophytes, probably because it received no spores (68, p. 313-314). Insufficient time to migrate from northern to southern Wisconsin may account for the absence, in forests of the latter section, of the boreal element of the bark-inhabiting

cryptogams, characteristic of the northern forests (26, p. 229-230).

Bryophyte communities. There are some basic concepts, given by Herzog, which may well serve as an introduction to this part of the review. Individual mosses, he said, are usually found with others of the same species in a particular species union. Associations, on the other hand, are of different species usually. Pure moss formations occur only where other plant growth is reduced as on bare rock, on high moor and on moist tundra. Since the substrate determines the lack of higher plants and the characteristics of the moss formation, one should speak of a formation of rock cliffs, rock slides, rolling rock, etc. Usually, however, the plant formation names of higher plants, such as beechwoods and high moor, are used.

The analysis of bryophyte communities in a red maple swamp forest is difficult because of their fragmentary nature and the involved microhabitats, according to Cain and Penfound. The concepts of community structure, such as dominance and minimal area, cannot be applied readily (15, p. 400). In the Great Smoky Mountains, Cain and Sharp were able to arrange 23 of the 34 bryophyte communities, found in the forest associations of the cove hardwood and subalpine forest types, into two alliances, ten unions and fourteen facies (16, p. 266-271). Phillips established four bark bryophyte unions in southern Ireland. The most characteristic species of each union, the one with high fidelity to a given union on the basis of higher cover and greater constancy, was named (69, p. 24-31).

Absence of bryophytic unions on the ground and the presence of epiphyllous bryophytic unions, with hepatics as common dominants, distinguishes tropical rain forest from deciduous and coniferous forests of temperate regions, according to Richards (77, p. 327).

To determine community structure, Hale analyzed possible mathematical combinations of eleven different species of cryptogams on the same individual of oak. A combination of four particular species, all lichens, occurred on 50% of the oak trees in the openings. Five other cryptogamic species occurred more frequently on 99% of the oak trees in the woods. This indicated that there are two different cryptogamic communities, one in the oak openings and one in the oak woods (35, p. 60-62).

Studies of Succession. Cooper observed that, in the evolution of xerophytic forest on Isle Royale in Michigan, the forest mosses, such as Calliergon schreberi and Hylocomium proliferum, precede the forests. They invade the Cladonia mats, shutting off the light and air and superseding the lichens (23, p. 201-204). The pattern of succession after fires in Maine, Jamaica and England begins with Marchantia polymorpha, a long-day plant that tolerates acidity and grows well on cinders. It is usually accompanied by Polytrichum spp. or Funaria hygrometrica. Within two to five years, the Marchantia is crowded out by the mosses, except in the moister, more shaded areas (80, p. 186-188).

Some degree of stabilization is necessary for a succession of bryophytes to occur on sand. Scant mosses are present on the beaches in the Chicago area where wind and water move the sand and the evaporation rate is high. On the foredunes, where Populus, Prunus and Salix obstruct the sand and evaporation is less, the mosses may be present as cushions. In the oak dune stages, except on north slopes, sand or sediment cover prevents yearly regeneration and entrance of mosses (85, p. 455-466). Richards agreed that mosses cannot enter a dune area until the dunes are stabilized; this is accomplished on the Norfolk, England beaches by flowering plants. When a typical hypnoid species is buried by sand, the main stem grows forward, forming a tuft of new, vertically growing branches. (74, p. 131).

Cooper listed these stages in the rock shore succession on Isle Royale in Michigan: crustose lichens and Grimmia ovata; foliose lichens and Hedwigia; then fruticose lichens with mosses infrequent because of the competition offered by the tall and spreading lichens (23, p. 199-204). When he revisited this area after seventeen years and compared photographs, he thought that the mosses may have extended their areas a little (24, p. 3-4).

Sharp also commented on the very slow colonization of bryophytes on rocks. Lichens may appear first, to be followed by bryophytes, or the reverse may occur (79, p. 326). Parsitism of the moss by lichens may explain why lichen-moss sequence is not always carried out (50, p. 325). Where seepage of moisture

occurs, liverworts may be pioneers (85, p. 471-474); in Tennessee cedar glades blue-green algae occue first on unshaded rocks (71, p. 240).

In screes, small quiescent areas are formed in front of blocks around which rock fragments slide. There the cushions of Rhacomitrium spp. act as beds for the germination of parsley fern spores (47, p. 323-326). Cryptogamic species in the minor depressions in granite are endemics because of the extreme conditions (58, p. 751-757). The pH of rocks determines the pioneer plants. On alkaline limestone, Grimmia apocarpa appears first, but on acidic sandstone, Fissidens spp. are pioneers (31, p. 92-93).

Open, pioneer boulder communities of mosses are made up of small plants with many rhizomes. The small, closed community, the plants of which lack these anchoring structures, cannot establish itself on the steep sides of boulders but it can invade the open, pioneer communities. The reverse cannot occur because the small, closed community, when anchored, can shade out the others (76, p. 114-115).

Young trees have no bryophytes because the bark is too smooth. As soon as fissures appear, acrocarpous mosses form tufts, each attached at one point. Pleurocarpous mosses require several points of attachment and come in when the bark is cracked a good deal. They rapidly crowd out the acrocarpous species by greater power of vegetative reproduction, except on windy sites (57, p. 340-342).

To determine succession on tree trunks, Phillips staked out permanent quadrats on ten pairs of young and older trees, side by side. He found the hepatic, Frullania, as a pioneer, sometimes persisting but usually followed by acrocarpous moss species, then by the pleurocarpous species (68, p. 315).

Autoecological studies. Field ecology constantly faces questions of why plants grow as they do and why they grow where they do. Since there are many of these questions posed in the Three Sisters Primitive Area study on bryophytes, a brief section on autoecological literature is included. This shows how few, creditable pieces of work have been completed.

The detailed study of a particular bryophyte species, Hylocomium splendens, by Tamm is the only paper of this sort in the literature, available by reason of translation from the Swedish. An enumeration of the fields of study with respect to Hylocomium provides some idea of his thoroughness. His studies dealt with: seasonal growth curves and variations in growth; variations in production and structure of the Hylocomium community caused by light and humidity; the nutrient content of Hylocomium and its manner of nutrient uptake; the supply of plant nutrients to the moss carpet; behavior of the plant with respect to environmental factors, such as water, CO_2 concentration, temperature, exposure to sun, litter fall and pH; and factors determining the structure of the Hylocomium community. Although this study can serve as a model for others, he cautioned that it is unsafe to generalize from one

species to others (84).

In an introductory study, Gimingham and Birse determined that a moss community will have a characteristic growth form in the conditions ecologically favorable for the species (30, p. 543). Birse then tested the reproduction of ten growth forms of 21 different species under different combinations of light and humidity. With high humidity, regardless of light, most species showed erect growth; low humidity, especially with high light, resulted in prostrate shoots in mats. Some species have a high degree of plasticity so that they produce either the erect or prostrate forms with differences in light and humidity (3, p. 722-725). In the study on effect of ground water supply, tall turfs with divergent branches were found to dominate wherever the water table is always near the surface. Tall turfs with erect branches, short turfs and rough and smooth mats never occur in reach of the water table (4, p. 22-24). Growth form also reflects conditions of illumination; the weft occurs where illumination is 5-13% whereas the thread form occurs at 1% illumination (5, p. 40).

Rapid water movement occurs on the outer surfaces of most moss plants, according to Bowen's introductory study. The movement varies in speed with the form and arrangement of the leaves and the habit of the plant (6, p. 177-178). In mosses of wet environments, conduction is most rapid on the outside with very little internal movement (7, p. 421). Mosses of damp habitats are variable, some with well-developed central strands depending upon internal

conduction primarily (8, p. 659-660). Mosses, of dry habitats, such as Polytrichum commune, show certain morphological modifications, such as strongly decurrent leaf bases, and they are tufted in nature (9, p. 909).

Henry (1929), using different light intensities with temperature and humidity kept as in natural conditions, found some moss species are totally modified and others not (39, p. 84). Ikenberry (1938) worked on pH and determined that spores of a moss germinate over a wider range than the species needs for growth (44, p. 273-278).

METHODS

The field work of this study occupied the summers of 1957, 1958 and 1959 with revisitation of some portions of the area in 1960. The studies of the first summer were concentrated in the Olallie section. In 1958 the Horse Creek-Horse Lakes area, the country along Olallie Trail and some parts of the high country were studied. During 1959, work was completed in the Olallie section and in the high country. The size of the area and the great diversity of habitats involved determined the reconnaissance nature of the work. Plate 1, p. 123, a map of the Three Sisters Primitive Area, shows the locations of the stands examined in this study.

During the first summer, studies were made on: Horse Creek Trail to Roney Creek, three and one-half miles; Castle Creek Way, two miles; Eugene Creek Way, one-half mile; and Olallie Trail, four and one-half miles.

The trees and shrubs were studied in 20 by 20 meter (1/10 acre) quadrats. Three lines of ten quadrats, each one meter square, were located in each large quadrat. All of these lines of meter square quadrats were at approximate right angles to Horse Creek. Because of the great number of logs, stumps and brush heaps, it was frequently necessary to move quadrats out of line. Detailed studies of the shrub, forb and terrestrial species were made in these meter square quadrats. Total cover of all shrubs and total forb cover were recorded but the cover of each bryophyte species was recorded

separately. Slope, exposure and nature of ground cover, such as brush, logs, rocks and needles, were recorded. Altitude was estimated from contour maps.

Basal area was used to indicate the cover of each tree species. The coverage classes for shrubs, forbs, and all bryophytes in quadrats of all sizes used in the study, were similar to those used by Cain and Sharp (16, p. 265). Class 5 represented 75-100% cover; class 4, 50-75% cover; class 3, 25-50%; class 2, 5-25%; class 1, 1-5%; and class 6, less than 1% cover, was recorded as + in this study.

Terrestrial, epilithic, epixylic and corticolous species were studied separately, as Cain and Sharp did in their study in the Great Smokies (16, p. 259-265). These four groups of bryophytes, according to substratum, are too unlike in species composition in the Three Sisters Area to group them together.

Epilithic species were studied in two by five decimeter quadrats. The species on the tops of the rocks and along the sides were recorded separately. This distinction was not used in tabulation of results for no appreciable differences in species were observed, perhaps because the rocks are relatively small.

Epixylic species were also studied in two by five decimeter quadrats. The species were noted and the cover of each was recorded. Quadrats on the tops and those on the sides of the logs were distinguished in the records. All of the surface of a log that showed a distribution of not more than three species and that had

more than one-half of the area covered by bryophytes was sampled. Species on burned logs were so designated. Species on logs with intact bark were included if the direction of the bryophyte growth showed clearly that they were not corticolous species. A study of species on cut ends of logs along lower Horse Creek was made.

Corticolous bryophytes were noted and a few trees of different species were mapped, using cross section paper. A few maps to show distribution of the bryophyte species on branches of Acer circinatum were made. A study of the effect of tree position on corticolous bryophyte distribution was made during a steady rain when water movement on the trunks was easily observed.

The method of sampling used on lower Horse Creek was changed as soon as work was begun on Castle Creek Way because of the steepness of the slopes and the scantiness of the bryophyte cover. The coverages of all terrestrial species of bryophytes were recorded for all meter square quadrats that showed any bryophytes. For example, an average cover of 5 for a particular bryophyte species in two quadrats of the 400 in the 20 by 20 meter quadrat was recorded as 5(2). This change in procedure resulted in a saving of time that made it possible to examine more stands. Covers of shrub and forb species were recorded only for the 20 by 20 meter quadrats.

Logs and larger rocks with adequate bryophyte cover were sampled in the same way as on lower Horse Creek. Distributions of corticolous species were noted but, since they are relatively scarce outside lower Horse Creek, very little mapping was done.

In 1958, studies were made at Horse Lake, Middle and Lower Horse Lakes, along McBee Trail, on Horse Mountain and at Sisters Mirror Lakes. By means of a pack trip, the areas along Olallie Trail to the Guard Station, on Horse Pasture and Olallie Mountains, along Park Trail, on Horse Creek Trail from Horse Lake to Cedar Swamp, and the forests around Cedar Swamp were sampled.

In 1959, additional work was done in the high country along Foley Ridge Trail and on Skyline Trail from Frog Camp to Sunshine Shelter, and on Rebel Rock Trail in the Olallie section. Part of this summer was spent at the herbarium of the University of Washington in identifying the specimens. The lower Horse Creek and Horse Lake areas were revisited in 1960, when photographs were taken.

RESULTS

A survey of the combinations of tree and bryophyte species, observed in all of the stands sampled in the study, showed that there is not a haphazard distribution of the terrestrial bryophytes but that certain species are usually found associated with certain combinations of tree species. On this basis and the similarity of physiographic features, such as slope and altitude, ten groups of stands were established tentatively. There is much variability in shrub and forb species in stands included in the same group, however. High basal area for a tree species is considered as indicating dominance of that species.

Group A stands occur at about 2500 feet altitude, are mostly level, and show Pseudotsuga menziesii, Thuja plicata and usually one or more of these species, Abies grandis, Tsuga heterophylla and Acer macrophyllum.

Group B stands occur at about 4000 feet altitude, on moderate slopes and show Pseudotsuga menziesii, Tsuga heterophylla, and sometimes Abies grandis.

Group C stands are at 2800 to 3500 feet altitude and on steep south or southwest exposures. Pseudotsuga menziesii is usually accompanied by some of these species, Libocedrus decurrens, Arbutus menziesii, Castanopsis chrysophylla, and occasionally Pinus lambertiana.

Group D, the stands on very steep hillsides, include a

few over-mature Pseudotsuga menziesii and great numbers of Tsuga heterophylla, and sometimes Thuja plicata, in variable sizes.

Group E stands extend along Horse Creek trail from Horse Lake to seven miles from the end of Horse Creek road. The country traversed by the trail shows a steady downgrade from east to west and is topographically rather uniform. The upper, eastern end of the area, above the Horse Lakes, is more level and shows Picea engelmanni mixed with the Pseudotsuga menziesii, Abies amabilis and Tsuga heterophylla characteristic of the remainder.

Group F stands are at 4000 to 5000 feet altitude, are level or with a slight slope, and most of them show some Picea engelmanni mixed with Abies amabilis or, in the swamp areas, with Abies lasiocarpa. Pseudotsuga menziesii occurs in some of these stands.

Group G is very large and heterogeneous. These stands are on slopes from 20 to 30 degrees and at 4000 to 5700 feet. They all show trees of some species of the true firs, Abies grandis, A. amabilis, A. procera and A. lasiocarpa. Pseudotsuga menziesii is present in some stands. Despite the variations mentioned, the same species of terrestrial bryophyte is common to a majority of these stands. Until further investigation has been made, it may be better to lump them together rather than to separate them into a number of smaller groups.

Group H is probably the most uniform as to tree and shrub species, the lack of forbs, and the terrestrial bryophyte species. These stands are found on very slight slopes from 5000 to 6000 feet.

Tsuga mertensiana and Abies amabilis are characteristic.

Group I stands are mostly at about 5000 feet and show Pinus contorta, Tsuga mertensiana and Abies lasiocarpa. Group J stands are found above 6000 feet and show Tsuga mertensiana, sometimes in almost pure stands, but usually with some Abies amabilis. Many of the stands of the latter group are in coarse soil or pumice. The two groups both have low shrub and forb cover and an overlap of about the same bryophyte species.

In the data on tree species, the numbers represent basal area of each species in that particular stand. For terrestrial bryophyte species, 2.5(4), for example, represents 4 quadrats of the 400 in the 20 by 20 meter quadrat with an average cover of 2.5. For epilithic and epixylic species the same method of expressing cover is used. If there are two or more different species in a quadrat, the combination is shown by indentation. Rhacomitrium patens, written with Lescuraea patens indented below it and Brachythecium curtum forma indented below the Lescuraea, indicates a quadrat in which these three species are present, with the first named having the greatest cover. 3,2,1(1) indicates that the first named species has a cover of 3, the second of 2 and the third of 1. (1) indicates that one quadrat shows this combination of species with these cover values.

Table 1

Stand Description and Terrestrial Bryophyte Species of Group A

Stand numbers	2-1	2-2	6	168	169	170
Location	Horse Creek Tr., near jct. with Castle Creek Way	Same as 2-1	Eugene Creek Way, ½ mi.	Rebel Rock Tr. ½ mi.	Rebel Rock Tr. ¼ mi.	Rebel Rock Tr. near S. Fork, McKenzie River
Altitude	2200	2200	2200	2200	2200	2100
Slope, exposure	level	level	level	15°SW	15°SW	15°SW
Ground cover (needles, logs, rocks, pumice)	---	---	---	---	---	---
Shrub cover	3.5	2.5	1	2	2	2
Shrub species						
Acer circinatum	X	X	X	X	X	X
Corylus rostrata			X	X		
Berberis nervosa				X	X	X
Forb cover	5	4.5	4	4	2	1
Forb species						
Smilacina sessilifolia			X			
Oxalis oregana	X	X				
Tiarella unifoliata	X					
Hydrophyllum tenuipes	X	X	X			
Viola glabella			X			
V. sempervirens					X	X
Asarum caudatum			X			
Vancouveria hexandra			X			
Linnaea borealis				X		
Satureja douglasii				X	X	X
Montia sibirica			X			
Tree species						
Pseudotuga menziesii		27	23	2	9	20
Thuja plicata	5	16	7	1	4	+
Populus trichocarpa			17			
Acer macrophyllum	6	8	6			
Abies grandis	8	41	12			
Terrestrial bryophyte species						
Mnium insigne	1(8)	2(15)	+			
M. menziesii				1(1)		
Eurhynchium oreganum	+	+		4(10)	2.5(5)	4(4)
Rhytidiadelphus triquetrus		+		2.5(2)	3.5(9)	
Hylocomium splendens					+(1)	
Camptothecium megaptilum				5(3)		1(3)

Table 1, continued

Stand Description and Terrestrial Bryophyte Species of Group A

Stand numbers	1-1	1-2	130	132	3-1	3-2
Location	Horse Creek Tr. near Horse Creek Shelter	Horse Creek Tr. near Horse Creek Shelter	Cedar Swamp	Cedar Swamp	Castle Creek Way	Castle Creek Way
Altitude	2200	2200	4000	4000	2300	2300
Slope, exposure	level	level	level	level	5°NE	5°NW
Ground cover (needles, logs, rocks, pumice)	logs, brush	logs, brush				
Shrub cover	3	1	1		1	1
Shrub species						
Acer circinatum	X	X				
Corylus rostrata	X	X				
Rhododendron californicum		X				
Castanopsis chrysophylla seedlings		X				
Berberis nervosa			X		X	
Forb cover	1	1	1	1	1	1
Forb series						
Trillium ovatum	X					
Smilacina sessilifolia	X	X	X	X		
Clintonia uniflora			X			
Oxalis oregana	X	X				
Viola sempervirens	X	X			X	
Asarum caudatum		X				
Linnaea borealis		X				
Tiarella unifoliata			X			
Achlys triphylla				X		
Trientalis latifolia				X	X	
Chimaphila umbellata					X	
Tree species						
Pseudotsuga menziesii	28	79		20	45(3 trees)	56(6)
Thuja plicata	4	1	46	22	14(2 trees)	9
Populas trichocarpa			2			
Tsuga heterophylla					18	43
Abies grandis			3	11		
Pinus monticola	1		Picea +	Picea 3		
Terrestrial bryophyte species						
Mnium insigne	+					
Eurhynchium oreganum	2(30)	2.5(10)	2(3)	2(5)	4.5(200)	5(400)
Rhytidiadelphus triquetrus	1(30)	1(10)		2(2)	+	
R. loreus		+				
Hylocomium splendens			2(1)			
Camptothecium megaptilum	+					+
Brachythecium curtum forma			2(1)			
Rhytidiopsis robusta			2(1)			

Table 2

Epilithic Species of Group A Stands

Stand numbers	3-1, 3-2
Scleropodium caespitosum	5(11)
Mnium insigne	5,1(1)
Rhytidiadelphus triquetrus	
Eurhynchium oreganum	4,1.5(2)
Mnium insigne	2,1,2(1)
Mnium insigne	
Rhytidiadelphus triquetrus	5,+(1)
Mnium menziesii	5(1)
Eurhynchium oreganum	
Rhytidiadelphus triquetrus	3,1,1(2)
Scleropodium caespitosum	4,+,1(1)

Table 3

Epixylic Species of Group A Stands

Stand numbers	1	2	3	6
Hylocomium splendens	4.5(3)		5(2)	
Plagiothecium undulatum	2.5,1(2)			
Rhytidiadelphus loreus	4,1(1)			
Eurhynchium oreganum	4,1(1)		3,2(1)	
Rhytidiadelphus triquetrus	4.5,1(3)	1,4(1)		
Eurhynchium oreganum	5,3,1(1)			
Rhytidiadelphus triquetrus	4.5(2)			5(1)
Eurhynchium oreganum	4,1(1)		5,1(1)	
Eurhynchium oreganum			4.5(5)	
Rhytidiadelphus loreus			5(1)	
Dicranum fuscescens				
Aulacomnium androgynum**	3.5,1(3)			
Aulacomnium androgynum				
Hypnum circinale				
Buxbaumia piperi**		2,1,+(1)		
Scapania nemorosa				
Dicranum fuscescens	4,1(1)			
Cephalozia media*			5(1)	
Tetraphis pellucida*	5,2(1)			
Mnium punctatum				5(1)
Eurhynchium oreganum			3,1(1)	
Pseudoisothecium stoloniferum			1,4,1(1)	
Cephalozia media	5,1(1)			
Pseudoiso tetraphis*				
Pseudoisothecium stoloniferum			2.5,2(2)	
Tetraphis pellucida*				5,1(2)
Mnium insigne		5(4)		
Rhytidiadelphus triquetrus		3.5,1(9)		
Eurhynchium oreganum		3,2,1(1)		
Eurhynchium oreganum		1.5,2.5(2)		
Mnium menziesii		1.5,1.5,2.5(2)		
Tetraphis pellucida*				
Lepidozia reptans*				5,1(1)
Cephalozia media*				1,2,2.5(2)
Hypnum circinale			5(1)	
Scapania nemorosa**			4,1.5(5)	
Pseudoisothecium stoloniferum			2,1,2(1)	
Dicranum fuscescens				
Cladonia sp.*			4,+,1(1)	
Plagiothecium denticulatum				
Lophozia sp.*		3.5,2(2)		
Eurhynchium oreganum		2,2(1)		

* vertical (on sides)
** on burned logs

Table 4

Epixylic Species On Cut Ends Of Logs
Group A

Lepidozia reptans, *Riccardia latifrons* and *Tetraphis pellucida* is the basic combination.

Of the 14 log ends observed, six showed this grouping in the following proportions: 5,2,1; 5,0,1; 3,3,1; 3,4,4; 4,0,3; 4,3,3.

On four of the logs, this basic combination, or part of it, was found with the lichen, *Icmadophila ericetorum* in these proportions: 4,3,2,1; 3,0,2,+; 4,0,5,1; 5,0,0,1.

On two of the logs this basic combination, or part of it, was found with the lichen, *Cladonia* sp., in these proportions: 4,2,+,+ and 3,+,+,2.

On one of the logs this basic combination, or part of it, was found with *Lophozia* sp. in this proportion, 4,0,4,1.

Table 5

Distribution of Corticolous Bryophytes
With Relation to Tree Position, Group A

Tree species	Direction tree leans	Wet side of tree	Maximum bryophyte development	Minimum bryophyte development
Thuja plicata	S	N	N to 6 feet	S to 2 feet
	NW	SE	SE to 25 feet	N only Cladonia sp.
	NE	SW	SW to 50 feet	N only Cladonia sp.
	N	-	N, E & W to 50 feet	S to 3 feet
	SE	W	W to 6 feet	S & E 2 feet
	W	N	N & W to 10 feet	S to 1 foot
Tsuga heterophylla	N	S	S to 8 feet	N only Cladonia sp.
	NE	S	S to 8 feet	N only Cladonia sp.
	S	N	N to 15 feet	S none
Abies grandis	S	N	N to 8 feet	
	upright	all sides	about 3 feet on all sides	
Pseudotsuga menziesii	SW	NE	NE to 40 feet	S scattered
	N	S	S to 2 feet	N none
	N	S	S to 15 feet	N none
	S	N	N to 15 feet	S scant

SUMMARY OF GROUP A STANDS

There are three subgroups, the first being the flood plain stands 2-1, 2-2 and 6, in which Pseudotsuga menziesii, Thuja plicata, and Abies grandis are accompanied by Acer macrophyllum. All three stands show Acer circinatum and all have a forb cover of 4 and 5. This is predominantly of Oxalis oregana and Hydrophyllum tenuipes. Mnium insigne is abundant in 2-1 and 2-2 (Plate 7, p. 133) (Plate 8, p. 133). It is scarce in 6 but no other species of bryophyte is present on the ground in this stand.

The second subgroup consists of the stands above flood level, 1-1, 1-2, 180, 132, 168-170 (incl.). In these Pseudotsuga menziesii and Thuja plicata are sometimes accompanied by Abies grandis but not by Acer macrophyllum. Of these seven stands, five show both Eurhynchium oreganum and Rhytidiadelphus triquetrus (Plate 3, p. 125) and two show only Eurhynchium oreganum but have other bryophyte species present.

The third subgroup of stands, 3-1 and 3-2, represents remnants of the old Pseudotsuga menziesii forests with a few trees of d.b.h. of 40 to 70 inches. Stand 3-2 shows an abundance of small diameter Tsuga heterophylla, in addition to the overmature Douglas fir, and it is probably a later stage in succession. Both of these stands show an almost continuous carpet of Eurhynchium oreganum with very low shrub and forb cover (Plate 14, p. 141) (Plate 15, p. 141).

A summary of cover-abundance of the epixylic species shows that in the first subgroup Mnium insigne, Hylocomium splendens and Eurhynchium oreganum are the three highest. The Mnium insigne also has heavy ground cover in 2-1 and 2-2.

Hylocomium splendens, (Plate 12, p. 137), usually in combination with other epixylic species such as Eurhynchium oreganum and Rhytidiadelphus triquetrus, predominates in 1-1, 1-2 and 3 above the flood plain level.

Tetraphis pellucida, Cephalozia media, Lepidozia reptans and Lophozia sp., the latter three all hepatics, prefer vertical sides of logs to the tops.

Probably the moss species that is the pioneer on burned logs is Aulacomnium androgynum, which appears to grow directly on the charred wood (Plate 11, p. 137). It forms great numbers of gemmae, a method of asexual reproduction which may favor its spread in this habitat. The very interesting, but highly infrequent Buxbaumie piperi, is sometimes found on burned logs in later stages.

The series of cut ends of logs shown in Table 4 has a basic pattern of two hepatics, Lepidozia reptans and Riccardia latifrons, together with the moss, Tetraphis pellucida, which grows in tufts (Plate 9, p. 135). Lichens are also involved and when they are present there are fewer bryophytes.

Scleropedium caespitosum is the most common epilithic species (Plate 16, p. 143). This species and the much less abundant

Mnium menziesii (Plate 14, p. 141) are the only two species not also found on the ground in some of the stands of this group.

Figures 1-6 provide some idea of the abundance of corticolous bryophyte species which often grow up to five and six feet on the trunks. The Acer circinatum branches are draped with mats of mosses, Gamptothecium lutescens predominating (Plate 5, p. 129). In stands 2-1 and 2-2 the scene is strongly reminescent of the rain forests of the Olympics. The lower part of Rebel Rock trail is not comparable but some other places along the South Fork of the McKenzie are more like lower Horse Creek in the abundance of corticolous species.

On most trees in this area, after a steady rain, the under side of the trunks, i.e., the side toward which the tree leans, remains dry and the upper side is dripping with rain. The moss distribution is less on the under side, being scant (Plate 13, p. 139). Or the cover may be largely of lichens whereas on the upper, moist side the bryophytes extend up the trunk much farther, even to 25-50 feet on Thuja plicata of 40 to 50 d.b.h.

Table 6

Stand Descriptions and Terrestrial Bryophyte Species of Group B

Stand numbers	128	129	134	135	136
Location	Cedar Swamp near Horse Creek Falls	Same as 128	Cedar Swamp below Elkhorn Camp	Same as 134	Same as 134, 135
Altitude	4200	4200	4000	4000	4000
Slope, exposure	35°W	35°W	30°SW	30°S	10°S
Ground cover (needles, logs, rocks, pumice)	---	---	---	---	---
Shrub cover	2+	2+	2	2	1+
Shrub species					
Berberis nervosa	X	X		X	
Linnaea borealis	X	X			X
Pachystima myrsinitis			X		
Salix sp.			X		
Gaultheria ovalifolia				X	
Taxus brevifolia				X	
Forb cover	+	+	2		1
Forb species					
Clintonia uniflora			X		
Chimaphila umbellata	X	X			X
Tree species					
Tsuga heterophylla	2	.3	5	6	
Pseudotsuga menziesii	40	20	13	5	14
Abies grandis	3 young		15	2	.6
Picea engelmanni		.3	2.2		.5
Terrestrial bryophyte species					
Rhytidiopsis robusta	4(9)	3.5(8)	4(10)	4.5(270)	
Eurhynchium oreganum	3(1)	1.5(3)	2(1)		
Dicranum fuscescens			5(1)	1(1)	
Hylocomium splendens	2(1)	2(2)			
Camptothecium megaptilum	1(2)	1.5(2)			2(1)
Rhytidiadelphus triquetrus		1(1)			
Brachythecium curtum forma					+

Table 6, continued

Stand Descriptions and Terrestrial Bryophytes of Group B

Stand numbers	156	157	158	159	160
Location	Foley Ridge	Foley Ridge	Foley Ridge	Foley Ridge	Foley Ridge
Altitude	4000-3500	4000-3500	3500-3000	3500-3000	3500-3000
Slope, exposure	30°SW	20°S	10°W	10°W	10°S
Ground cover (needles, logs rocks, pumice)	---	---	---	---	---
Shrub cover	3	+	1	+	
Shrub species					
Vaccinium membranaceum	X	X			
Arctostaphylos nevadensis	X		X		
Gaulteria shallon			X		
Pachystima myrsinitis				X	
Forb cover	1	4	2	5	5
Forb species					
Xerophyllum tenax	X	X	X	X	X
Chimaphila umbellata	X			X	X
Achlys triphylla		X			
Pyrola secunda				X	
Tree species					
Tsuga heterophylla	4	8	10	30	2
Pseudotsuga menziesii	26			1	
Abies grandis	1	1	small		2
Pinus monticola	1			1	
Terrestrial bryophyte species	none	none			
Rhytidiopsis robusta			3.5(10)	3(7)	4+(7)
Eurhynchium oreganum					1(2)
Dicranum fuscescens				+(2)	1.5(2)
Camptothecium megaptilum				5(2)	
Pohlia nutans			2.5(2)	+(1)	
Brachythecium velutinus			1.5(3)		
Bryum sandbergii			1(2)		

Table 6, continued

Stand Descriptions and Terrestrial Bryophytes of Group B

Stand numbers	87	88	8
Location	Jct. Olallie and French Pete Trs.	Olallie Tr., past jct., French Pete	Olallie Tr. 1¼ mi.
Altitude	5000	5000	3500
Slope, exposure	5°E	10°E	5°N
Ground cover (needles, logs, rocks, pumice)	---	---	---
Shrub cover	1+	1	
Shrub species			
Berberis nervosa	X		X
Linnaea borealis	X		X
Gaultheria ovalifolia	X		X
Vaccinium membranaceum		X	
Forb cover	+	1	+
Forb species			
Viola sempervirens	X		X
Xerophyllum tenax		X	
Rubus pedatus		X	
Tree species			
Tsuga heterophylla	4	1	53
Pseudotsuga menziesii	2	12	17
Pinus monticola	2		3
Terrestrial bryophyte species			
Rhytidiopsis robusta	2.5(5)	3(7)	
Eurhynchium oreganum			3(15)
Camptothecium megaptilum			1(10)
Pohlia nutana	2.5(3)		
Polytrichadelphus lyalli	4(1)		

Table 7

Epilithic Species of Group B Stands

Stand numbers	128	134	156
Rhytidiopsis robusta			
Hylocomium splendens	2,2(1)		
Scleropodium caespitosum	4(1)		
Camptothecium lutescens		5(3)	
Lescuraea radicosa		1,5(1)	
Lescuraea patens		4(1)	5(1)
Claopodium crispifolium		5(14)	
Brachythecium velutinus		3,2(2)	
Rhacomitrium varium		2,2(1)	
Rhacomitrium varium		4.5(4)	2.5(2)

Table 8

Corticolous Species of Group B Stands

Stand numbers	134	156
Picea engelmanni	Ptilidium californicum Hypnum subimponens Brachythecium curtum forma	
Abies amabilis		Rhytidiopsis robusta Heterocladium procurrens Dicranum fuscescens Ptilidium californicum Large foliose lichens above 5 feet

SUMMARY OF GROUP B STANDS

Tsuga heterophylla and Pseudotsuga menziesii are present, sometimes also Abies grandis. Shrub cover varies from scant on Foley Ridge to 2 in the other stands. Berberis nervosa is present in four of the eleven stands. Forb cover is variable, ranging from scattered and scarce in Cedar Swamp to abundant on Foley Ridge, with Xerophyllum tenax, being the most common (Plate 21, p. 147).

In four of the thirteen stands, both Rhytidiopsis robusta and Eurhynchium oreganum are found on the ground, in five only Rhytidiopsis (Plate 20, p. 147) and in one only Eurhynchium. Two stands have no terrestrial bryophytes and one has another species.

Of the epilithic species, Claopodium crispifolium (Plate 31, p. 159) has the most cover. Rhacomitrium varium and Camptothecium lutescens are less extensive. No epixylic species and very few corticolous species were recorded which reflects the drier sites.

Table 9

Stand Descriptions and Terrestrial Bryophyte Species of Group C

Stand numbers	7-1	7-2	161	162	163	165
Location	Olallie Tr., 2 mi.	Olallie Tr., 2 mi.	Rebel Rock Tr., 1 3/4 mi.	Rebel Rock Tr., 1 1/2 mi.	Rebel Rock Tr. 1 1/4 mi.	Rebel Rock Tr., 1 mi.
Altitude	2800	2800	3500	3300	3100	3000
Slope, exposure	15°S	15°S	30°S	30°SW	30°SW	30°S
Ground cover (needles, logs, rocks, pumice)				rocky	very rocky	
Shrub cover	+	+	1	1	3	4
Shrub species						
Berberis nervosa	X					X
Arctostaphylos columbiana	X			X	X	
Rhododendron californicum		X				
Corylus rostrata			X			
Holodiscus discolor			X	X		
Vaccinium membranaceum				X		
Symphoricarpos albus						X
Forb cover	+	1	1			
Forb species						
Goodyera decipiens	X					
Trientalis latifolia	X					
Linnaea borealis			X			
Saturej a douglasii			X			
Vancouveria hexandra			X			
Tree species						
Pseudotsuga menziesii	40	60	14	4	4	4
Libocedrus decurrens	40	1				4
Arbutus menziesii	20	6				
Castanopsis chrysophylla		1	2	young	1	
Pinus lambertiana		16				
Terrestrial bryophyte species			none	none	none	
Polytrichum juniperinum	4(1)					
Dicranum fuschscens	2(4)	1(1)				
Eurhynchium oreganum		1+(7)				3.5(3)
Rhytidiadelphus triquetrus						1(1)
Bestia sp.	2(4)					

Table 9, continued

Stand Descriptions and Terrestrial Bryophytes of Group C

Stand numbers	166	167	5
Location	Rebel Rock Tr., 1 mi.	Rebel Rock Tr. 3/4 mi.	Horse Cr. Tr. 3 mi.
Altitude	3000	2700	3000
Slope, exposure	30°S	30°SW	20-30°SW
Ground cover (needles, logs, rocks, pumice)	---	---	---
Shrub cover	+	4	1+
Shrub species			
Berberis nervosa	X		
Arctostaphylos columbiana		X	
Gaulteria shallon		X	
Rhododendron californicum			X
Forb cover			+
Forb species			
Viola sempervirens			X
Pyrola bracteata			X
Tree species			
Pseudotsuga menziesii	12	2	74
Libocedrus decurrens	1		
Castanopsis chrysophylla		+	+
Pinus lambertiana	7	13	
P. monticola			3
Terrestrial bryophyte species	none		
Eurhynchium oreganum		2(3)	
E. strigosum			1+(15)
Camptothecium megaptilum			+(1)
Bestia sp.		1(2)	

Table 10

Epilithic Species of Group C Stand

Stand numbers	5	7-1, 7-2
Scleropodium caespitosum	5(3)	5(1)
Rhytidiopsis robusta	2,4(1)	
Peltigera sp.		3,1(7)
Dicranam fuscescens		2,1,2(1)
Mnium spinulosum	5,2(1)	
Rhacomitrium canescens ericoides		3,2(1)
Homalothecium nuttalii		5,1(1)
Neckera douglasii		2.5,2.5(2)
Neckera douglasii		5(2)
Madotheca platphylla		
Scleropodium caespitosum		2,1(1)
Mnium spinulosum	4(1)	
Eurhynchium oreganum	4,2(1)	
Rhytidiadelphus triquetrus	2,3(1)	
Eurhynchium oreganum		
Rhytdiadelphus triquetrus	3,2(1)	
Mnium menziesii	4(1)	
Claopodium crispifolium	3(3)	
Scleropodium caespitosum	4,1(3)	
Rhacomitrium patens	3,1(1)	
Rhacomitrium patens	5(3)	3.5(2)
Rhacomitrium canescens ericoides	3(1)	
Rhacomitrium varium		3,2(1)
Homalothecium nuttallii	5(1)	5(1)
Pilophoron cereolus		5,2(1)
Dicranum fuscescens		
Rhytidiadelphus triquetrus	2,1(1)	
Polytrichum juniperinum	3,2(1)	
Heterocladium procurrens	5(1)	
Rhacomitrium heterostichum sudeticum		5(1)
Selaginella sp.		4,1(1)
Selaginella sp.		3.5(2)
Scleropodium caespitosum		
Neckera douglasii		2,1,1(1)
Antitrichia curtipendula		5(2)
Homalothecium nuttallii		2,2(1)
Scleropodium caespitosum		2,2(1)

Table 11

Epixylic Species of Group C Stands

Stand number	5
1. Tops of logs	
Dicranum fuscescens	5(3)
Hypnum subimponens	2.5,2.5(3)
Burhynchium oreganum	3,1(1)
Lophozia incisa	
Mnium punctatum	2,2,1,+(1)
Buxbaumia piperi	
2. Cut ends of logs	
Icmadophila ericetorum	5(1)
Lepidozia reptans	4,1(1)
Tetraphis pellucida	
Lepidozia reptans	
Lophozia incisa	1,4,3(1)
Lepidozia reptans	
Tetraphis pellucida	
Riccardia latifrons	4,1,1(1)

SUMMARY OF GROUP C STANDS

These stands all have south or southwest exposures, are very steep and extremely dry. The Pseudotsuga menziesii is accompanied by Libocedrus decurrens, Arbutus menziesii and Castanopsis chrysophylla.

Both shrub and forb species are scant and terrestrial bryophytes are scarce. There are some few patches of Eurhynchium oreganum and Rhtidiadelphus triquetrus in contrast to the much greater abundance of these two species in the Pseudotsuga menziesii along lower Horse Creek.

There is an abundance of epilithic species on small rocks partly buried in soil, on boulders and on rock cliffs, some of red volcanic form. Scleropodium caespitosum, Rhacomitrium patens and Claopodium crispifolium are the most abundant species.

The predominant epixylic species in stand five is Dicranum fuscescens. Cut ends of logs show the same combinations of species as do those along lower Horse Creek.

The corticolous species are almost entirely lichens.

Table 12

Stand Descriptions and Terrestrial Bryophytes of Group D

Stand number	9	10	4-1	4-2	4-3	4-4
Location	Olallie Tr., 5 mi.	Olallie Tr. 4½ mi.	Castle Creek Way 2 mi.	Castle Creek Way 2 mi.	Castle Creek Way 1½ mi.	Castle Creek Way 1 mi.
Altitude	4500	4000	3200	3200	3000	2500
Slope, exposure	20°S	30°S	45°N	45°N	45°N	45°N
Ground cover (needles, logs, rocks, pumice)	needles, twigs 1½-2 in.	needles, twigs 1½-2 in.	needles, twigs 1-2 in.	needles, twigs 1-2 in.	logs, branches	logs, branches
Shrub cover	1	+	--	--	--	--
Shrub species						
Vaccinium membranaceum	X					
Berberis nervosa	X	X				
Forb cover	1	+	+	+	+	+
Forb species						
Corallorhiza striata	X					
Goodyera decipiens						X
Phlox speciosa	X					
Asarum caudatum	X					
Githiopsis specularioides		X				
Pyrola bracteata			X			
Tiarella unifoliata			X	X		
Coptis laciniata			X	X	X	
Vancouveria hexandra					X	
Pteridium aquilinum	X					
Tree species						
Pseudotsuga menziesii	112(21 trees)	100 + snags	14	56	55	18
Tsuga heterophylla	.3		110	8	30	18
Abies grandis	5					
Acer macrophyllum					7	
Thuja plicata	snags			+		7
Pinus monticola	snag	snags				
Terrestrial bryophyte species	none	none				
Eurhynchium oreganum			+		1+(7)	2+(14)
E. strigosum				1(1)		
Brachythecium velutinus			+	+		
Plagiothecium seligeri			+			
Rhytidiopsis robusta				3(1)	1+(4)	
Mnium spinulosum				2(1)		
Polytrichadelphus lyalli						+
Ditrichum heteromallum						+

Table 13

Epilithic Species of Group D Stands

Stand numbers	9	4-2	4-3
Claopodium crispifolium	4(1)	5(2)	
Antitrichia californica	2.5(5)		
Brachythecium velutinus	+		
Scleropodium caespitosum		5(5)	5(2)
Rhacomitrium patens			4,1(2)
Rhytidiopsis robusta			2,4(1)

Table 14

Epixylic Species of Group D Stands

Stand number	4-3
Dicranum fuscescens	5(1)
Hypnum circinale	4,1.5(4)
Mnium punctatum	3,1,1(3)
Hypnum circinale	
Mnium punctatum	4,2(1)
Scapania nemorosa	4,1(2)
Dicranum fuscescens	2,3,1(5)
Mnium punctatum	
Dicranum fuscescens	
Heterocladium procurrens	5,1,+,(1)
Heterocladium procurrens	
Rhytidiopsis robusta	3,2(1)
Cephalozia media (cut ends of logs)	5(4)

Table 15

Corticolous Species of Group D Stands

Stand numbers	9	10
Pseudotsuga menzesii	*Hypnum circinale* *Dicranum fuscescens*	Near bases of few trees *Hypnum circinale* *Brachythecium velutinus*
Abies amabilis	*Hypnum circinale* (very little), abundant lichens	

SUMMARY OF GROUP D STANDS

The best way to summarize the stands of this group is to say that they are very steep, being subject to erosion and very shady. The ground is covered by a very heavy layer of twigs, needles and down timber. The total basal area of the tree species is very high. This is the result of many individual trees of variable sizes filling in the spaces between the massive Pseudotsuga menziesii.

Probably as a result of such a combination of extreme conditions, the ground bryophytes are very scarce. Remnants of Eurhynchium oreganum and Rhytidiopsis robusta of Group B are here or, more often, there are no bryophytes on the ground.

Scleropodium caespitosum and Claopodium crispifolium are the most abundant epilithic species.

Dicranum fuscescens is the only epixylic species and Hypnum circinale the only corticolous species. The Plagiothecium seligeri reported as on the ground is actually on rotted wood in the ground.

Table 16

Stand Descriptions and Terrestrial Bryophytes of Group E

Stand numbers	112(a)(b)	31	111	30	113(a)	114
Location	Horse Creek Tr. above Horse Lake 13½ mi.	Horse Cr. Tr., 13 mi.	Horse Cr. Tr., Burnt Top jct. 12½ mi.	L. & M. Horse Lks. Tr., ¼ mi. below Horse Cr. Tr.	Horse Creek Tr., 12 mi.	Horse Creek Tr. 11 3/4 mi.
Altitude	4900	4900	4900	4800	4800	4700
Slope, exposure	SW facing rocky ridge	20°W	level	--	5°S	--
Ground cover (needles, logs, rocks, pumice)	---	---	---	---	---	---
Shrub cover	---	2	4	+	---	---
Shrub species						
Vaccinium membranaceum		X	X	X		
V. myrtillus microphyllum		X	X			
Gaulteria ovatifolia			X			
Forb cover		2	1	+	4	
Forb species						
Xerophyllum tenan		X	X	X		
Clintonia uniflora					X	
Hypopitys sp.			X			
Fragaria bracteata				X		
Viola glabella					X	
Valeriana sitchensis					X	
Rubus pedatus					X	
Tree species						only epilithic spp. studied
Pseudotsuga menziesii	8.3		4		10	
Tsuga heterophylla	3.2	22	18	42		
Abies amabilis		7	27	young	63	
Pinus contorta	1		1.2			
P. monticola	1	13	20		20	
Picea engelmanni		2	10	2 young	42	
Terrestrial bryophyte species	none	none				
Rhytidiopsis robusta			3.5(2)			
Brachythecium hylotapetum					+	
B. curtum forma					2.5(7)	
Dicranum fuscescens			2(3)			
Pohlia nutans				5(3)		
Polytrichum juniperinum				2(3)		
Polytrichadelphus lyalli			2(3)			

Table 16, continued

Stand Descriptions and Terrestrial Bryophytes of Group E

Stand number	115	116	117	118-9	120	121
Location	Horse Cr. Tr., $11\frac{1}{2}$ mi.	Horse Cr. Tr., 11 mi.	Horse Cr. Tr., $10\frac{1}{2}$ mi.	Horse Cr. Tr., $9\frac{1}{2}$ mi.	Horse Cr. Tr., $9\frac{1}{4}$ mi.	Horse Cr. Tr., $9\frac{1}{4}$ mi.
Altitude	4700	4600	4500	4500	4400	4400
Slope, exposure	15°S	level	10°N	10°S	10°S	15°S
Ground cover (needles, logs rocks, pumice)	---	---	---	---	---	---
Shrub cover	4	---	3	---	+	+
Shrub species						
Vaccinium membranaceum	X		X			
Rosa gymnocarpa					X	X
Forb cover	1	5	2	+	2	2
Forb species						
Smilacina sessilifolia		X				
Clintonia uniflora	X					
Goodyera decipiens			X		X	X
Achlys triphylla	X	X	X		X	X
Chimaphila umbellata	X		X	X		
Tiarella unifoliata		X				
Adenocaulon bicolor		X				
Pyrola secunda	X				X	X
Tree species						
Pseudotsuga menziesii	52	42	20	9+young	27	27
Tsuga heterophylla			5			
Abies amabilis	+	7	.3	3	.2	.2
Picea engelmanni		14				
Terrestrial bryophyte species	none					
Rhytidiopsis robusta		3(2)	3.5(19)		+(1)	1.5(2)
Eurhynchium oreganum		2.5(14)	2(1)		1.5(6)	2.5(2)
Camptothecium megaptilum					+(1)	
Brachythecium hylotapetum		1.5(4)			2(3)	3.5(2)
B. curtum forma		1(4)		+	2(1)	3(1)
Dicranum fuscescens			3(1)			

Table 16, continued

Stand Descriptions and Terrestrial Bryophytes of Group E

Stand numbers	122	123	124	125
Location	Horse Cr. Tr., 9¼ mi.	Horse Cr. Tr., 9 mi.	Horse Cr. Tr., 7½ mi.	Horse Cr. Tr., 7 mi.
Altitude	4200	4200	4200	4200
Slope, exposure	15°S	5°S	10°S	10°S
Ground cover (needles, logs, rocks, pumice)	---	---	---	---
Shrub cover	2	2	5	5
Shrub species				
Vaccinium membranaceum	X			
Rubus parviflora	X	X		
Rosa gymnocarpa	X	X		
Gaulteria shallon			X	X
Pachystima myrsinitis			X	X
Tree species				
Pseudotsuga menziesii	4		79	79
Tsuga heterophylla			4	
Abies amabilis			+	
A. grandis		27	2 young	
Picea engelmanni		.3		
Terrestrial bryophyte species				
Rhytidiopsis robusta	2(3)	3(3)	3(10)	4(7)
Burhynchium oreganum	1+(1)		2(3)	2.5(2)
Camptothecium megaptilum	2(1)			
Brachythecium hylotapetum	1.5(3)	3(6)		
B. curtum forma	3(5)	3(8)		

Table 17

Epilithic Species of Group E Stands

Stand numbers	31	116(c)
Homalothecium nuttallii	2(1)	
Claopodium crispifolium		
Lescuraea patens		
Rhacomitrium patens		
Cladonia sp.		1,2,1,2(1)
Lescuraea patens	+(1)	
Lescuraea stenophylla		
Brachythecium velutinus		
Rhacomitrium patens	1,1,1(1)	

Table 18

Epixylic Species of Group E Stands

Stand numbers	118-9	120
Dicranum fuscescens		
Plagiothecium seligeri		
Aulacomnium androgynum		2,1,1(1)
Eurhynchium oreganum		
Mnium spinulosum		4,1(1)
Hypnum circinale	4.5(3)	

Table 19

Corticolous Species of Group E Stands

Stand numbers	113(b)	115
Abies amabilis	Hypnum circinale	
Pseudotsuga menziesii		Hypnum circinale Dicranum fuscescens

SUMMARY OF GROUP E STANDS

Of the 16 stands along Horse Creek trail, four show both Pseudotsuga menziesii and Tsuga heterophylla and seven show Pseudotsuga without the Tsuga. Six, those above the Horse Lakes, show Picea engelmanni, three with a basal area of 5 or more. In most of these stands, Abies amabilis is also present, sometimes with high basal area.

Vaccinium membranaceum and Vaccinium myrtillus microphyllum are the most common shrubs, being present in six of the stands, mostly at the upper or eastern end of the trail. Forbs are low in cover with some Xerophyllum tenax.

In the part of the trail comparable in tree species to Group B, but with Abies amabilis replacing the Abies grandis, the combination of Rhytidiopsis robusta and Eurhynchium oreganum occurs in seven of 16 stands and only Rhytidiopsis robusta in two. Two stands show no ground bryophytes. Three stands showing Brachythecium hylotapetum and B. curtum forma were associated with Picea engelmanni; three were not.

Both epilithic and epixylic species are scant. Scant Hypnum circinale represents the corticolous species.

Table 20

Stand Descriptions and Terrestrial Bryophyte of Group F

Stand numbers	84	85	89	90	91	98
Location	Upper French Pete Tr.	Upper French Pete Tr.	Olallie Tr. to G. S.	Olallie Tr. to G. S.	Olallie Tr. to G. S.	Olallie Tr. to G. S.
Altitude	4500	4500	5000	5000	5000	5000
Slope, exposure	10°W	10°W	5°E	level	level	10°S
Ground cover (needles, logs, rocks, pumice)	---	---	---	---	---	much duff
Shrub cover	1	+	+	+	+	+
Shrub species						
Rubus parviflorus	X					
Acer circinatum		X				
Alnus temuifolia		X				
Rosa gymnocarpa			X	X	X	
Pachystima myrsinitis						X
Forb cover	3	3+	4	4	4	4
Forb species						
Smilacina sessilifolia	X	X				X
Disporum oreganum			X	X	X	
Clintonia uniflora						X
Asarum caudatum	X					
Achlys triphylla		X	X	X		
Tiarella unifoliata		X				
Pyrola secunda		X				
Pteridium aquilinum	X					
Tree species						
Picea engelmanni	4	20	22	20	20	1
Abies amabilis	21	41	29	1	1	
A. grandis						60
Pseudotsuga menziesii	22					
Terrestrial bryophyte species	none	none	none	none		none
Brachythecium hylotapetum					5(4)	
Rhytidiopsis robusta					5(3)	
Mnium punctatum					5(2)	

Table 20, continued

Stand Descriptions and Terrestrial Bryophytes of Group F

Stand numbers	100	101	102	127	133	131
Location	Olallie B. S.	E. of Olallie G. S.	Same as 101	S. end, Cedar Swamp	Cedar Swamp	Cedar Swamp
Altitude	5000	4800	4800	4000	4000	4000
Slope, exposure	10°S	5°S	5°S	level	5°S	5°S
Ground cover (needles, logs, rocks, pumice)	---	---	---	---	---	---
Shrub cover	+	---	---	1	1	+
Shrub species						
Berberis nervosa					X	X
Forb cover	5	4	4	2	1	1
Forb species						
Caltha biflora	X					
Lysichitum americanum	X					
Veratrum viride	X					
Xerophyllum tenax		X	X			
Clintonia uniflora					X	
Smilacina sessilifolia						X
Viola sempervirens		X				
V. glabella			X			
Cornus canadensis				X	X	
Chimaphila umbellata				X		
Tiarella unifoliata				X	X	
Achlys triphylla					X	X
Trientalis latifolia						X
Tree species						
Picea engelmanni	64	68	64	43	63	12
Abies amabilis		5 young	1		3	
A. grandis		3	3			
Pinus monticola		20				
Tsuga heterophylla					2	
Pseudotsuga menziesii	2					21
Terrestrial bryophyte species						
Brachythecium hylotapetum		4(5)	3.5(7)	3(5)	1(1)	
B. curtum forma	+	3(4)	2(3)			1(1)
Rhytidiopsis robusta		1(1)		3.5(6)	2(7)	1(4)
Bryum sandbergii		1(1)	2(2)			2(1)
Eurhynchium oreganum					1.5(4)	

Table 20, continued

Stand Descriptions and Terrestrial Bryophytes of Group F

Stand numbers	104	105	107	108	109(a)	109(b)
Location	Park Tr. 9 mi.	Park Tr. 8½ mi.	Park Tr. 6 mi.	Park Tr. 6 mi.	Park Tr. 5¼ mi.	Park Tr. 5¼ mi.
Altitude	4600	4600	4600	4700	4900	4900
Slope, exposure	5°S	level	level	10°W	10°N	10°W
Ground cover (needles, logs rocks, pumice)	heavy needle	heavy needle	heavy needle	heavy needle	heavy needle	heavy needle
Shrub cover	1	1		1	+	+
Shrub species						
Vaccinium membranaceum	X			X	X	X
Gaultheria ovatifolia		X				
Forb cover	2	4	2	+	+	+
Forb species						
Xerophyllum tenax	X			X		
Veratrum viride		X				
Ligusticum americanum		X				
Rubus pedatus	X	X				
Pedicularis racemosa	X					
Viola sempervirens	X				X	X
Asarum caudatum	X					
Chimapila umbellata				X		
Pyrola secunda					X	X
Tree species						
Picea engelmanni	36	37	22	.3	2	young
Abies amabilis	6	3 young				
A. lasiocarpa			.44		.4	3 young
Pinus contorta		1.6				
P. monticola	20					
Tsuga mertensiana		1.4		1.0	24	young
Pseudotsuga menziesii				22		
Terrestrial bryophyte species		none				
Brachythecium hylotapetum			5(1)			
B. curtum forma	2(5)		2(7)		+	
Rhytidiopsis robusta	1(1)			+(2)		
Bryum sandbergii	2(2)			3(7)	2.5(8)	5(12)
Dicranum fuscescens				+		

Table 20, continued

Stand Descriptions and Terrestrial Bryophytes of Group F

Stand numbers	28	29	26	25	44
Location	Middle Horse Lake	Middle Horse Lake	Between Middle and Lower Horse Lake	Lower Horse Lake	Fisher Lake
Altitude	4700	4700	4700	4700	5500
Slope, exposure	level	5°S	level	level	level
Ground cover (needles, logs, rocks, pumice)	---	---	---	---	---
Shrub cover	1	1	2	1	1
Shrub species					
Vaccinium membranaceum		X	X	X	X
V. myrtillus microphyllum					X
Gaultheria ovatifolia					X
Phyllodoce empetriformis					X
Rosa gymnocarpa			X		
Juniperus sibirica	X				
Forb cover	+	1	2	+	1
Forb species					
Veratrum viride					X
Clintonia uniflora		X			
Xerophyllum tenax	X	X	X		X
Achlys triphylla				X	
Tiarella unifoliata				X	
Githiopsis specularioides			X		
Valeriana sitchensis	X			X	
Pyrola picta			X		
Pteridium acuilinum	X				
Tree species					
Picea engelmanni	31	5		19	20
Abies amabilis		31	18	30	20
A. grandis				19	
Pinus monticola					44
Tsuga heterophylla			2.4		
Pseudotsuga menziesii	15		39		
Terrestrial bryophyte species			none		
B. curtum forma		3.5(3)		2(1)	
Rhytidiopsis robusta		5(1)		5(1)	3(5)
Dicranum fuscescens					1.5(4)
Polytrichadelphus lyalli		*6(5)			
Polytrichum juniperinum		3.5(6)			
Mnium punctatum				3.5(2)	

* outside quadrat

Table 20, continued

Stand Descriptions and Terrestrial Bryophytes of Group F

Stand numbers	19	20	21	22	33	27
Location	Horse Lake	Horse Lake	Horse Lake	Horse Lake	Horse Lake	near middle Horse Lake
Altitude	5000	5000	5000	5000	5000	4700
Slope, exposure	level	level	level	5°S	level	---
Ground cover (needles, logs, rocks, pumice)	---	---	000	---	---	---
Shrub cover	+	2	+	+	+	
Shrub species						
Vaccinium membranaceum	X	X				
V. myrtillus microphyllum				X		
Forb cover	1+	1+	+	+	+	1
Forb species						
Smilacina sessilifolia	X					
Clintonia uniflora	X		X			
Trillium ovatum					X	
Xerophyllum tenax						X
Caltha biflora		X				
Achlys triphylla	X					
Tiarella unifoliata	X					
Rubus pedatus	X			X	X	
Chimaphila umbellata			X			
Pyrola secunda			X		X	X
Viola sempervirens		X			X	
Tree species						
Picea engelmanni	42	7	22		58	1.1 + 2 young
Abies amabilis	44	5	59		16	18
A. lasiocarpa		59		+		
Pinus contorta	+	+				
P. monticola		+				2.0
Tsuga mertensiana						2.0
Pseudotsuga menziesii						39
Terrestrial bryophyte species						
Brachythecium hylotapetum	+					
B. velutinas	+				+	
Rhytidiopsis robusta	+					
Bryum sandbergii		+(2)				4(2)
Dicranum fuscescens			+			
Polytrichadelphus lyalli	+					2(1)
Polytrichum juniperinum		+(1)		1(3)		

Table 21

Epilithic Species of Group F Stands

Stand numbers	20	27	89	108
Lescuraea patens				3.5(2)
Rhacomitrium heterostichum	5,1(1)			
Powdery lichen	4,2(1)			
Brachythecium velutinus	5(2)			
Rhacomitrium heterostichum	3.5(2)	5(3)	5(1)	
Rhacomitrium patens				
Lescuraea patens			3,1(1)	
Brachythecium curtum forma			2,3,1(1)	
Rhacomitrium varium				4(3)

Table 22

Epixylic Species of Group F Stands

Stand numbers	19	33	26	85
Dicranum fuscescens	+	+		
D. strictum		+	+	
Cephalozia media			+	
Hypnum circinale				5(4)
Dicranum strictum				2,2(3)
D. fuscescens				3,1(1)

Table 22, continued

Stand numbers	131	104	108	109(a)
Dicranum fuscescens			+	+
D. strictum		+		
Hypnum circinale	+			
Plagiothecium seligeri	+			
Eurhynchium oreganum	+			
Pseudoisothecium stoloniferum	+			
Rhytidiopsis robusta				+
Pohlia nutans				+
Lophozia porphyroleuca				+

Table 23

Corticolous Species of Group F Stands

Stand numbers	19	21	26	25
Tsuga mertensiana	Rhytidiopsis robusta			
Abies lasiocarpa		Pohlia nutans, Dicranum fuscescens		
Pseudotsuga menziesii			Dicranum strictum, Ptilidium californicum	
Pinus monticola				Dicranum strictum, Ptilidium californicum

Table 23, continued

Stand numbers	84	88	89	98
Abies grandis	Pseudoisothecium stoloniferum Hypnum circinale			Hypnum circinale up to one foot on N, less on S side
A. amabilis	Hypnum circinale, Ptilidium californicum		Ptilidium californicum Lophozia porphyroleuca	
Tsuga heterophylla		Hypnum circinale, Scapania nemorosa		
Picea engelmanni				Hypnum circinale less abundant on S side

Table 23, continued

Corticolous Species of Group F Stands

Stand numbers	100	102	105
Abies amabilis		To one foot on N side: Brachythecium velutinus, Bryum sandbergii, Hypnum circinale, Pohlia nutans	
Picea engelmanni	Plagiothecium seligeri on root Brachythecium velutinus Mnium spinulosum	Above combination also observed on Picea	Ditrichum heteromallum
Pinus contorta			Ditrichum heteromallum

Table 23, continued

Stand numbers	107	131
Abies grandis		Plagiothecium seligeri Hypnum circinale Pseudoisothecium stoloniferum Eurhynchium oreganum
A. lasiocarpa	Brachythecium velutinus, B. asperrimum	
Picea engelmanni	Above combination also observed on Picea	Above combination also observed on Picea
Pinus contorta	Above combination also observed on Pinus	
Thuja plicata		Above combination also observed on Thuja

SUMMARY OF GROUP F STANDS

Twenty-one of the 29 stands in this group show Picea engelmanni with a basal area of 5 or more; six have this species present but with a basal area of less than 5; two show no Picea. Associated with the Picea is Abies amabilis with a basal area of 5 or more in 12 stands and of less than 5 in six stands. One swampy stand near Horse Lake shows A. lasiocarpa instead of A. amabilis. Pseudotsuga menziesii occurs in six of the stands with a basal area of 5 or more.

The level nature of five stands is reflected in the occurrence of forb species such as Veratrum viride, Ligusticum americanum and Caltha biflora. Shrub cover is low in all and forb cover varies from relatively heavy along Olallie Trail to scant in all other stands. Stands, especially along Park Trail, show a very heavy ground cover of needles and twigs.

Thirteen of the stands show either Brachythecium hylotapetum, B. curtum forma or both. Seven show no ground bryophytes, these stands being primarily along Olallie Trail. Three show Bryum sandbergii, often with other species; two show Rhytifiopsis robusta, often with other species. Four stands have small covers of other species. Four of those showing Bryum sandbergii, without either Brachythecium hylotapetum or B. curtum forma, have low spruce cover.

The epilithic species are Rhacomitrium heterostichum, R. patens, R. varium and Lescuraea patens. Epixylic species are

generally scant but Hypnum circinale, Dicranum fuscescens and D. strictum are the more common of these.

Of the corticolous species, Hypnum circinale is the most common and seems to show no specificity as to the tree species on which it occurs. An interesting rust-colored hepatic, Ptilidium californicum, appears in some stands but it also shows no specificity as to host tree.

Table 24

Stand Descriptions and Terrestrial Bryophytes of Group G

Stand numbers	50	50(a)	54	55	56	57
Location	Ollallie Tr., 5¼ mi.	Olallie Tr., 5¼ mi.	Olallie Tr., by shelter	Horse Pasture Mt. Tr., jct. with Indian Way	Horse Pasture Mt. Tr. below Indian Way jct.	Horse Pasture Mt. Tr., ½ mi. to shelter
Altitude	4800	4800	5000	5400	5300	5100
Slope, exposure	30°N	10°SW	30°N	10°SW	15°W	30°W
Ground cover (needles, logs rocks, pumice)	---	---	---	---	---	---
Shrub cover		+		+	+	+
Shrub species						
Sambucus glauca				X		
Pachystima myrsinitis					X	
Amelanchier florida					X	
Rubus spectabilis						X
Ribes sp.				X		
Rosa gymnocarpa		X				
Forb cover	1	4		4	5	+
Forb species						
Smilacina sessilifolia				X		
Xerophyllum tenax				X	X	
Veratrum viride						X
Montia sibirica				X		
Rumex acetosella				X		
Phlox speciosa	X					
Asarum caudatum	X					
Vancouveria hexandra	X					
Rubus pedatus		X				
Pyrola secunda		X				
Tree species						
Abies procera	60					
A. amabilis	16	8 young				
A. lasiocarpa				28+ snags	21	
Pinus monticola	2		(Epilithic		2	(Epilithic
Tsuga mertensiana	+		species			species
Pseudotsuga menziesii			only)		4	only)
Terrestrial bryophyte species					+	
Bryum sandbergii	2(1)	3(4)		2(4)		
Dicranum fuscescens	4(1)					
Polytrichadelphus lyalli				1(1)		

Table 24, continued

Stand Descriptions and Terrestrial Bryophytes of Group G

Stand numbers	59	60	61	62	63	64
Location	Horse Pasture Mt. Tr., ¼ mi. to shelter	Same as 59	Same as 59, 60	Same as 59, 60, 61	Olallie Tr. SE of shelter	Olallie Tr. SE of shelter
Altitude	5000	5000	5000	5000	4800	4800
Slope, exposure	10°W	10°W	30°W	15°W	30°SW	15°W
Ground cover (needles, logs rocks, pumice)	---	---	---	---	---	---
Shrub cover			4		1	1
Shrub species						
Vaccinium membranaceum			X			
Acer circinatum					X	X
Pachystima myrsinitis					X	
Forb cover	2	3	1	1	1	1
Forb species						
Smilacina sessilifolia		X			X	
Asarum caudatum				X		
Rubus pedatus		X	X	X		
Achlys triphylla	X	X		X		
Hypopitys sp.	X					
Dicentra formosa				X		
Chimaphila umbellata						X
Pyrola secunda						X
Tree species						
Abies procera		21	34	31		
A. amabilis	63	9	2	12		20
A. grandis					13	23
Pinus monticola		21	15			
Tsuga mertensiana			1			
Pseudotsuga menziesii					21	16
Terrestrial bryophyte species					none	
Bryum sandbergii	2(1)	1(3)	3(7)	3(10)		
Dicranum fuscescens						+
Polytrichadelphus lyalli			+	+		
Brachythecium curtum forma	1(4)					

Table 24, continued

Stand Descriptions and Terrestrial Bryophytes of Group G

Stand numbers	65	66	69(a)	69(b)	70	71
Location	Olallie Tr., E Fork Tr. jct.	Olallie Tr., Indian Way jct.	Quaking Asp Swamp	Quaking Asp Swamp	Quaking Asp Tr. to Olallie Tr.	Same as 70
Altitude	4800	4800	4000	4000	4200	4200
Slope, exposure	30°S	E, W ridge	10°S	10°S	10°W	35°S
Ground cover (needles, logs, rocks, pumice)	---	---	heavy duff	heavy duff	---	---
Shrub cover		1	1	1	2	4
Shrub species						
Vaccinium membranaceum		X				
Acer circinatum			X	X	X	X
Rubus parviflorus			X			
Forb cover		1	+	+	1	1
Forb species						
Smilacina sessilifolia			X	X		X
Clintonia uniflora		X				
Xerophyllum tenax		X				
Achlys triphylla		X				
Tiarella unifoliata		X				
Chimaphila umbellata			X		X	
Githiopsis specularioides				X		
Pyrola bracteata						X
P. secunda			X	X		
Pteridium aquilinum			X			
Tree species						
Abies amabilis	27		10 young	20		20
A. grandis	15	27	22	5	41	4
Pinus monticola				20		
Pseudotsuga menziesii	13	27	35	3		5
Terrestrial bryophyte species			none	none		none
Bryum sandbergii	*3(4)	4(9)			1.5(4)	

* outside stand

Table 24, continued

Stand Descriptions and Terrestrial Bryophytes of Group G

Stand numbers	80	81	82	83
Location	Olallie Tr., Potholes to G. S.	Same as 80	Same as 80, 81	Same as 80, 81, 82
Altitude	5000	5000	5000	5000
Slope, exposure	20°S	10°S	10°S	5°S
Ground cover (needles, logs, rocks, pumice)	---	---	heavy needles and branches	---
Shrub cover	1	3	2	3
Shrub species				
Vaccinium membranaceum	X	X		X
Acer circinatum			X	
Forb cover	+	3	2	2
Forb species				
Smilacina sessilifolia		X	X	
Clintonia uniflora			X	X
Disporum oreganum				X
Listera sp.				X
Pyrola secunda			X	X
Tiarella unifoliata				X
Chimaphila umbellata				X
Rubus pedatus	X		X	
Ligusticum americanum	X			
Anemone sp.	X			
Pteridium aquilinum	X	X	X	
Tree species				
Abies grandis	26	.2	14	20
A. amabilis		1.2	27	20
Pinus monticola	23	+		
Tsuga mertensiana				
Pseudotsuga menziesii	24		20	20
Terrestrial bryophyte species			none	
Bryum sandbergii	4.5(15)	1(1)		2(4)
Polytrichadelphus lyalli		3.5(7)		
Ditrichum heteromallum		3(3)		

Table 24, continued

Stand Descriptions and Terrestrial Bryophytes of Group G

Stand numbers	92	93(a)	93(b),(c)	94	95
Location	Olallie Mt.	Olallie Mt. Tr.	Olallie Mt. Tr.	Olallie Mt. Tr.	Olallie Mt. Tr. near saddle
Altitude	5700	5600	5600	5500	5500
Slope, exposure	45°W	45°W	45°W	45°W	10°N
Ground cover (needles, logs, rocks, pumice)	much dead timber	---	---	---	---
Shrub cover	+	+	+	4	2
Shrub species					
Vaccinium membranaceum				X	X
Amelanchier florida	X				
Pachystima myrsinitis		X			
Rosa gymnocarpa		X	X		
Acer circinatum				X	
Forb cover	2	4	4	+	+
Forb species					
Smilacina sessilifolia	X				
Heuchera sp.	X				
Aquilegia formosa		X	X		
Pyrola secunda		X	X		
Chelone nemorosa		X	X		
Rubus pedatus				X	X
Tree species					
Abies grandis	18	4	4	1	29
Pinus monticola	1				
Tsuga mertensiana		+		20	4
Pseudotsuga menziesii		4	4		
Terrestrial bryophyte species	none				
Bryum sandbergii		4(8)	4(2)	3(9)	3(3)
Polytrichadelphus lyalli					1(5)
Rhytidiopsis robusta		2(3)			
Eurhynchium strigosum		1.5(2)	3.5(4)		
Ditrichum heteromallum					3(5)
Plagiothecium denticulatum			3(1)		

Table 25

Epilithic Species of Group G Stands

Stand numbers	59	61	62	92
Claopodium crispifolium	5(4)			5(1)
Lescuraea stenophylla				3,2(1)
Mnium sp.				
Heterocladium procurrens				
Lescuraea radicosa	5(2)			
Foliose lichen				
Rhacomitrium patens	2,2,1(1)			
Lescuraea patens				
Camptothecium lutescens				
Rhacomitrium patens				
Claopodium crispifolium				
Pseudoisothecium stoloniferum		5(1)		
Lescuraea patens		3,1(1)		
Rhacomitrium patens		4.5(2)		
Pseudoisothecium stoloniferum		3,2(1)		
Rhacomitrium heterostichum				
Claopodium crispifolium				
Rhacomitrium varium			5(2)	
Lophozia minor			1,2.5(2)	

Table 25, continued

Stand numbers	93(c)	54	57
Claopodium crispifolium	4(5)		
Lescuraea stenophylla			
Mnium sp.	3,2(1)		
Heterocladium procurrens	5(1)		
Lescuraea radicosa			
Foliose lichen			
Rhacomitrium patens			
Lescuraea patens			4(2)
Camptothecium lutescens	2,2(1)		
Rhacomitrium patens			4,1(1)
Claopodium crispifolium			2,3(1)
Pseudoisothecium stoloniferum			
Lescuraea patens			
Rhacomitrium patens			4.5(2)
Pseudoisothecium stoloniferum			
Rhacomitrium heterostichum		5(3)	
Claopodium crispifolium		2.5,2(3)	
Rhacomitrium varium			
Lophozia minor			

Table 26

Epixylic Species of Group G Stands

Stand numbers	69(a)	69(b)	82	83	50	92
Dicranum strictum						
Hypnum circinale		3.5,1.5(4)				
Lophozia porphyroleuca	2,1,1(3)					
Lophozia porphyroleuca			2.5,1.5(3)			
Hypnum circinale		5(5)	4.5(3)			
Dicranum fuscescens			4,1(1)			
Lophozia porphyroleuca			4,1(1)			
Eurhynchium strigosum						
Pohlia nutans				4,1,1(1)		
Dicranum fuscescens			4(1)			
Lophozia porphyroleuca			4,1(1)			
Lichen					1,1(4)	
Polytrichadelphus lyalli				5(6)		
Brachythecium velutinus						+

Table 27

Corticolous Species of Group G Stands

Stand numbers	50	61	64
Abies procera	Plagiothecium denticulatum, Hypnum circinale, Dicranum strictum	Hypnum circinale and Dicranum fuscescens one foot up trunk on downhill side	
A. amabilis		Same as for Abies procera	Scant Hypnum circinale
Pseudotsuga menziesii			Hypnum circinale extends 2 feet up trunk

Table 27, continued

Stand numbers	65	69(b)	70	71
Abies amabilis		Scant Hypnum circinale at base		Hypnum
Pseudotsuga menziesii	Hypnum circinale at base	Scant Hypnum circinale at base		Hypnum circinale on north side; Dicranum strictum, Cladonia sp., Ptilidium californicum on S and W
Acer circinatum				Lescuraea stenophylla on prostrate branches
Abies grandis			Hypnum circinale to 2 feet on uphill side, Lescuraea stenophylla on root, Dicranum suscescens	

Table 27, continued

Corticolous Species of Group G Stands

Stand numbers	79	92	93(c)
Abies grandis	Hypnum circinale, Dicranum strictum		Plagiothecium seligeri, Ptilidium californicum
Exposed roots of Abies grandis		Lescuraea stenophylla	
Abies lasiocarpa		Lescuraea stenophylla, Brachythecium velutinus	

SUMMARY OF GROUP G STANDS

All of these stands have some species of Abies. The distribution is as follows: four stands with Abies procera and A. amabilis; eight with A. amabilis and A. grandis; two with A. amabilis only; nine with A. grandis only; and two with A. lasiocarpa only. Two of the 27 stands were studied for epilithic species only.

Shrub cover in most stands is low. Composition of the cover is rather variable as might be expected with stands ranging from 4000 to 5700 feet in altitude and with slopes from 45°W and 30°SW to 10°N. Forb cover on Olallie Mt. and on Horse Pasture Mt. is relatively high but low in the other stands; no one species or group of species is common to very many stands.

Seventeen of the 25 stands show Bryum sandbergii. Nine of these, including one with Brachythecium curtum forma, have some other species as well. Six stands have no terrestrial bryophytes and two have a scanty cover of them.

Claopodium crispifolium has the most cover of the epilithic species with Rhacomitrium patens and Pseudoisothecium stoloniferum considerably less.

Of the epixylic species, Hypnum circinale is the most abundant with Dicranum fuscescens and D. strictum (Plate 40, p. 171) much less. Hypnum circinale is also the most common corticolous species and occurs on a number of species of trees.

Table 28

Stand Descriptions and Terrestrial Bryophytes of Group H

Stand numbers	110	45	46(b)	47	48	49
Location	Park Tr., 1½ mi. to Horse Lk. G. S.	McBee Tr., 3/4 mi. to jct. with Skyline Tr.	McBee Tr., ½ mi. to jct. with Skyline Tr.	McBee Tr., ¼ mi. to jct. with Skyline Tr.	Same as 47	Same as 47, 48
Altitude	5000	5000	5000	5000	5000	5000
Slope, exposure	20°NE	10°E	10°E	5°N	5°N	10°N
Ground cover (needles, logs, rocks, pumice)	Mat of needles, twigs	Mat of needles, twigs	Mat of needles, twigs	Mat of needles, twigs	Mat of needles, twigs	Mat of needles, twigs
Shrub cover	+	3	1	4	3	3
Shrub species						
Vaccinium membranaceum	X	X	X	X	X	X
V. myrtillus microphyllum			X	X		
Gaulteria ovatifolium			X		X	
Phyllodoce empetriformis			X			
Forb cover	+			+	1	
Forb species	X				X	
Xerophyllum tenax	X				X	
Viola sempervirens				X		
Pyrola secunda					X	
Rubus pedatus					X	
Tree species						
Tsuga mertensiana	.1	20		64	8	14
Abies amabilis	7	49	+	32	62	45
Pinus monticola	+		+			
Terrestrial bryophyte species						
Dicranum fuscescens	4.5(200)	2(10)	2.5(11)	2(10)	1.5(6)	3(10)
Rhytidiopsis robusta			3(6)			

Table 28, continued

Stand Descriptions and Terrestrial Bryophytes of Group H

Stand numbers	150	151	152	154	155	67
Location	Foley Ridge Tr., Buck Meadows Jct.	Foley Ridge Tr., west of Buck Meadows Jct.	Foley Ridge Tr., Sub. Peak Jct.	Same as 152	Same as 152, 154	Olallie Tr., jct. with Castle Cr. Way
Altitude	5500	5500	5800	5500	5500	5200
Slope, exposure	10°S	level	10°NW	20°S	10°S	25°S
Ground cover (needles, logs, rocks, pumice)	mat of needles twigs	mat of needles twigs	mat of needles twigs	mat of needles twigs	mat of needles twigs	mat of needles twigs
Shrub cover	+					+
Shrub species						
Vaccinium membranaceum	X					
Forb cover		2		1		
Forb species						
Xerophyllum tenax				X		
Lutkea pectinata		X				
Rubus pedatus		X				X
Tree species						
Tsuga mertensiana	31		19	1	7	3
Abies amabilis	5	8	4 + 50 young	21	9	24
Terrestrial bryophyte species						
Dicranum fuscescens	+	2+(1)		3(2)	2.5(9)	
Bryum sandbergii			3(1)			3(3)
Polytrichadelphus lyalli			5(2)			3(5)

Table 28, continued

Stand Descriptions and Terrestrial Bryophytes of Group H

Stand numbers	73	74	75	77	78	23
Location	Quaking Asp Swamp near Olallie Tr.	Same as 73	Same as 73, 74	Olallie Tr. S of Potholes	Same as 77	Elk Lake to Horse Lake, 3 mi.
Altitude	4500	4500	4500	5000	5000	5500
Slope, exposure	30°E	30°E	30°E	30°NE	30°N	10°W
Ground cover (needles, logs, rocks, pumice)	twigs, needles	twigs, needles	twigs, needles	twigs, needles	twigs, needles	mat of twigs, needles
Shrub cover		2		1	1	4
Shrub species						
Vaccinium membranaceum		X		X	X	
V. myrtillus microphyllum						X
Forb cover	1	1		1	1	
Forb species						
Xerophyllum tenax					X	
Trillium ovatum				X		
Viola sempervirens				X		
Rubus pedatus	X	X				
Pyrola secunda	X					
Tree species						
Tsuga mertensiana	57	18	.3	20	14	119
Abies amabilis	11	11	15	42	47	1.2
Pinus monticola			2			
Terrestrial bryophyte species				none	none	
Dicranum fuscescens						1(200)
Bryum sandbergii			4(5)			1(200)
Polytrichadelphus lyalli	4.5(7)	3(10)				

Table 28, continued

Stand Descriptions and Terrestrial Bryophytes of Group H

Stand numbers	171	172	173	174	175	176
Location	Oregon Skyline Tr.-Frog Camp to Sunshine Shelter	Same as 171	Same as 171, 172	Same as 171, 172, 173	Same as 171-174 (incl.)	Same as 171-174 (incl.)
Altitude	6000	6000	5500	5500	5500	5500
Slope, exposure	10°NE	5°N	15°E	5-10°E	10-15°E	Depression
Ground cover (needles, logs, rocks, pumice)	---	much debris	much debris	much debris	much debris	---
Shrub cover	2	2	1	1	---	---
Shrub species						
Vaccinium membranaceum	X			X		
V. myrtillus microphyllum	X	X	X	X		
Forb cover	+	+				
Forb species						
Rubus pedatus	X	X				
Tree species						
Tsuga mertensiana		40	14	36		
Abies amabilis	45	22	22	34	45	45
Terrestrial bryophyte species					none	
Dicranum fuscescens	3.5(7)	2(2)	3.5(7)	4(13)		4(7)
Bryum sandbergii			2(1)			

Table 28, continued

Stand Descriptions and Terrestrial Bryophytes of Group H

Stand numbers	177	178	179
Location	Skyline Tr. Frog Camp to Sunshine Shelter	Same as 177	Same as 177, 178
Altitude	5500	5500	5000
Slope, exposure	depressed	depressed	10°SW
Ground cover (needles, logs, rocks, pumice)	heavy duff	heavy duff	much down timber
Shrub cover			2
Shrub species			
Vaccinium myrtillus microphyllum			X
Forb cover			1
Forb species			
Xerophyllum tenax			X
Rubus pedatus			X
Tree species			
Tsuga mertensiana		34	13
Abies amabilis	45	2	5
Terrestrial bryophyte species		none	
Dicranum fuscescens	4(24)		2(2)
Polytrichum juniperinum			1.5(2)
Pohlia nutans			1(3)

Table 29

Epilithic Species of Group H Stands

Stand numbers	46(b)	49	75	77	152	175
Dicranum fuscescens	5(3)			5(1)	5(3)	
Rhacomitrium patens	2,3(1)					
Lescuraea stenophylla	5(2)					
L. patens				4.5(7)		5(5)
Dicranum fuscescens				4,1(1)		
Brachytecium velutinus						4.5(9)
Polytrichadelphus lyalli	3,3(1)					
Heterocladium procurrens	5(2)	3(1)				
Dicranum fuscescens		4,1.5(2)				
Bryum sandbergii			5(1)			
Lescuraea patens			2,1(1)			
Hypnum subimponens						
Lescuraea patens			2,1(1)			

Table 30

Corticolous Species of Group H Stands

Stand numbers	23	75	78	175
Tsuga mertensiana	Dicranum strictum in crack; D. fuscescens at base		Hypnum circinale Plagiothecium denticulatum	
Abies amabilis		Ptilidium californicum	Map	Scant Ptilidium californicum

SUMMARY OF GROUP H STANDS

Of the 27 stands, all except four show both Tsuga mertensiana and Abies amabilis and these show only the latter species. Of the shrubs, Vaccinium membranaceum occurs alone in eight stands, with V. myrtillus microphyllum in three, and the latter species occurs alone in three stands. Forbs are scarce. Rubus pedatus occurs in eight stands and Xerophyllum tenax in five.

Eighteen of the 27 stands have Dicranum fuscescens: Four show no terrestrial bryophytes and the others show Polytrichadelphus lyalli and Bryum sandbergii, either alone or in combination. The Dicranum is found on rotting wood in soil.

Lescuraea patens has the most cover of the epilithic species with Dicranum fuscescens, so abundant on soil, second in importance on the rocks. Probably investigation would show that the rocks are covered with soil in which rotting wood is present.

There are no epixylic species and the corticolous species are scarce.

Table 31

Stand Descriptions and Terrestrial Bryophytes of Group I

Stand numbers	103	180	181	182	39
Location	Jct. Park Tr., Eugene Creek Way	Frog Camp to Sunshine Shelter	Same as 180	Same as 180, 181	Jct. Mirror Lk. Tr., Skyline Tr.
Altitude	4700	5000	5000	5000	6400
Slope, exposure	level	level	level	level	level
Ground cover (needles, logs, rocks, pumice)	---	---	---	---	pumice
Shrub cover	3	5	5	5	
Shrub species					
Vaccinium membranaceum		X	X		
V. myrtillus microphyllum	X	X	X	X	
Forb cover	1	1	1	1	+
Forb species					
Xerophyllum tenax	X	X	X	X	
Juncus sp.					X
Tree species					
Pinus contorta	33	16	12	12	20
Tsuga mertensiana	3	10	8	8	50 young
Abies lasiocarpa			2	2	5 young
Terrestrial bryophyte species					
Polytrichum juniperinum		+	1(1)	2.5(4)	
P. piliferum	2(5)				3(5)
Pohlia nutans	2.5(9)	+	2(1)	1.5(2)	
Dicranum fuscescens			3(2)	1.5(2)	

Table 31, continued

Stand Descriptions and Terrestrial Bryophytes of Group I

Stand numbers	42	43	43(b)	12	96	97
Location	Horse Mt. trail near lookout	Horse Mt. trail	Fisher Lake	Black Crater Trail	Olallie Mt., saddle	Olallie Mt., saddle
Altitude	5900	5500	5500	5000	5000	5000
Slope, exposure	S ridge	20°E	10°N	5°N	5°E	5°E
Ground cover (needles, logs rocks, pumice)					heavy needle	heavy needle
Shrub cover	1		+			+
Shrub species						
Ceanothus velutinus	X					
Amelanchier florida	X					
Archtostaphylos nevadensis	X					
A. Uva-ursi	X					
Vaccinium membranaceum		X				
V. myrtillus microphyllum		X				
Sambucus glauca						X
Forb cover	+	1	+		+	+
Forb species						
Lupinus sp.	X					
Aster alpigenus	X	X				
Pedicularis racemosa		X				
Rubus pedatus			X			
Juncus sp.					X	
Carex sp.						X
Tree species						
Pinus contorta	30	20	13	74		37
Tsuga mertensiana	20	7	59	17	21	2 young
Abies lasiocarpa		4 young		74	1	2
A. amabilis		15				
Pinus monticola			15			
P. albicaulis	20					
Terrestrial bryophyte species	none		none			
P. piliferum					4(5)	2(5)
Polytrichadelphus lyalli		3(5)				
Bryum sandbergii				3(13)		
B. argenteum				3(2)		

Table 32

Stand Descriptions and Terrestrial Bryophytes of Group J

Stand numbers	35	36	37	38	13	14
Location	Sisters Mirror Lakes	Sisters Mirror Lakes	Sisters Mirror Lakes	Sisters Mirror Lakes	Green Lakes	Green Lakes
Altitude	6400	6400	6400	6400	6500	6500
Slope, exposure	level	level	level	level	15°W	15°W
Ground cover (needles, logs, rocks, pumice)	pumice	pumice	pumice	pumice	---	---
Shrub cover	2	2	2		2	2
Shrub species						
Vaccinium sp.		X	X			
V. myrtillus microphyllum	X				X	X
Phyllodoce empetriformis		X				
Forb cover	+	+	1	1	1	1
Forb species						
Luzzula glabrata	X				X	X
Lupinus sp.	X				X	X
Carex sp.	X		X	X		
Juncus sp.			X	X		
Potentilla flabellifolia		X				
Castilleja pumicola		X				
Lutkea pectinata			X			
Polygonum newberryi				X		
Tree species						
Tsuga mertensiana	103	101	86		180	60
Abies lasiocarpa	42		32			11
Pinus albicaulis					1	
P. contorta				few young		4
Terrestrial bryophyte species						
Polytrichum juniperinum	4(3)	3(1)			1(2)	2(5)
P. piliferum	+			+		
Polytrichadelphus lyalli		1(5)			+(1)	4(27)
Pohlia nutans			2.5(7)			*3(4)

* outside stand

Table 32, continued

Stand Descriptions and Terrestrial Bryophytes of Group J

Stand numbers	15	16	17
Location	Husband Lake	Husband Lake	Obsidian camp on Skyline Tr.
Altitude	6300	6300	6300
Slope, exposure	5°S	5°S	10°SW
Ground cover (needles, logs, rocks, pumice)	pumice	pumice	pumice
Shrub cover	1	2	2
Shrub species			
Vaccinium sp.	X	X	
V. myrtillus microphyllum		X	X
Cassiope mertensiana	X		
Forb cover	+	+	1
Forb species			
Lutkea pectinata	X		
Luzzula glabrata	X	X	X
Lupinus sp.			X
Carex, sp.			X
Tree species			
Tsuga mertensiana	90	90	137
Abies lasiocarpa		10	23
A. amabilis		2	20
Pinus albicaulis			1
Terrestrial bryophyte species			
Polytrichum juniperinum	1(2)	+	1.5(6)
P. piliferum			

Table 33

Corticolous Species of Group I and J Stands

Stand numbers	13	15	17	181	182
Tsuga mertensiana	Pohlia nutans, Polytrichum juniperinum	Pohlia nutans, Polytrichum juniperinum, Dicranum strictum Plagiothecium denticulatum, Lophozia porphyroleuca	Plagiothecium denticulatum		Hypnum circinale, Plagiothecium elegans, Lophozia porphyroleuca
Abies amabilis				Pohlia nutans, Lophozia porphyroleuca	

SUMMARIES OF GROUPS I AND J STANDS

These two groups show enough overlap in habitat conditions, tree species and bryophyte species that they will be discussed together.

Most of the stands of Group I are found at lower altitudes than are those of J, being from 4700 to 5900 feet. Pinus contorta, Tsuga mertensiana and Abies lasiocarpa are the dominant tree species. Five of these 11 stands show Vaccinium membranaceum and V. myrtillus microphyllum; the others are variable as to species and there is variation as to cover, also. There is variability as to forb cover and forb species also.

Group J stands are all at about 6300 to 6500 but with exposure varying from level to about 15°W. Tsuga mertensiana, Abies lasiocarpa, sometimes A. amabilis and sometimes Pinus albicaulis, are the tree species. Of the eight stands, seven show either Vaccinium sp. or V. myrtillus microphyllum or a combination of these two. Forb cover is low and the scattered Carex sp. and Luzzula glabrata are rather common.

The terrestrial bryophyte species of the stands in these two groups are Polytrichum juniperinum in seven stands, P. piliferum in four, and those all in Group I, Polytrichadelphus lyalli in four and Pohlia nutans, considered a weed species, (Plate 41, p. 171) in five stands.

Epilithic and epixylic species are scant and the corticolous species are some of the same species as are found on the ground.

DISCUSSION

Although this study is in the nature of a reconnaissance, some tentative conclusions can be drawn. A number of correlations between particular tree species and particular species of terrestrial bryophytes are evident. There is a lesser degree of correlation between tree species and the epilithic and epixylic species of bryophytes. Corticolous species reveal more of a quantitative than a qualitative correlation with the tree species.

The two stands, 3-1 and 3-2 of Group A, with overmature Pseudotsuga menziesii, are characterized by Eurhynchium oreganum as the ground moss. This uniform bryophyte cover continues along Castle Creek Way for one-half mile or so above these stands (Plate 14, p.141)(Plate 15, p. 141). The Eurhynchium diminishes gradually as the hill sides become steeper and the stands of Group D are approached. In stands 1-1 and 1-2 along lower Horse Creek and stands of lower Rebel Rock Trail where the Pseudotsuga is smaller, the Eurhynchium is associated with Rhytidiadelphus triquetrus (Plate 3, p. 125). A correlation between Pseudotsuga menziesii and Eurhynchium oreganum was reported in the Mt. Rainier area (41, p. 152-153). None of the stands in the Three Sisters Area is exactly equivalent to the Mt. Rainier Pseudotsuga community for there is some Thuja plicata present in all of the Oregon stands. The uniform layer of Eurhynchium oreganum in what must have been preponderantly Pseudotsuga menziesii,

150-200 years ago, indicates a probable correlation between these tree and the bryophyte species in this area.

With the presence of Acer macrophyllum and Hydrophyllum tenuipes in stands 2-1, 2-2 and 6, indicating that they are subject to floods, the Eurhynchium oreganum is replaced by Mnium insigne (Plate 7, p. 133). This represents a change from a moss species of mat growth form to a canopy forming species (30, p. 543). The predominating effect of ground water supply upon the growth form aspect of a bryophyte community is indicated (4, p. 22-24). Mnium insigne has scattered leaves (Plate 8, p. 133) so that internal, rather than external, conductance of water probably occurs (8, p. 659-660), another reflection of the damp situation.

Within stands of Group A, Rhytidiadelphus triquetrus is found on the ground, on rocks and on logs. The weft growth form, which it represents (30, p. 543, has the widest range of microhabitats because it is only moderately dependent on ground water (4, p. 22-24).

Oxalis oregana is present in the stands along lower Horse Creek and along Eugene Creek Way. All of these stands, except the latter, show abundant terrestrial bryophyte cover. Perhaps some relationship between this forb and the abundance of terrestrial bryophytes exists. Watson has suggested that Oxalis may sometimes eliminate moss but that in other cases it may prepare the ground better for bryophytes to establish themselves (89, p. 141).

A combination of Rhytidiopsis robusta (Plate 19, p. 145) (Plate 20, p. 147) and Eurhynchium oreganum accompanies the Tsuga heterophylla-Pseudotsuga menziesii in stands of Groups B and E. At Mt. Rainier National Park the predominant moss species in Tsuga heterophylla-Thuja plicata community is Rhytidiopsis robusta, with Eurhynchium oreganum in amounts related to the abundance of Pseudotsuga. In the higher altitude Abies amabilis-Tsuga heterophylla community, Rhytidiopsis continues to be the predominant moss. Higinbotham and Higinbotham concluded that this bryophyte species is correlated with the occurrence of Tsuga heterophylla (41, p. 159). A summary of the correlations of Groups B and E of the Three Sisters Area shows as many stands with Pseudotsuga only and both Rhytidiopsis and Eurhynchium as with both Pseudotsuga and Tsuga and both bryophyte species. At Proxy Falls on the McKenzie Highway, which is outside the Three Sisters Area, with old Tsuga heterophylla predominating, there is an abundance of Rhytidiopsis robusta on the soil, on rocks and extending upward on the bases of trees.

The occurrence of certain bryophyte species and tree species together points to similar habitat tolerances in some cases. This must be so in stands of Group C, those on south and southwest exposures. There the trees are far apart so that both they and the bryophytes are exposed to insolation, high temperatures, wind and low humidity. The low bryophyte cover, except on rocks, reflects the severe conditions in this habitat. Cantlon, in comparing conditions and vegetation on north and south slopes in New Jersey,

found 40 degrees greater insolation at all seasons on south slopes than on north slopes. Air and soil temperatures are higher and daytime wind velocity is greater. On the north slopes having more atmospheric moisture at midday (18, p. 246-250), the terrestrial mosses provide 25 times greater cover. 25% of the trees on this slope show good colonies of corticolous species in contrast to only 10% on the south slope (18, p. 254-256).

There is a close relationship between the ground vegetation and the age of the plantation. At about 25 years the thicket of the pole stage opens up and the tendency of the forest trees to eliminate the ground flora is halted (63, p. 17). Stands of Group D, with such an abundance of relatively small Tsuga heterophylla under the few, very large Pseudotsuga, show very few breaks in the canopy although they are older than 25 years (Plate 22, p. 149). Shrubs, forbs and terrestrial bryophytes are very scant.

The heavy mat of needles and twigs under Picea engelmanni (Plate 24, p. 151) in Group F stands is the substratum for Brachythecium hylotapetum and B. curtum forma (Plate 26, p. 153). These species are found almost exclusively within the Picea stands of the Three Sisters Area covered by the study. However, a brief examination of Picea engelmanni-Abies lasiocarpa stands on Squaw Creek in the eastern part of the Area, showed neither of these two Brachythecium species, perhaps because of the lower rainfall. Tamm called attention to the better growth of Hylocomium under the

distal parts of spruce trees than near the center of the crown because of the smaller amount of needle litter there (84, p. 105-106). Some moss species can grow underneath a litter cover and pierce through it be means of stiff vertical shoots (84, p. 106) or by julaceous tips (73, p. 273). This litter cover in the Three Sisters Area is often an inch or more thick, which precludes such activity on the part of the bryophytes.

Tree species determine, more by their litter probably than by their shade (73, p. 273), which bryophyte species are present in an area and their relative abundances. This may be through the effect upon available nitrogen. Pine, spruce and hemlock release little basic matter into soil, thereby inhibiting the bacterial activity necessary to provide this mineral element (19, p. 1063). Or, if the litter decays very slowly, bryophyte growth is retarded. Beechwoods (89, p. 142) and Killarney oakwood (76, p. 117), both with heavy, slow-decaying leaf litter, have scant ground bryophyte cover. Introduction of conifers into deciduous forest increases the rate of decay and bryophytes increase in abundance (89, p. 470). The stands of Group H, the Abies - amabilis-Tsuga mertensiana (Plate 32, p. 161), have a very thick, compact, interwoven mat of needles and twigs bound together by a fungal mycelium (Plate 33, p. 163). Ground bryophytes, except for the Dicranum fuscescens on buried logs, are missing. The Dicranum is not very robust and it may be presumed that, if the

forest continues to be undisturbed, the patches of this moss will be completely buried.

Dicranum fuscescens (Plate 34, p. 163) under Abies amabilis and Tsuga mertensiana certainly represents a species in a habitat modified profoundly by the trees. The dense shade and high humidity favor rotting of logs. Since this is undoubtedly a climax, decomposition has been going on for a long time. This bryophyte species, which is found on well-rotted logs but not on the ground in stands of Groups C and D, is found on the ground in stands of Group H because the wood of the logs is imbedded in the soil. The correlation of Dicranum fuscescens with the Tsuga and Abies, because of the 300 years or so of development, is very well-defined. This tree species-bryophyte species correlation is also mentioned for the Mt. Rainier area. However, Rhytidiopsis robusta, reported as present there, was not found in the Three Sisters Area (41, p. 156-159).

Species of the Polytrichaceae are predominant in the higher altitude stands of Groups I and J. They are present in stands of other groups also but other species are more common there. At higher altitudes the other species are largely gone. Polytrichum piliferum occurs in the dry Pinus contorta forests (Plate 35, p. 165) where dust often buries the plants so that only the tips of the shoots are exposed (Plate 36, p. 165). Two reports of the ability of this species or of closely related ones to continue growth under these conditions is in the literature, Conard

said that errect species, such as P. commune, are capable of growing upward as fast as soil is washed around them (21, p. 347-351). Leach remarked that the underground stems of P. piliferum and P. juniperinum (Plate 37, p. 167) are not killed by being buried; new shoots come up from them to the surface. Some vertical sections through sand with P. piliferum on peat show living shoots of the moss down to 20 centimeters (48, p. 98-100).

P. piliferum and P. juniperinum are also considered as pioneers on rock detritus. Small fragments of the moss plants, lodged between rock fragments one or two centimeters in diameter, are anchored there by rhizoids (48, p. 98-100). This may explain the occurrence of P. juniperinum and Polytrichadelphus lyalli (Plate 39, p. 169) in pumice-covered areas in the Three Sisters Area. It is true that often they are restricted to creek banks and to the areas within the Tsuga mertensiana clumps but they are also sometimes found where there is pumice on the ground.

In addition to the problems of unstable or otherwise unfavorable substratum, these high altitude Polytrichaceae are subject to desiccation. The opinions of different research workers, concerning the efficacy of certain morphological modifications found on Polytrichum spp. in conserving water, are contradictory. Grout considered that the small, thick-walled cells of the gametophytes are a means of conserving water (33, p. 98). But Herzog cautioned that rolled leaf margins, sheaths and bent leaf bases, which are characteristic of true xerophytes, are also shown by

some hydrophytic members of the Polytrichaceae but to a lesser degree (40, p. 57). Watson agreed that many of the mosses with these special protective devices are not true xerophytes but considered that they are able to live under less moist conditions (88, p. 189). Patterson added that checking the xeric-mesic series of mosses reveals little or no correlation between xerophytism of bryophytes and their absorption of atmospheric moisture (66, p. 12).

The epilithic species are not uniformly distributed. For example, Scleropodium caespitosum (Plate 16, p. 143), which covers many rocks in stands of A, C and D, is lacking at altitudes above 4000 feet. Very little Claopodium crispifolium (Plate 31, p. 159) is found along lower Horse Creek but it does occur abundantly on Horse Creek Trail above Horse Lake Pasture Mountain and on Olallie Mountain. Stands of Group F, those with Picea engelmanni, show more Rhacomitrium and Lescuraea species (Plate 27, p. 155) and (Plate 28, p. 155). In the most favorable bryophyte habitats, along lower Horse Creek and the lower part of Castle Creek Way, bryophytes are found on all substrata. When the ground becomes unfavorable, because of drying or because of needles or brush, the epilithic species may persist as they do in stands of Groups C and D.

Epilithic species face a number of problems. First, they must become established on the rock and they are favored in this by fissures filled with decomposition crumbs (40, p. 73). Boulders and cliffs in the Three Sisters Area have rough surfaces with many crevices. Then, too, certain combinations of weather conditions

apparently are necessary for the attachment of the bryophytes to the rocks. Keever, working with Grimmia laevigata which grows on smooth granite, concluded that wind and water bring pieces of the plant to the rock. If the rock is wet every four or five days for two or three weeks, without dislocating the strands, protonemata are formed. These become anchored if cool, cloudy weather is followed by dry, sunny days as in the spring and fall (46, p. 28).

In the case of rock moss communities, there is also a question whether certain species are excluded because of the high light intensity or because of high day temperature or because of high saturation deficit (75, p. 371). The species of Rhacomitrium, exposed to high light intensity on rocks in stands of all groups except A and C, may be protected by dark brown and black pigments. The effectiveness of dark color in leaves as a light protective device has been confirmed. Sometimes, however, these pigments may be growth product substances not involved in light protection (40, p. 60-63).

Five of the ten groups of stands show scant or no epixylic species, either because there are no appreciable numbers of logs or because the logs are too dry. (Plate 35, p. 165). Four of the remaining five stands show Dicranum fuscescens. Sometimes the terrestrial bryophytes extend over the logs. This is so at lower Horse Creek and lower Castle Creek Way where Eurhynchium

oreganum is both on the ground and on the logs. Hylocomium splendens and Rhytidiadelphus triquetrus, found on the ground in very few stands in the Three Sisters Area, are present on the logs along lower Horse Creek. In the flood plain stands, Mnium insigne, the characteristic terrestrial species, is also found on logs to some extent.

The bryophyte flora varies on the vertical sides and cut ends of logs from that on the tops of logs, there being many more hepatics there. A few species, such Aulacomnium androgynum (Plate 11, p. 137), are pioneers on burned logs.

Most of the logs along lower Horse Creek are well decomposed and the bryophyte species on them probably represent late stages of succession. McCullough worked out eight decay stages on fallen logs in virgin spruce-fir forest in the Gothic Natural Area in Colorado. These ranged from D1 and D2, logs with intact bark, through D5, having loose fragments of wood, to D8, decay complete and soil formed. He then showed which bryophyte and lichen species are present at each of these stages in mesic, xeric and bog successions (49, p. 510-512). Using his criteria, most of the logs on lower Horse Creek are at stages D5 and D6; those in Abies amabilis-Tsuga mertensiana stands are very near D8.

The heights to which corticolous bryophytes grow along lower Horse Creek range from five and six feet to as much as 20 feet on some Thujas in the flood plain areas. Figures 4, 5, and 6

provide some idea of their extent. This appears to be a response to the higher humidity for corticolous bryophytes and lichens are known to extend farther up tree trunks in humid areas (90, p. 476). On trees in stands other than those on lower Horse Creek, they extend a foot or less, often being only on the extreme base or on exposed roots as shown in Figures 8, 9, 11 and 12. Cain and Penfound mentioned that there are fewer epiphytes up the tree trunks in a red maple forest because of lack of moisture. They added that there are fewer epiphytes near the base because of competition (15, p. 410). The latter condition probably does not exist anywhere in the Three Sisters Area.

Tree trunks do represent a severe habitat. Often the trunks above the bases of trees in exposed stand, as those of Group C, are occupied almost entirely by lichens (Fig. 10, p. 120).

Wind is another factor determining the distribution and abundance of corticolous bryophytes. Quercus in sheltered sites has a heavy moss cover but on trees exposed to wind there is less (51, p. 83). In Ann Arbor, Michigan woods lacking shrubs and with free wind, there are no bryophytes (68, p. 314). This probably partly determines corticolous bryophyte scarcity in stands of Group C and in the high altitude stands, I and J, although in the latter, insolation may be an important factor also.

Hypnum circinale as a corticolous species (Plate 10, p. 135), is found over quite a wide spread of habitats and tree

species. It is present on some tree species in stands of all groups. The host tree species include: Thuja plicata, Figure 4; Pseudotsuga menziesii, Figure 5; Abies grandis, Figures 6 and 12; Tsuga heterophylla, Figure 8; Abies procera, Figure 9; and Abies amabilis Figure 11. It appears to be scarce on Picea engelmanni and Tsuga mertensiana. There is no record of its presence on Abies lasiocarpa, Pinus contorta and P. monticola. It remains as one of the very few moss species found on trees covered with lichens almost from the base.

Higinbotham and Higinbotham found a correlation between Tsuga heterophylla and Hypnum circinale, the moss being primarily on logs and tree bases but also on the compact litter (41, p. 154-158). Perhaps if other corticolous species are present on other tree species, H. circinale may be restricted to the Tsuga. Where conditions are less favorable for corticolous species, as in the Three Sisters Area, H. circinale may spread to other tree species besides Tsuga because they are not otherwise occupied. No frequent mosses are specific to any tree but differences in bryophyte groups among trees are due to interactions among environment, bark, and tolerance to competition, according to Martin (51, p. 94). Hale concluded that the probability of finding one or more cryptogamic species on a randomly selected tree is a function of the interaction among three factors, the species of tree involved, the relative proportions of other tree species in the stand, and the presence of certain other cryptogams on the

same tree (35, p. 62).

Deciduous species, such as Populus trichocarpa and Acer macrophyllum (Plate 6, p. 131) have a much heavier cover of bryophytes than do any of the conifers. Wilson confirmed, by experimental means, her theory that different moss associations occur under the same physiographic conditions on different tree species because of variation in bark moisture conditions (91, p. 163-169). Patterson also emphasized the importance of the relative moisture-holding capacity of bark, if evaporational tension is high, in limiting distribution of corticolous bryophytes (65, p. 422-424).

Billings and Drew found six bryophyte unions on deciduous trees and only three on Tsuga, none on the deciduous trees also. There are two groups of corticolous species, those on the dry, fairly acid bark of Tsuga and those on the moist, less acid bark of deciduous trees. The bark of hardwoods is softer and more spongy, holding two to seven times as much moisture as does Tsuga bark, which is quite impervious (2, p. 325-326).

Some moss species, as Eurhynchium oreganum and Mnium menziesii, are never found above the bases of trees, except in cracks (Plate 10, p. 135), because the bark there is moister. When equilibrium between bryophyte community and moisture factors is reached in all zones on a tree, the bryophyte mat consists of several microclimaxes, each adapted to its own microclimate and microhabitat, Billings and Drew concluded (2, p. 325-326).

Ptilidium californicum, a corticolous hepatic, occurs above 4,000 feet altitude, primarily along Olallie Trail and trails leading into it. Phillips considered Ptilidium as one of the pioneer hepatics, occurring in dry habitats because of its ability to lodge on hard bark. The reddish-golden color may be a protective device against insolation (40, p. 60-63). It does occur on smooth Abies amabilis as well as on the checkered trunks of the Picea engelmanni and on the furrowed trunks of Pseudotsuga menziesii. Continued cracking of bark is a characteristic of the Pseudotsuga and this is considered as unfavorable for bryophyte establishment (75, p. 387). For most bryophytes fissures or cracks are necessary for establishment (34, p. 404), (51, p. 93); often the epiphytic vegetation starts at the cracks, then spreads longitudinally by cracks containing moisture (15, p. 410-411).

The upper surfaces of slanting coniferous tree trunks collect water in the case of direct rainfall. Most bryophytes are on the side of the tree where most rain falls; the lichens are on the other side as shown in Table 5, p. 33 . Watson made this same observation in British woods (90, p. 475). Similar observations have been reported on this relationship of slant to bryophyte distribution. Wilson mentioned that bulges on tree trunks retain moisture so that there is an abundance of bryophytes above them (91, p. 168). The upper sides of trunks inclined over ten degrees, are more favorable for bryophytes for they receive

more of the vertical rainfall (57, p. 340). The undersides of steeply sloping branches and of inclining trunks do not have well-developed associules of bryophytes (76, p. 120). Plate 13, p. 139, shows the bryophyte distribution on a leaning Pseudotsuga very clearly.

There are many unsolved problems concerning bryophytes in the Three Sisters Primitive Area. The area, except for lower Horse Creek, is not rich in bryophytes; perhaps, as suggested in the Review of the Literature, autoecological studies are needed to find out why it is so.

There are problems of bryophyte distribution also. Two species of moss in the area, both with very robust gametophytes, do not form sporophytes. One of these species is Hylocomium splendens (Plate 12, p. 137) which occurs along lower Horse Creek and around Cedar Swamp. There it forms continuous or mixed colonies, both on logs and on the soil. The other is Camptothecium megaptilum (Plate 42, p. 173), a robust, glossy form, in stands of Groups A, B, C and E. It never forms continuous mats but is always scattered throughout those of other species.

Martin spoke of some 50 species of mosses in New Zealand without sporophytes which must propagate themselves vegetatively so that they are rare or restricted since spore dissemination is the mechanism for wide dispersal (52, p. 110). The extreme boundary of a species is usually completely sterile. Some factor of the

environment, which is favorable to vegetative growth, apparently is below the optimum for the development of the sporophyte (40, p. 66-69)

More observations on the Picea engelmanni-Brachythecium hylotapetum (Plate 25, p. 153)-B. curtum forma correlation are needed. The distribution of B. hylotapetum is very interesting. It has been reported by Higinbotham and Higinbotham as occurring in northern Idaho forests with abundant Abies grandis and as also present in certain types of Abies lasiocarpa stands. It is found regularly in mature Thuja/Tsuga/Pachystima forests of north Idaho and northeastern Washington (42, p. 346-347). In the Three Sisters Area, of the thirteen stands in Groups E and F with this bryophyte species, it is accompanied by Abies sp. in eleven. However, since there are many stands in other groups with Abies sp. but no B. hylotapetum, the correlation with Picea engelmanni appears to be more significant. Since the sporophytes are formed in the very late fall, apparently maturing during the winter under the snow (42, p. 339), the matter of determining if this species fruits in this area may be difficult. None of the specimens collected showed any evidence of sporophytes.

Further work on the corticolous species would be profitable, providing that lichens are included. Perhaps an approach, such as that of Hale (35, p. 49-52), who plotted corticolous cryptogams along the continuum index for the tree species might

be applied here.

Some of the areas in the Three Sisters Primitive Area, such as the Potholes, Quaking Asp Swamp, around the Horse Lakes, and in Cedar Swamp, were not included in this study. Succession studies could be made of these. The work of Moore and Taylor (54, p. 137-139) on dense-canopied cedar swamps in Maine, mentions the lack of flowering plants, the carpet of Hylocomium proliferum over the hummocks, and the Mnium species present. This description applies to the Cedar Swamp forests to a considerable degree.

SUMMARY

1. One hundred fifty-five stands in the Three Sisters Primitive Area were studied as to species of trees, shrubs, forb and terrestrial bryophytes, the cover of each being recorded. Altitude, slope, exposre and unusual ground conditions of each stand were noted.

2. The area, except at lower Horse Creek, is not rich in bryophytes. Nevertheless, certain correlations between tree species and terrestrial bryophyte species are apparent. The stands were tentatively assembled in ten groups on the basis of these correlations.

The correlations shown are: (a) Pseudotsuga menziesii-Thuja plicata-Acer macrophyllum with Mnium insigne; (b) Pseudotusga menziesii-Thuja plicata ± Abies grandis with Eurhynchium oreganum and Rhytidiadelphus triquetrus; (c) over-mature Pseudotsuga menziesii-Thuja plicata-Tsuga heterophylla with Eurhynchium oreganum; (d) Tsuga heterophylla-Pseudotsuga menziesii with Rhytidiopsis robusta and Eurhynchium oreganum; (e) Picea engelmanni ± Abies amabilis and other tree species with Brachythecium hylotapetum- B. curtum forma; (f) Abies sp. with Bryum sandbergii; (g) Tsuga mertensiana and Abies amabilis with Dicranum fuscescens; (h) Pinus contorta and Tsuga mertensiana with Polytrichum piliferum and P. juniperinum; (i) Tsuga mertensiana, Abies lasiocarpa and Pinus albicaulis with P. juniperinum and Polytrichadelphus lyalli.

4. Epilithic species are usually different than the terrestrial species. They show some degree of correlation with tree species. Scleropodium caespitosum occurs in lower altitude stands having Pseudotsuga menziesii; Claopodium crispifolium, Rhacomitrium spp. and Lescuraea spp. are more abundant at 3500-5000 feet, above the usual range of the Pseudotsuga.

5. Epixylic species, except along lower Horse Creek, are scant. Dicranum fuscescens is the most wide spread of these.

6. Corticolous species are abundant along lower Horse Creek but decrease rapidly in the drier stands. Hynum circinale is the most widespread of these.

7. Two groups of stands have very few bryophytes, except epilithic species. These are the south and southwest exposure stands and the stands on very steep hillsides, with heavy shade because of the many small trees among the very few, very large, fire-scarred Pseudotsuga menziesii.

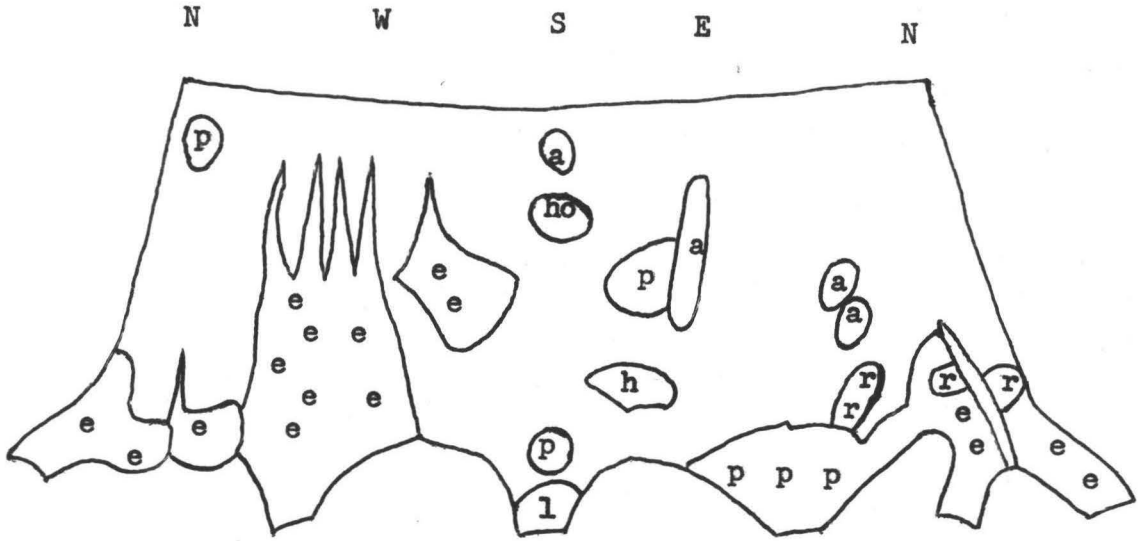


Fig. 1 - Abies grandis (2-1)

a - Antitrichia curtipendula
e - Eurhynchium oreganum
ho - Homalothecium nuttallii
p - Pseudoisothecium stoloniferum
r - Rhytidiadelphus triquetrus
l - lichen

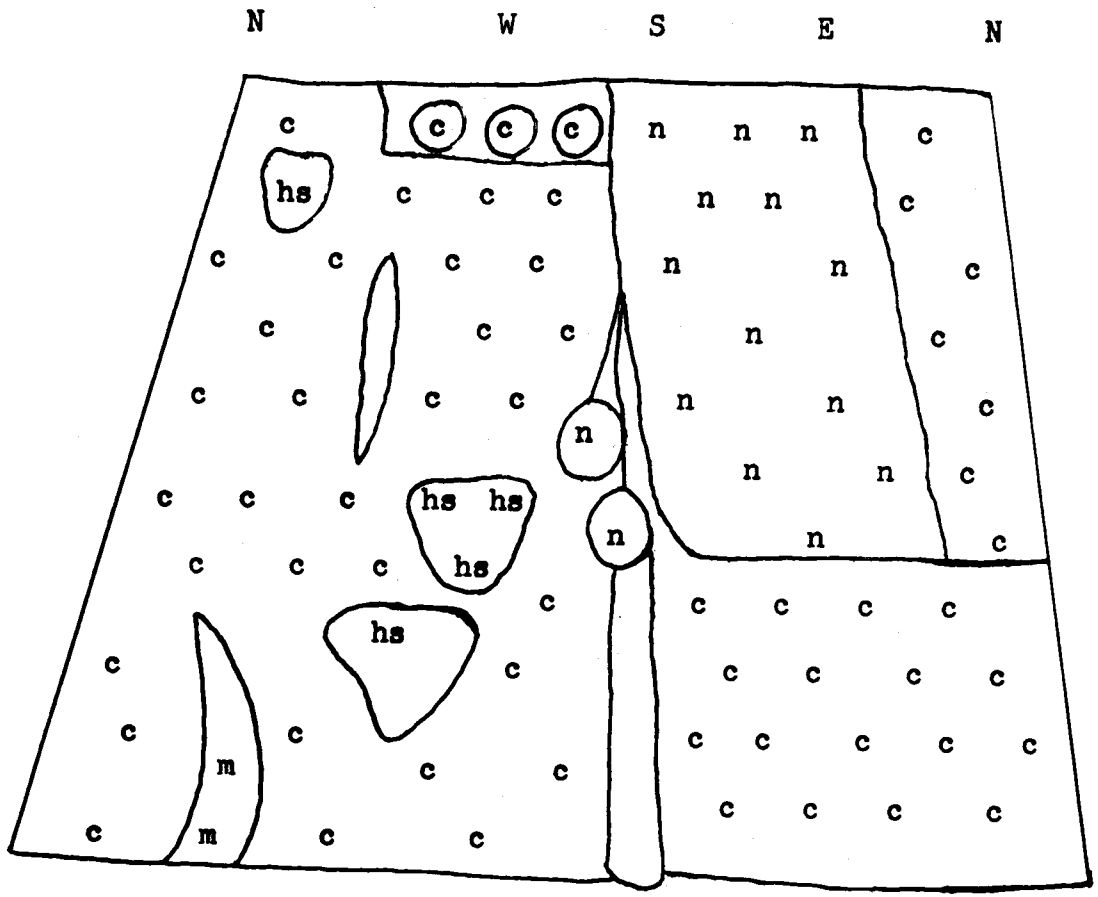


Fig. 2 - Acer macrophyllum (2-1)

c - Camptothecium lutescens
m - Mnium menzesii
n - Neckera douglasii
hs - Hypnum subimponens

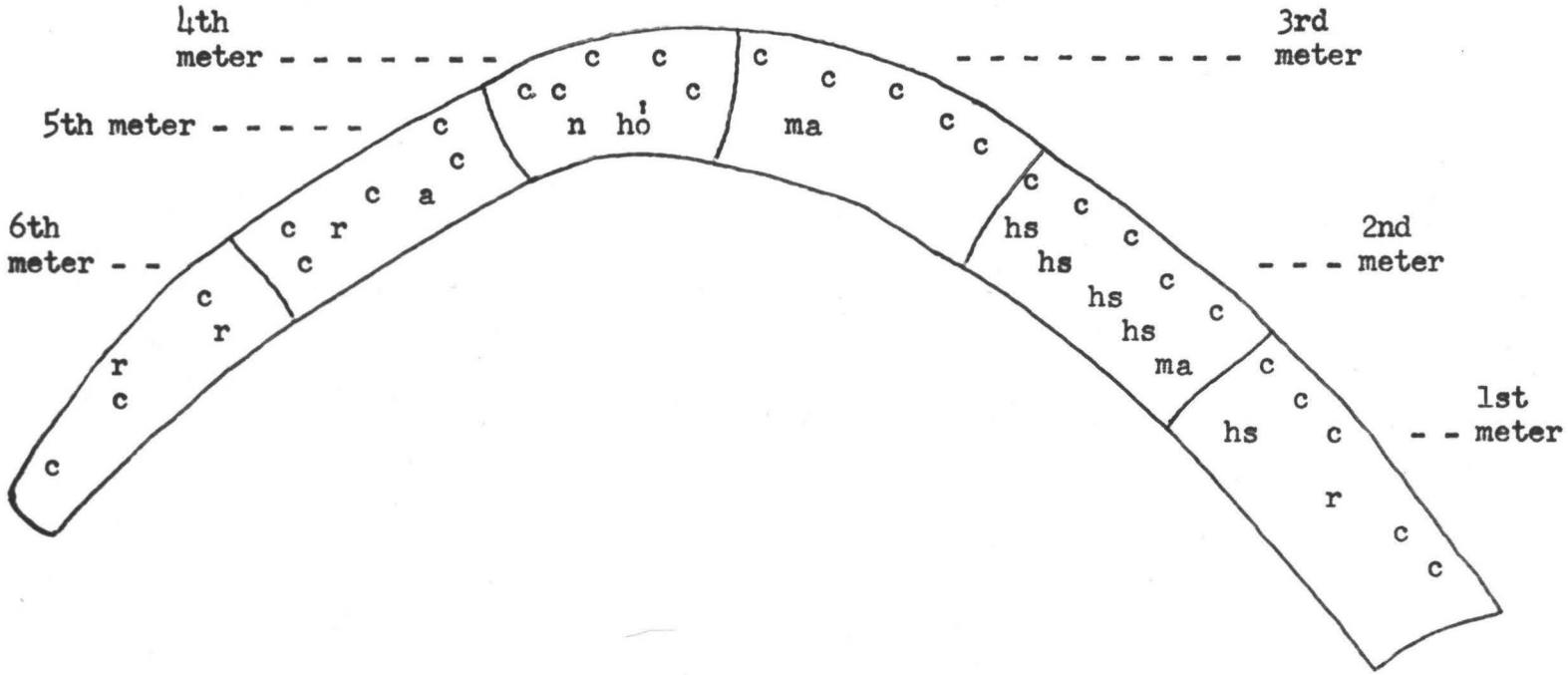


Fig. 3 - Acer circinatum branch (2)

c - Camptothecium lutescens
r - Rhytidiadelphus triquetrus
a - Antitrichia californica
n - Neckera douglasii
hȯ - Homalothecium nuttallii var. tenue
ma - Madotheca platyphylla
hs - Hypnum subimponens

The number of symbols in each meter indicates the relative cover of each species in that meter.

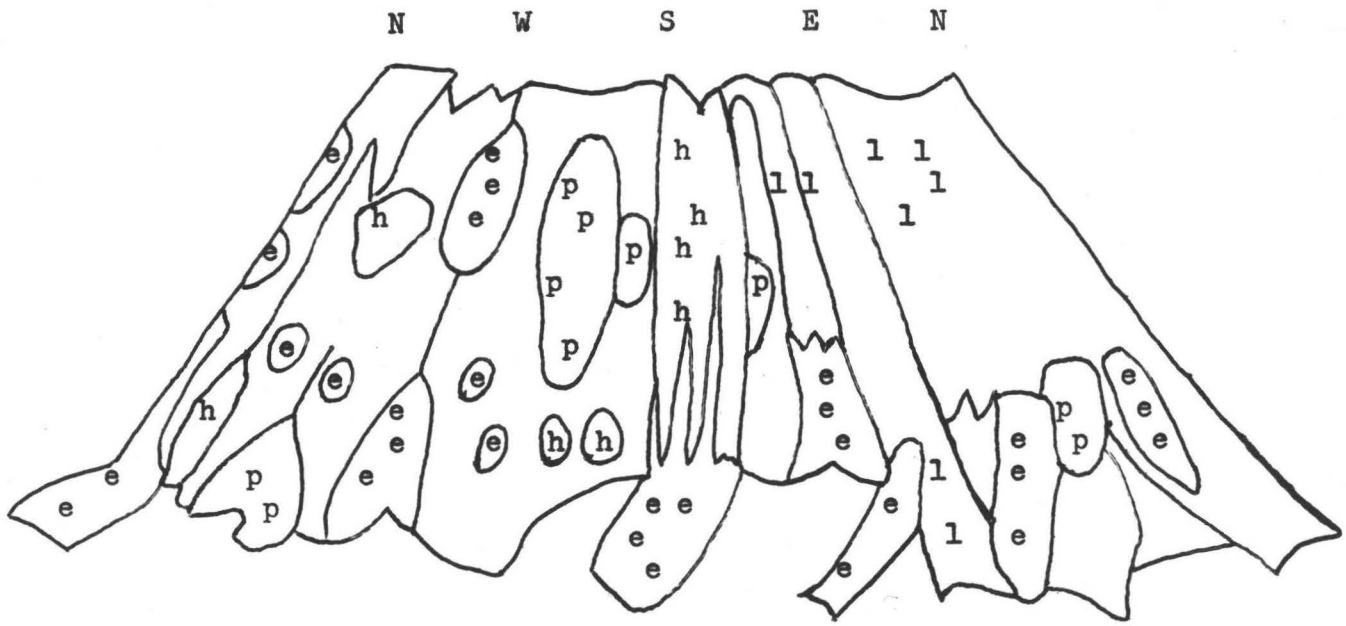


Fig. 4 - Thuja plicata (3-1)

e - Eurhynchium oreganum
h - Hypnum circinale
p - Pseudoisothecium stoloniferum
l - lichen

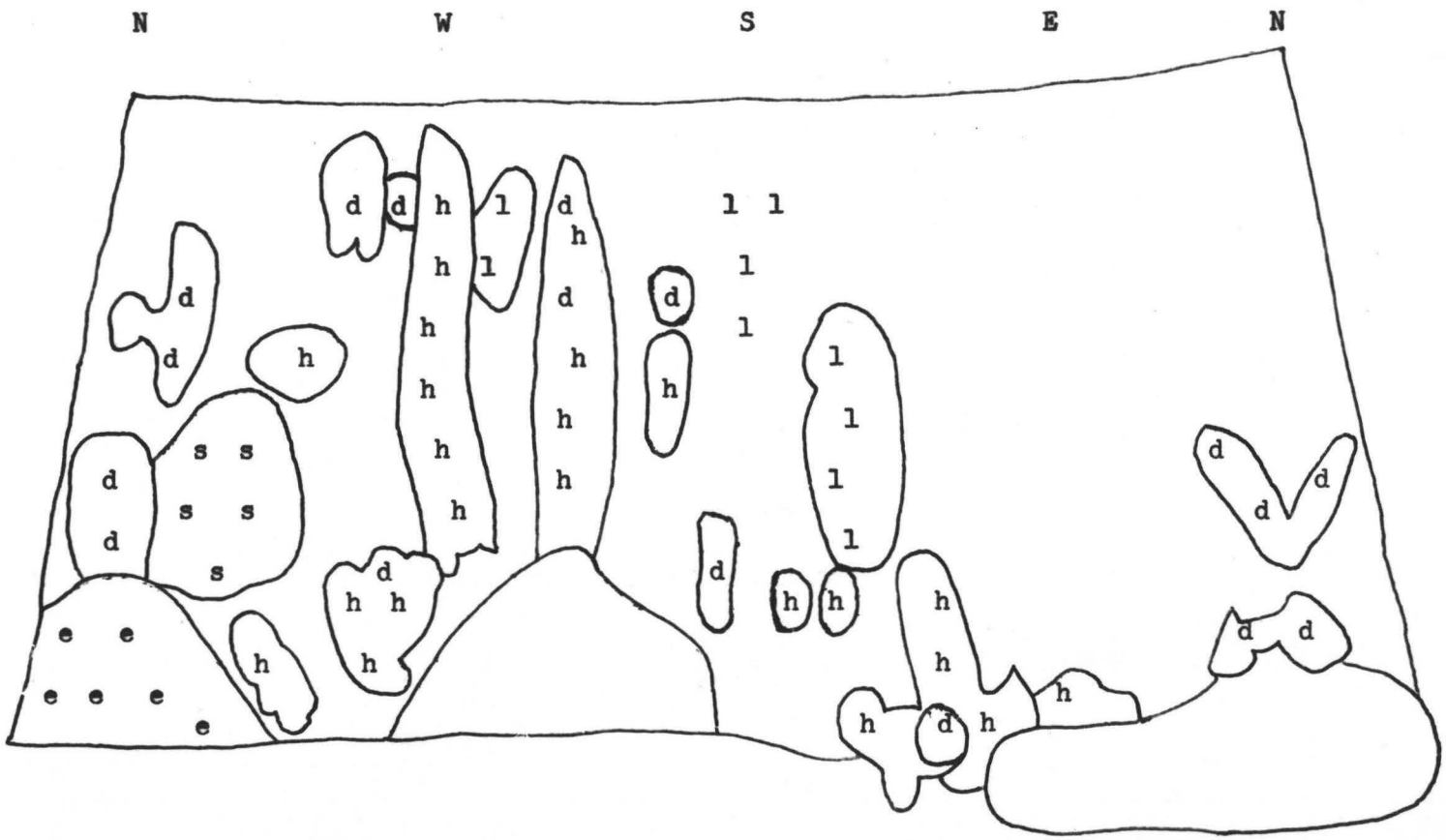


Fig. 5 - Pseudotsuga menziesii (3-1)

d - Dicranum fuscescens
e - Eurhynchium oreganum
h - Hypnum circinale
s - Scapania nemorosa
l - lichen

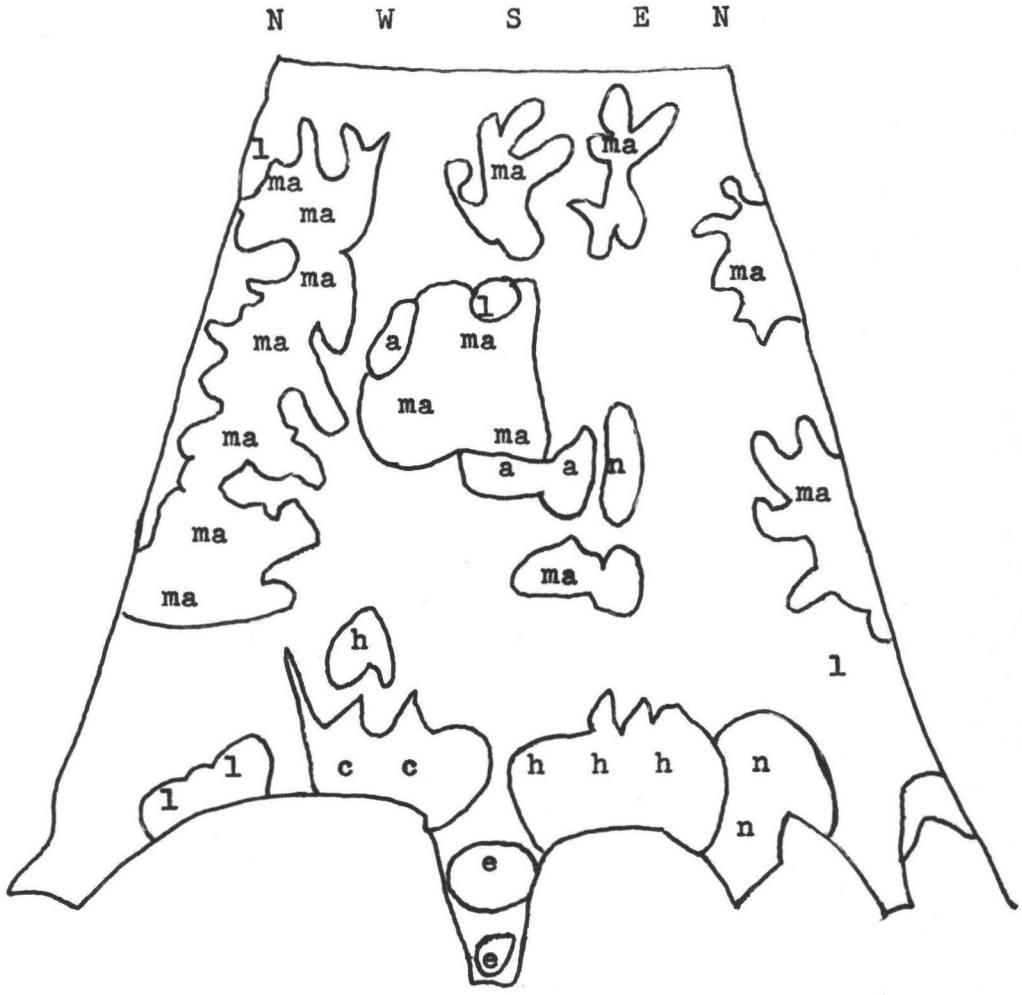


Fig. 6 - Abies grandis (6)

a - Antitrichia curtipendula
c - Camptothecium lutescens
e - Eurhynchium oreganum
h - Hypnum circinale
ma - Madotheca platyphylla
n - Neckera douglasii
l - lichen

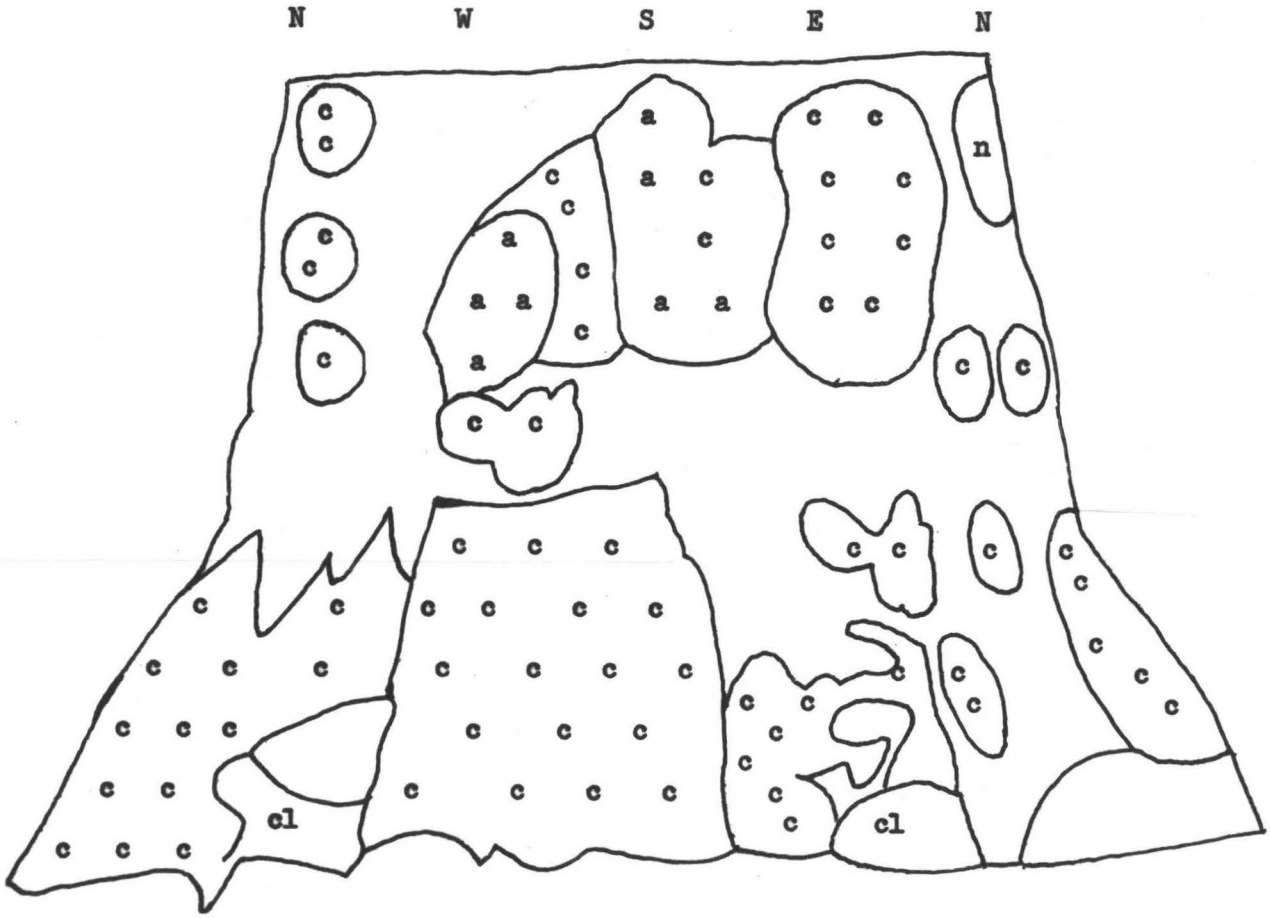


Fig. 7 - Populus trichocarpa (6)

a - Antitrichia curtipendula
c - Camptothecium lutescens
cl - Claopodium crispifolium
n - Neckera douglasii

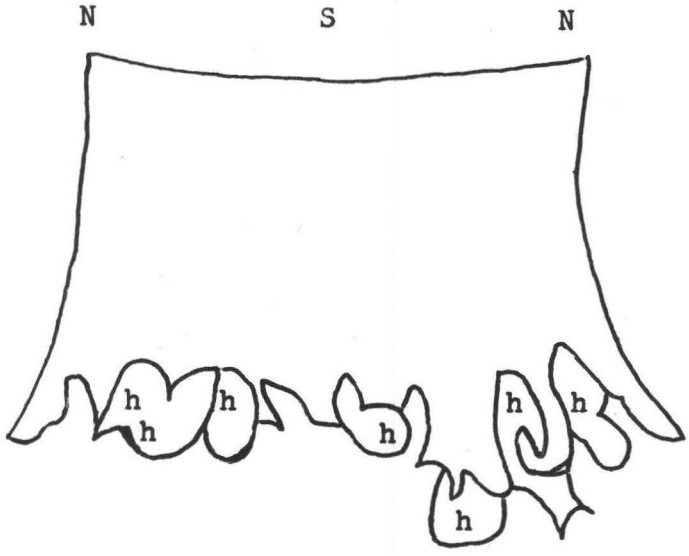


Fig. 8 - Tsuga heterophylla (4-1)

h - Hypnum circinale

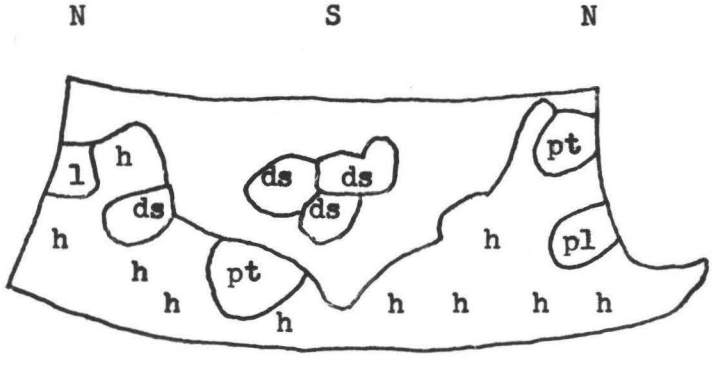


Fig. 9 - Abies procera (62)

ds - Dicranum strictum
h - Hypnum circinale
l - lichen
pl - Plagiothecium denticulatum
pt - Ptilidium californicum

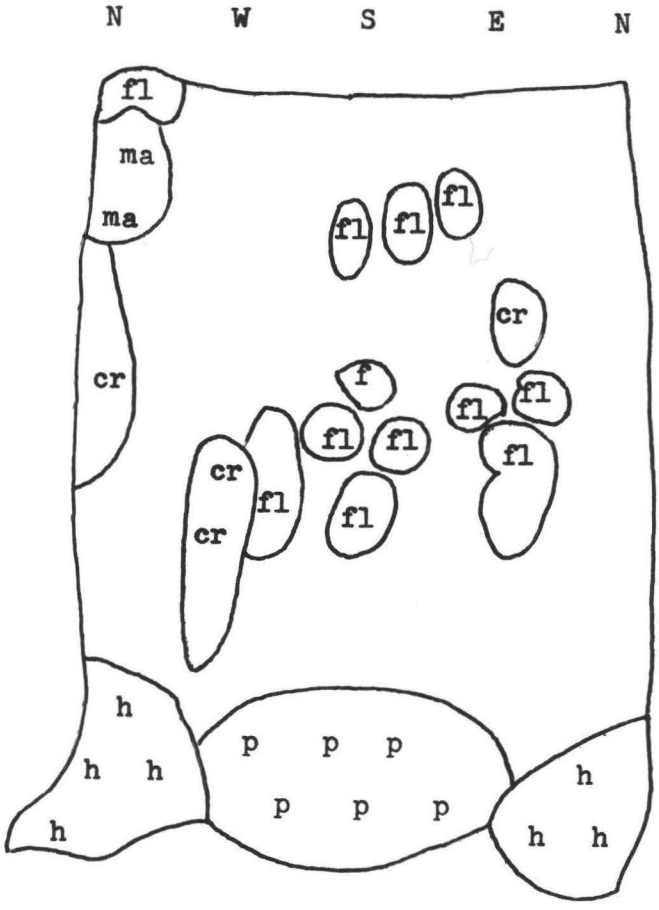


Fig. 10 - Castanopsis chrysophylla (7-2)

h - Hypnum circinale
p - Pseudoisothecium stoloniferum
m - Madotheca platyphylla

cr - crustose lichen
f - fruticose lichen
fl - foliose lichen

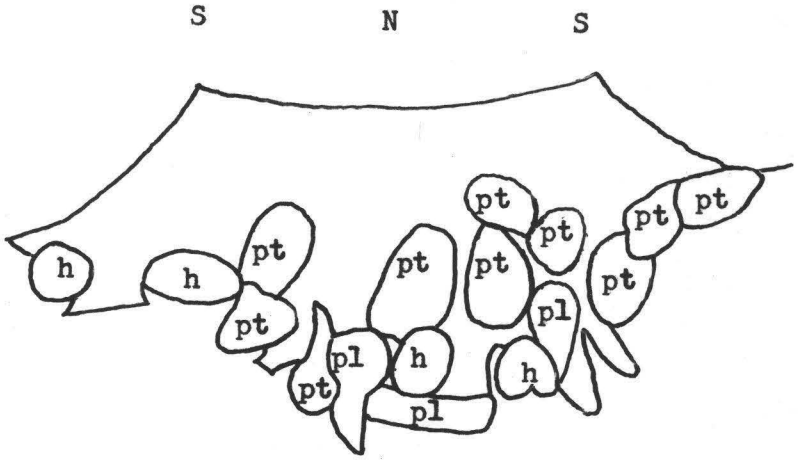


Fig. 11 - Abies amabilis (78)

h - Hypnum circinale
pl - Plagiothecium denticulatum
pt - Ptilidium californicum

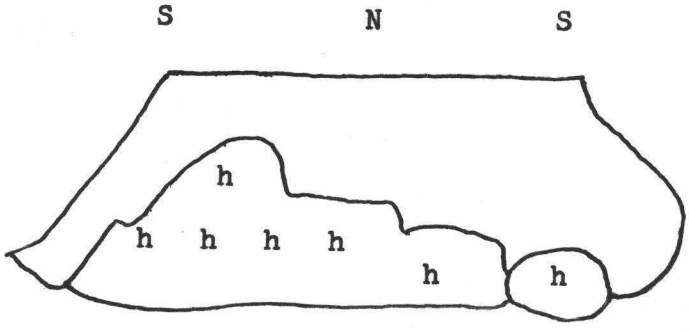


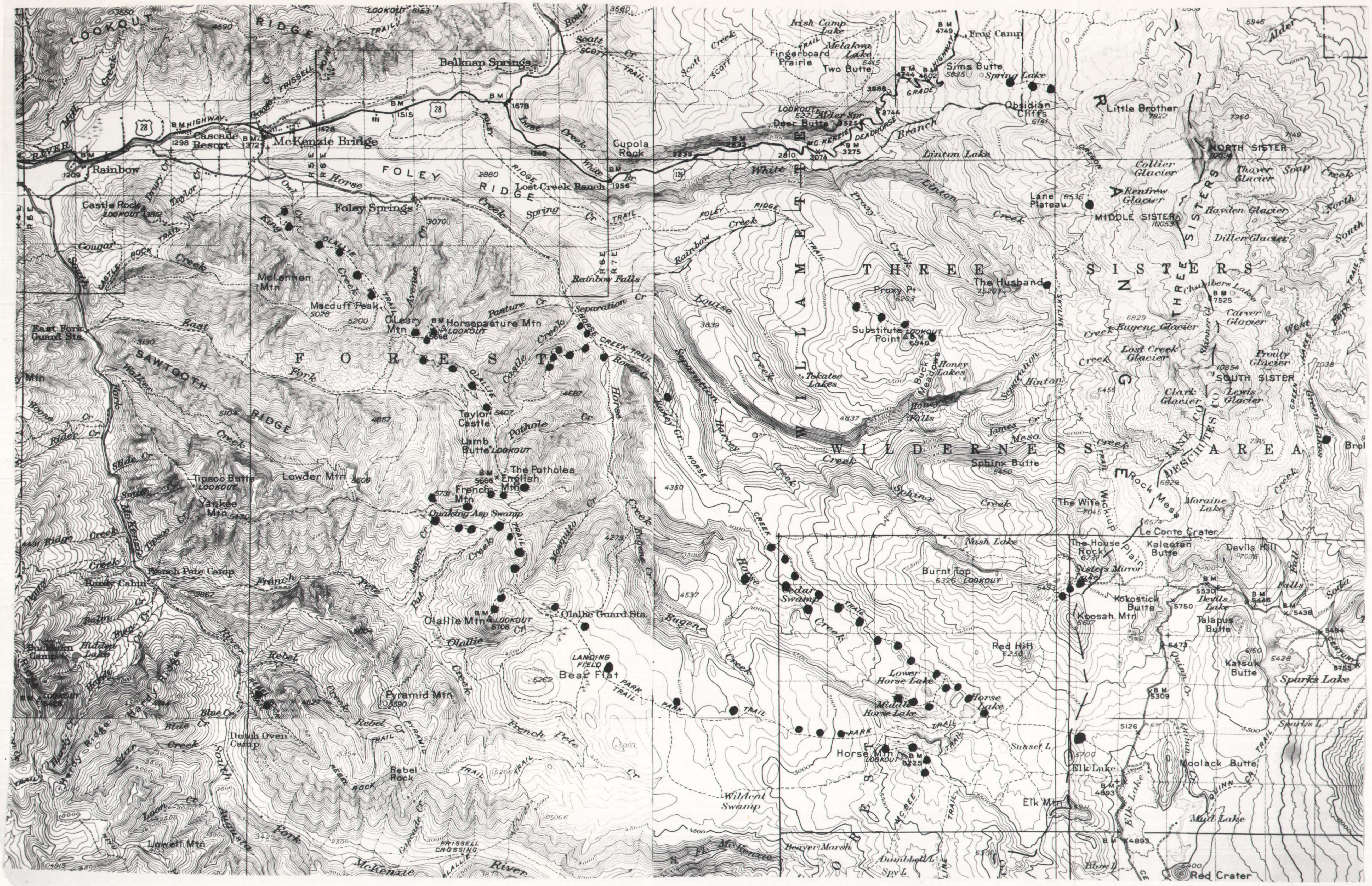
Fig. 12 - Abies grandis (80)

h - Hypnum circinale

Plate 1

Map of the Three Sisters Primitive Area showing locations of the stands in this study.

Copied from U. S. Department of the Interior, Geological Survey, Quadrangles for Waldo Lake, McKenzie Bridge, Three Sisters and Maiden Peak.



LOOKOUT RIDGE
Belknap Springs
McKenzie Bridge
Cascade Resort
Rainbow
Castle Rock
Cougar
Foley Springs
FOLEY RIDGE
Lost Creek Ranch
Cupola Rock
Rainbow Falls
McLennen Mtn
Macduff Peak
O'Leary Mtn
Horsepasture Mtn
East Fork Guard Sta.
SAWTOOTH RIDGE
Taylor Castle
Lamb Butte
The Potholes
English Mtn
French Mtn
Quaking Asp Swamp
Lowder Mtn
Tipsoo Butte
Yankee Mtn
French Pete Camp
Olallie Mtn
Olallie Guard Sta.
Pyramid Mtn
Bear Flat
Rebel Rock
Dutch Oven Camp
Lowell Mtn
Wildcat Swamp
Horse Mtn
Middle Horse Lake
Lower Horse Lake
Horse Lake
Cedar Swamp
Burnt Top
Nash Lake
Red Hill
Elk Lake
Elk Mtn
Sunset L.
Moolack Butte
Mud Lake
Red Crater
Fingerboard Prairie
Two Butte
Irish Camp Lake
Melakwa Lake
Frog Camp
Sims Butte
Spring Lake
Obsidian Cliffs
Alder Spr.
Deer Butte
Linton Lake
Little Brother
NORTH SISTER
Collier Glacier
Renfrew Glacier
Lane Plateau
MIDDLE SISTER
Hayden Glacier
Diller Glacier
Thayer Glacier
THREE SISTERS
WILLAMETTE
FOREST
WILDERNESS AREA
The Husband
Proxy Pt
Substitute Point
Tokatee Lakes
Honey Lakes
Sphinx Butte
Eugene Glacier
Lost Creek Glacier
Carver Glacier
Prouty Glacier
SOUTH SISTER
Clark Glacier
Lewis Glacier
Moraine Lake
The Wife
Le Conte Crater
The House Rock
Kaleetan Butte
Devils Hill
Sisters Mirror
Kokostick Butte
Koosah Mtn
Talapus Butte
Katsuk Butte
Sparks Lake

Plate 2

General view of the forest in Stands 1-1 and 1-2, Group A. Notice the abundance of vine maple, Acer circinatum, in the area and of logs and brush on the ground.

Plate 3

Forb and bryophyte cover, Stand 1-1, Group A. The forbs are Oxalis oregana, Viola sempervirens and Linnaea borealis. The more abundant moss species is Eurhynchium oreganum. There is some Rhytidiadelphus triquetrus at lower center in the photograph.

Plate 4

Thuja plicata snag, Stand 2, Group A.

This is a vestige of the forest of the area that was swept by fire 150 to 200 years ago. The lower part of the trunk is covered by lichens.

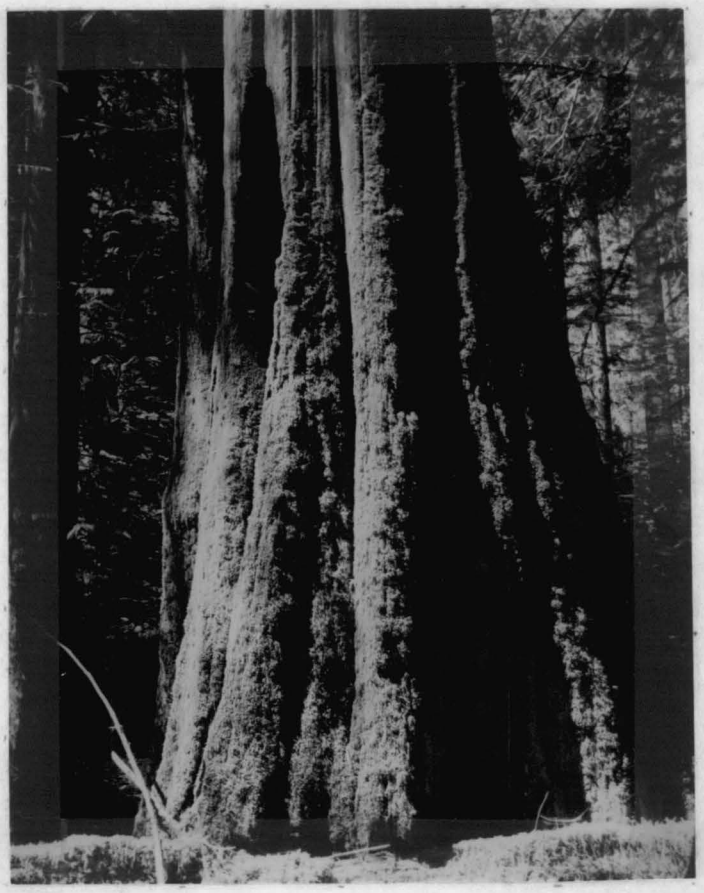


Plate 5

Acer circinatum showing the abundance of corticolous bryophytes, Stand 2, Group A.

The moss that hangs down from the branches is *Pseudoisothecium stoloniferum*. *Camptothecium lutescens* is predominant along the tops of the branches.

Plate 6

Acer macrophyllum showing corticolous bryophytes,

Stand 2, Group A

The predominant species is *Neckera douglasii*.

Plate 7

Forb and bryophyte cover, Stand 2, Group A.
The Mnium insigne is visible in the foreground, where the forbs, Oxalis oregana and Hydrophyllum tenuipes, have been removed.

Plate 8

Mnium insigne, terrestrial bryophyte, Stand 2, Group A.
This shows the plants with the leaves distorted as they are as soon as they have dried a little.

Plate 9

Epixylic cryptogams on end of log, lower Horse Creek. The whitish area is Icmadophila ericetorum. This lichen looks like grayish-green paint with orange fruiting bodies. Tetraphis pellucida, a moss, borders the crack in the log. The minute Riccardia latifrons is present near the upper edge of the picture, left of center.

Plate 10

Corticolous bryophytes near the base of Pseudotsuga menziesii, Stand 1, Group A.

The predominant species is Hypnum circinale. Some Eurhynchium oreganum extends upward along the cracks in the trunk.

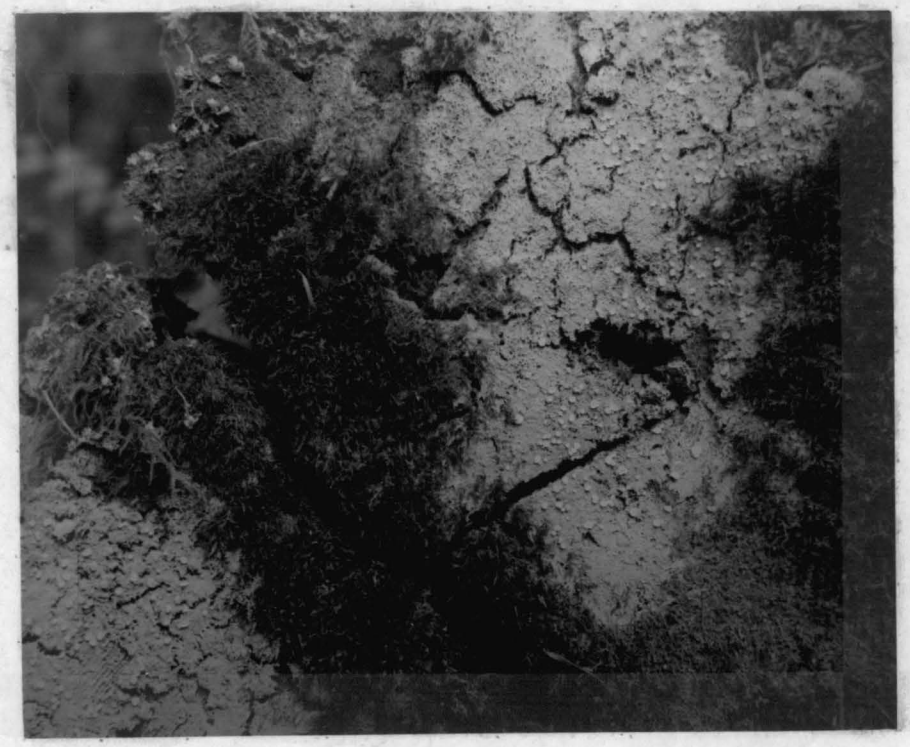


Plate 11

Aulacomnium androgynum on burned log, lower Horse Creek.

Plate 12

Hylocomium splendens on log, Stand 2, Group A.

The terminal segment, which originates below the tip of the shoot, forms the crook.

Plate 13

The effect of tree position on corticolous bryophyte distribution, lower Horse Creek.

The side with the moss, principally Hypnum circinale, faces south.

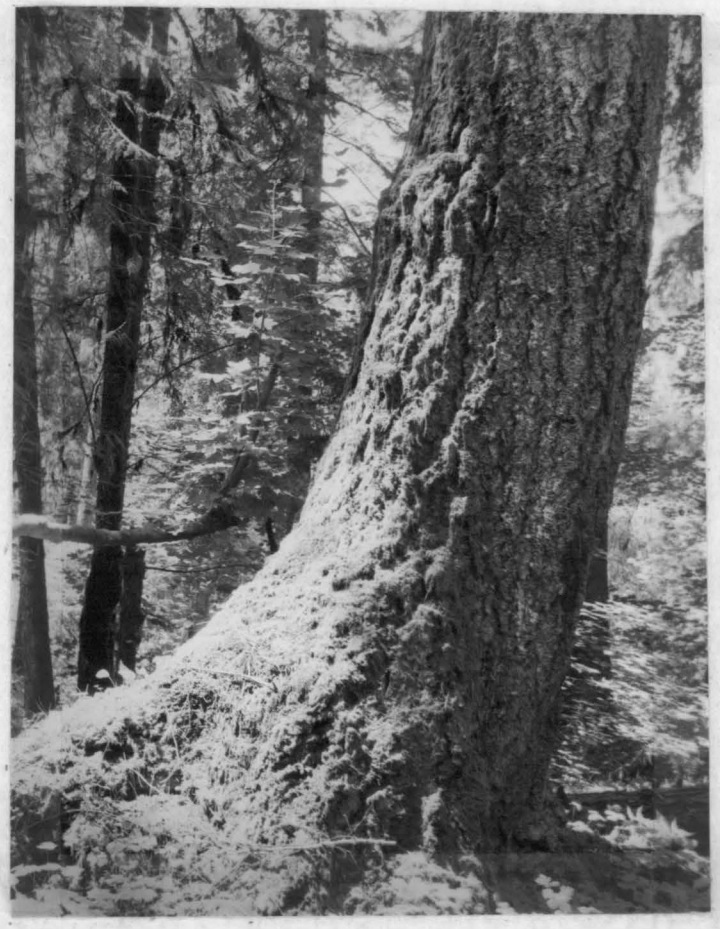


Plate 14

General view of forest showing carpet of Eurhynchium oreganum on the ground and logs, Stand 3, Group A.

Plate 15

Eurhynchium oreganum, terrestrial bryophyte of Stand 3, Group A.

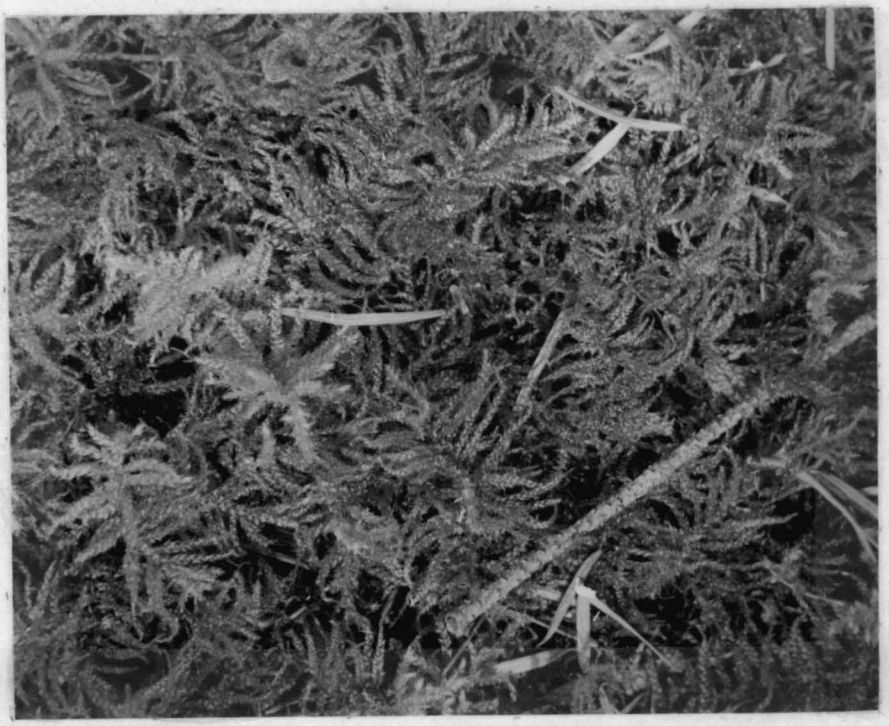


Plate 16

Scleropodium caespitosum on boulder, Stand 3, Group A.

Plate 17

Mnium menziesii on top of boulder, Stand 3, Group A.

Mosses of this species look like little trees.

Plate 18

Forest of *Pseudotsuga menziesii*, *Abies amabilis* and *Tsuga heterophylia*, Group B and E Stands.

The large tree is the *Pseudotsuga*. To the right of it are some *Abies* and the small trees back of the *Pseudotsuga* are *Tsugas*.

Plate 19

Mat of *Dicranum fuscescens* with *Rhytidiopsis robusta* on top, at the base of *Abies amabilis*, Group B Stands.

Plate 20

Rhytidiopsis robusta, terrestrial bryophyte of stands of Groups B and E.

Plate 21

Habitat view, Group B stands, showing young *Abies amabilis*, *Xerophyllum tenax*, and *Rhytidiopsis robusta* on the ground. *Dicranum fuscescens* is on the log.

Plate 22

General view of Stand 4, Group D.

Notice the large Pseudotsuga menziesii and the abundance of small trees, principally Tsuga heterophylla. Also, notice the steepness of the slope and the abundance of logs and brush on the ground.

Plate 23

Epixylic species, largely Dicranum fuscescens, Stand 4, Group D.

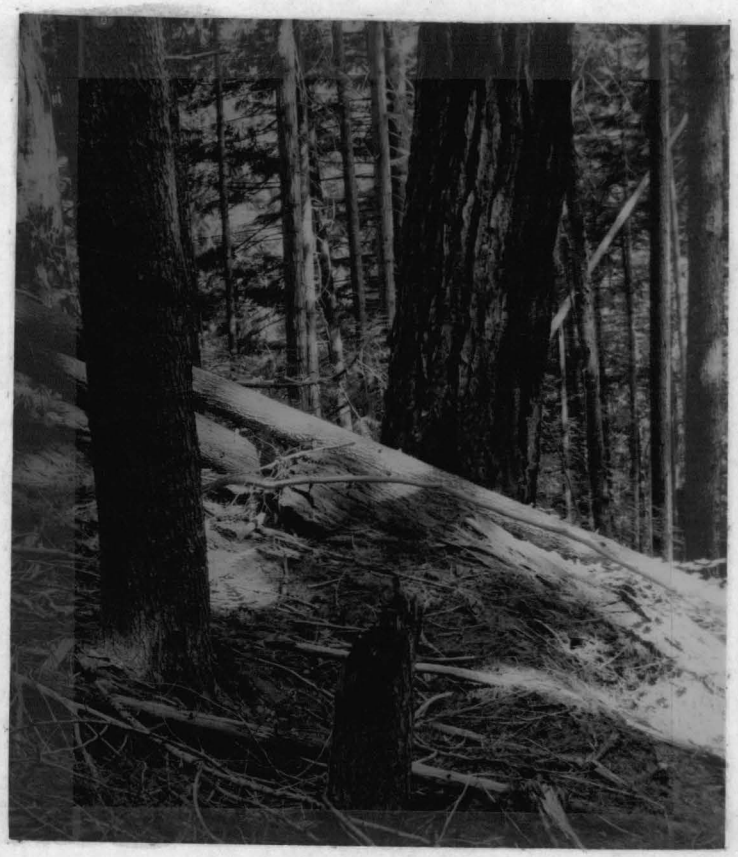


Plate 24

Picea engelmanni, Group F stands.

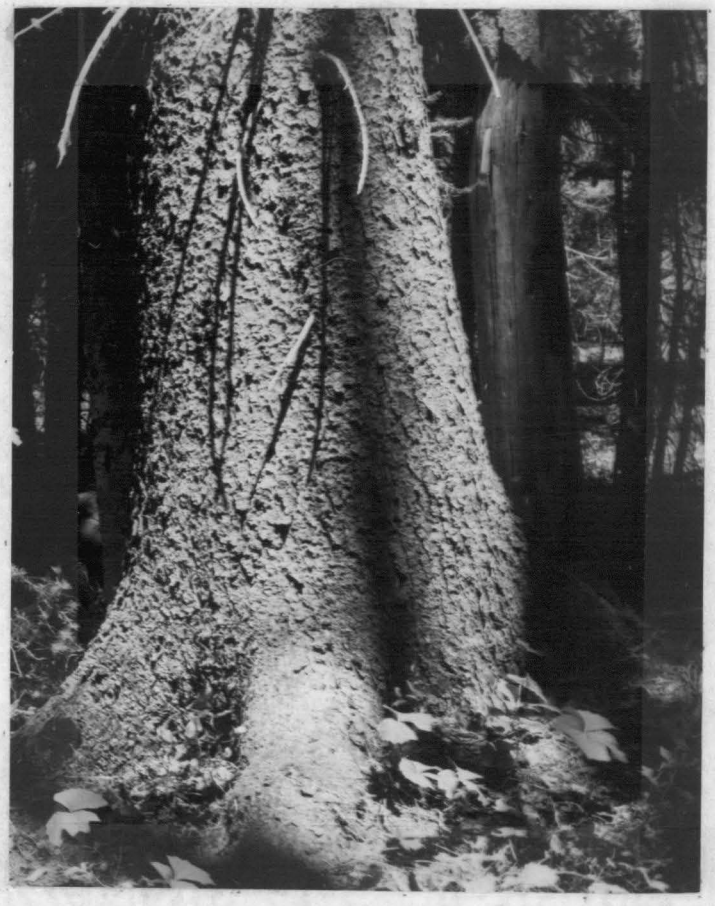


Plate 25

Brachythecium hylotapetum, terrestrial bryophyte,

Group F Stands.

Plate 26

Needle litter, Group F Stands, showing

Brachythecium curtum forma.

Plate 27

Rhacomitrium sp., on top of a boulder.

Plate 28

Lescuraea sp. on the side of a boulder.

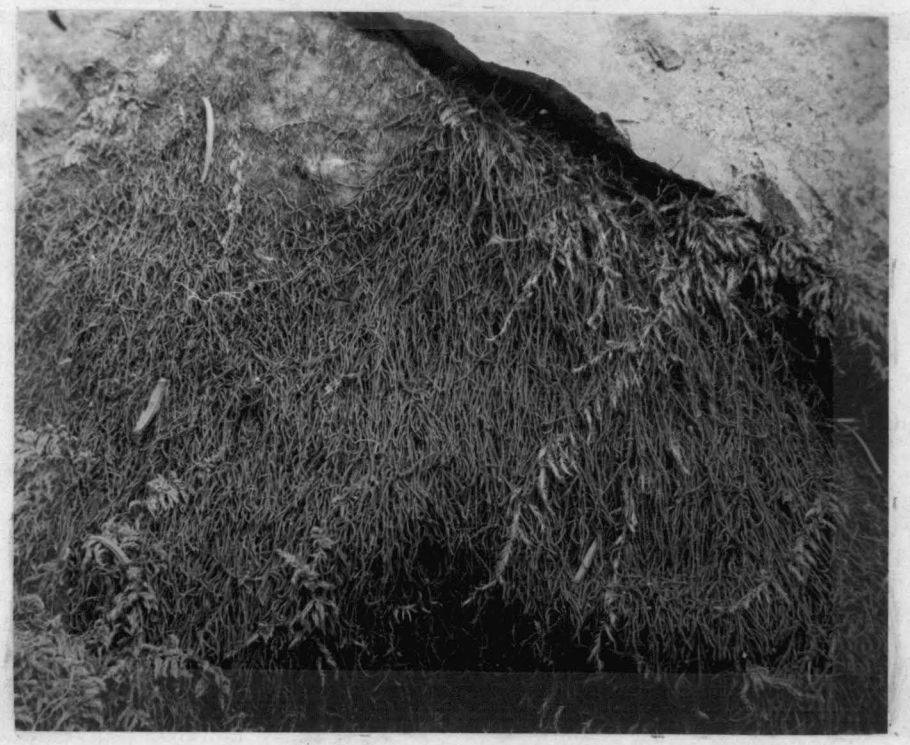


Plate 29

Abies lasiocarpa with *Bryum sandbergii* in the litter around its base, Group G Stands.

Plate 30

Bryum sandbergii, terrestrial bryophyte of Group G Stands.

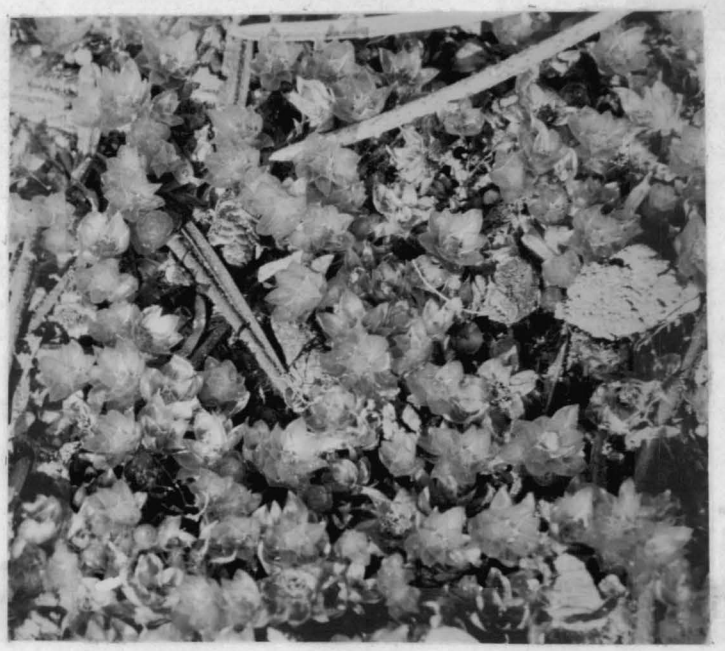


Plate 31

Claopodium crispifolium, often covering extensive vertical rock cliffs.

Plate 32

Forest of Tsuga mertensiana and Abies amabilis, Group H Stands.

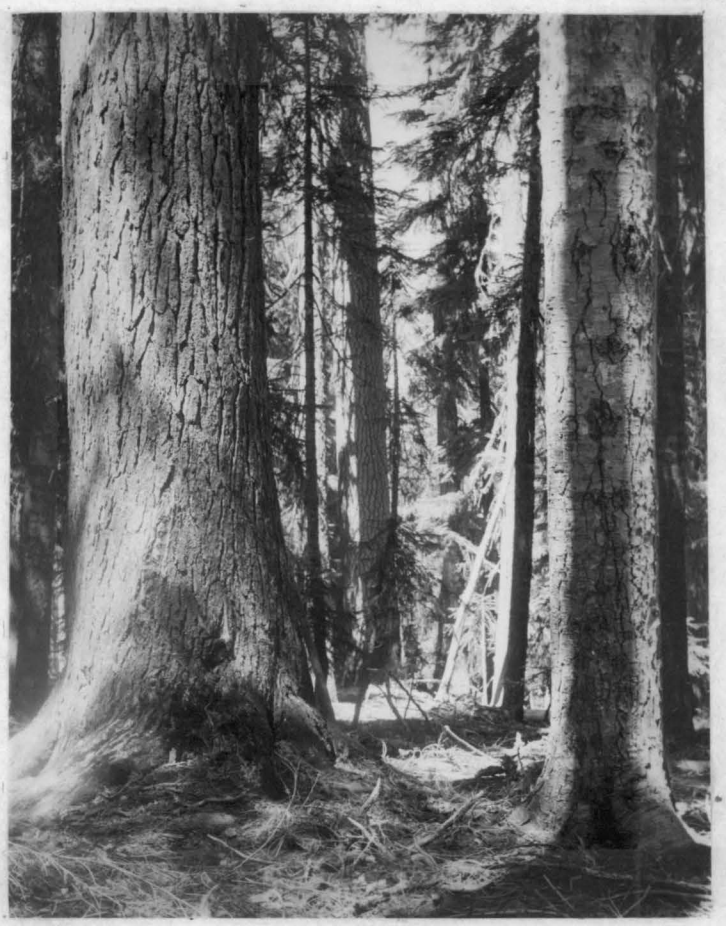


Plate 33

Compact, matted ground cover of Group H Stands, showing outlines of buried logs with Dicranum fuscescens on them.

Plate 34

Dicranum fuscescens, terrestrial bryophyte in Group H Stands, and epixylic in many other stands.

Plate 35

Pinus contorta forest, Group I Stands.

Notice the abundance of logs without bryophytes.

Plate 36

Polytrichum piliferum, terrestrial bryophyte of Group I Stands. Below the arrow is a group of these showing the white hairs at the tips of the plants. The leaves are tightly folded against the stems when the plants are dry.

Plate 37

Polytrichum juniperinum, terrestrial bryophyte, primarily of Group I and J Stands.

This is the common hair cap moss of this area. It derives this name from the hairy calyptra which covers the capsule.

Plate 38

Tsuga mertensiana, Group J Stands.

This tree species grows in compact groups, which are scattered throughout this high altitude area.

Plate 39

Polytrichadelphus lyalli, terrestrial bryophyte, primarily of Group J Stands.

Notice the small calyptra, which look like pointed scales on the tips of the capsules.

Plate 40

Dicranum strictum, a corticolous species.

Plate 41

Pohlia nutans, a terrestrial bryophyte species found in stands of many groups.

Plate 42

Camptothecium megaptilum, a robust, glistening species, that does not form sporophytes in this area.

Plate 43

Eastern entrance, from Elk Lake, to the area in which this study was made.


ENTERING
WILLAMETTE NATIONAL FOREST
THREE SISTERS PRIMITIVE AREA

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APPENDIX A

Cryptogamic Species Included in the Study

1. Antitrichia californica Sull.
2. A. curtipendula (Hedw.) Brid.
3. Aulacomnium androgynum Schwaegr.
4. Brachythecium asperrimum Mitt.
5. B. hylotapetum Hig.
6. B. curtum (Lindb.) Lindb. forma
7. B. velutinum (L.) Br. & Sch.
8. Buxbaumia piperi Best
9. Bryum sandbergii Holz.
10. Camptothecium lutescens (Huds.) Br. & Sch.
11. C. megaptilum Sull.
12. Cephalozia media Lindberg
13. Claopodium crispifolium (Hook.) R. & C.
14. Dicranum fuscescens Turn.
15. D. strictum Schleich.
16. Ditrichum heteromallum (Hedw.) E. G. Britton
17. Eurhynchium oreganum (Sull.) Jaeger. & Sauerb.
18. E. strigosum (Hoffm.) Br. & Sch.
19. Heterocladium procurrens (Mitt.) Rau & Hervey
20. Homalothecium nuttallii (Wils.) Grout
21. H. nuttallii tenue Kindb.
22. Hylocomium splendens (Hedw.) Bry. Eur.
23. Hypnum circinale Hook.
24. H. subimponens Lesq.
25. Icmadophila ericetorum (L.) Zahlbr.
26. Lepidozia reptans (Linne) Dumortier
27. Lescuraea patens (Lindb.) Arn. & Jens.
28. L. radicosa (Mitt.) Moenkem.
29. L. stenophylla (Ren. & Card. Kindb.)
30. Lophozia incisa (Schrader) Dumortier
31. L. porphyroleuca (Nees) Scheff
32. Madotheca platyphylla (Linne) Dumortier
33. Mnium insigne Mitt.
34. M. menziesii (Hook.) C. Muell.
35. M. punctatum (L.) Hedw.
36. M. spinulosum Br. & Sch.
37. Neckera douglasii Hook.
38. Pilophoron cereolus (Ach.) Th. Fr.
39. Plagiothecium denticulatum (L., Hedw.) Bry. Eur.
40. P. seligeri (Brid.) Lindb.
41. P. undulatum (L., Hedw.) Bry. Eur.

42. Pohlia nutans (Schreb.) Lindb.
43. Polytrichadelphus lyalli Mitt.
44. Polytrichum juniperinum Hedw.
45. P. piliferum Hedw.
46. Pseudoisothecium stoloniferum (Hook.) n. comb.
47. Ptilidium californicum (Austin) Underwood & Cook.
48. Rhacomitrium canescens ericoides (Web.) B. S. G.
49. R. heterostichum (Hedw.) Brid.
50. R. patens (Dicks.) Hueb.
51. R. varium (Mitt.) L. & J.
52. Riccardia latifrons Lindberg.
53. Rhytidiadelphus loreus (L., Hedw.) Wernst
54. R. triquetrus (L., Hedw.) Warnst
55. Rhytidiopsis robusta (Hook.) Broth.
56. Scapania nemorosa (Linne) Dumortier
57. Scleropodium caespitosum (Wils.) Br. & Sch.
58. Tetraphis pellucida Hedw. Sp. Musc.

APPENDIX B

Vascular Species Included in the Study

1. Abies amabilis (Dougl.) Forbes
2. A. grandis Lindl.
3. A. lasiocarpa (Hook.) Nutt.
4. A. procera Rehder
5. Acer circinatum Pursh.
6. A. macrophyllum Pursh.
7. Achlys triphylla (Smith) DC
8. Adenocaulon bicolor Hook.
9. Alnus tenuifolia Nutt.
10. Amelanchier florida Lindl.
11. Anemone deltoidea Hook.
12. Aquilegia formosa Fisch.
13. Arbutus menziesii Pursh.
14. Arctostaphylos columbiana Piper
15. A. nevadensis Gray
16. A. Uva-ursi (L.) Spreng
17. Asarum caudatum Lindl.
18. Aster alpigenus Gray
19. Berberis nervosa Pursh.
20. Caltha biflora DC.
21. Cassiope mertensiana (Bong.) D. Don
22. Castanopsis chrysophylla (Dougl.) A. DC
23. Castilleja pumicola Penn.
24. Ceanothus velutinus Dougl.
25. Chelone nemorosa Dougl.
26. Chimaphila umbellata (L.) Nutt. occidentalis (Rydb.) Blake
27. Clintonia uniflora (Schult.) Kunth.
28. Coptis laciniata Gray
29. Corallorhiza mertensiana Bong.
30. Cornus canadensis L.
31. Corylus californica (A. DC) Rose
32. Dicentra formosa (Andr.) DC
33. Disporum oreganum (Wats) Benth. & Hook.
34. Fragaria bracteata Heller
35. Gaultheria ovatifolium Gray
36. G. shallon Pursh.
37. Githiopsis specularioides Nutt.
38. Goodyera decipiens (Hook.) St. John & Const.
39. Holodiscus discolor (Pursh) Maxim.
40. Hydrophyllum tenuipes Hel.
41. Juniperus sibirica Burgsd.

42. Libocedrus decurrens Torrey
43. Linnaea borealis L. americana (Forbes) Rehder
44. Lutkea pectinata (Pursh.) Hook.
45. Lysichitum americanum St. John
46. Montia sibirica (L.) Howell
47. Oxalis oregana Nutt.
48. Pachystima myrsinitis (Pursh.) Raf.
49. Pedicularis racemosa Dougl.
50. Phlox speciosa Pursh.
51. Phyllodoce empetriformis (Sm.) D. Don
52. Picea engelmanni (Parry) Engelm.
53. Pinus albicaulis Engelm.
54. P. contorta Dougl.
55. P. lambertiana Dougl.
56. P. monticola Dougl.
57. Polygonum newberryi Small.
58. Populus trichocarpa Torr. & Gray
59. Potentilla flabellifolia Hook.
60. Pseudotsuga menziesii (Mirb.) Franco
61. Pteridium aquilinum pubescens Underw.
62. Pyrola bracteata Hook.
63. P. picta Smith
64. P. secunda L.
65. Rhododendron californicum Hook.
66. Rosa gymnocarpa Nutt.
67. Rubus parviflorus Nutt.
68. R. pedatus Smith
69. R. spectabilis Pursh.
70. Rumex acetosella L.
71. Sambucus glauca Nutt.
72. Satureja douglasii (Benth.) Brig.
73. Smilacina sessilifolia (Baker) Nutt.
74. Symphoricarpos albus (L.) Blake
75. Thuja plicata Lambert.
76. Tiarella unifoliata Hook.
77. Trientalis latifolia Hook.
78. Trillium ovatum Pursh.
79. Tsuga heterophylla (Ra.) Sarg.
80. T. mertensiana (Bong.) Carr.
81. Vaccinium membranaceum Dougl.
82. V. myrtillus L. microphyllum Hook.
83. Valeriana sitchensis Bong.
84. Vancouveria hexandra (Hook.) Morr. & Dcne.
85. Veratrum viride Ait.
86. Viola glabella Nutt.
87. V. sempervirens Greene
88. Xerophyllum tenax (Pursh.) Nutt.