AN ABSTRACT OF THE THESIS OF

Arthur Wesley Bailey for the M. S. in Range Management
(Name) (Degree) (Major)

Date thesis is presented May 22, 1963

Title CHARACTERIZATION OF SELECTED PLANT COMMUNITIES WITHIN THE TILLAMOOK BURN IN NORTHWESTERN OREGON

Abstract approved [redacted]
(Major professor)

A study was initiated in 1961 to characterize seral plant communities in a part of the Cedar Creek drainage in the Tillamook Burn. Stratification of vegetation into ecological units was a necessary first step in conifer-animal damage studies supported by the Oregon State Game Commission.

Reconnaissance information was recorded in 92 stands and seven major plant communities were tentatively recognized. Association tables were constructed for analysis of the constancy and canopy coverage data recorded in 42 intensively sampled stands. Two communities that occupied small parts of the study area were described using reconnaissance only. The plant associes is recognized as the seral equivalent to the climax plant association.

Five soil series previously mapped were in the study area. The Meda, Astoria, Trask and Kilchis soil series were

recognizeable and adequately characterized. The Hembre soil series was found to be too general for application to either synecological research or land management. For this investigation, the series was separated and described as the Hembre I and Hembre II soil series.

The *Alnus rubra/Polystichum munitum* associes is on lower elevation, north-facing slopes. The associes is in a topographic position to benefit from lateral seepage and to have low summer transpiration rates. It is on Meda, Astoria and Hembre II soil series.

The *Alnus rubra-Acer circinatum* associes is on convex, north-facing slopes at usually slightly higher elevations than the *Alnus/Polystichum* associes. It is topographically located to benefit from lateral seepage and to have a low summer transpiration rate. The associes is on Hembre II and Trask soils.

The *Acer circinatum-Corylus californica* associes is highly variable in species composition and cover. It has a xeric and a mesic phase. Stands are always located in positions to benefit from lateral ground water seepage and are generally located on all but north-facing slopes. The associes is generally on deep Astoria or Hembre II soils, but on bottom slopes it may be on the lithosolic Trask series.

The *Rubus parviflorus/Trientalis latifolia* associes is on upper slopes and on nearly all aspects at higher elevations. It is usually on lithosolic Kilchis soils.

The *Pteridium aquilinum/Lotus crassifolius* is on the deeply weathered Hembre I soil series. It is at higher elevations on most slope directions.

The *Vaccinium parvifolium/Gaultheria shallon* associes is dominated by two late seral or climax species. Drainage is good to excessive on south-facing convex slopes or ridgetops. Macroclimate is apparently the major controlling factor since there is little relation between soil series or solum depth.

The *Acer macrophyllum/Symphoricarpos mollis* and the *Acer macrophyllum-Alnus rubra* associes are described with reconnaissance data only. The former is on extremely steep, south-facing rock and talus slopes. The latter is on floodplains of major streams. It may have a water table in the rooting zone part of the year.

Both shade-intolerant, early seral species and shade-tolerant, late seral or climax species have specific environmental requirements for growth and survival. The vegetation, 17 years after fire, reflects environmental controls and may be used to stratify the landscape into units of equivalent effective environment.

Succession is apparently slow in most communities and under natural conditions most communities would have remained in a

dynamic, seral state for many years.

Implications of the study to game management are discussed. A basis of vegetation stratification suitable for game management studies was established. A relatively rapid method of inventorying and mapping winter deer forage production by plant communities has been demonstrated. A key for recognizing the plant associes was developed.

CHARACTERIZATION OF SELECTED PLANT COMMUNITIES WITHIN THE TILLAMOOK BURN IN NORTHWESTERN OREGON

by

ARTHUR WESLEY BAILEY

A THESIS

submitted to

OREGON STATE UNIVERSITY

in partial fulfillment of
the requirements for the
degree of

MASTER OF SCIENCE

August 1963

APPROVED:

[redacted]

Professor of Range Ecology

In Charge of Major

[redacted]

Head of Department of Animal Science

[redacted]

Dean of Graduate School

Date thesis is presented May 22, 1963

Typed by Jolene Hunter Wuest

ACKNOWLEDGMENTS

The author wishes to express his sincere appreciation to Dr. Charles E. Poulton for his guidance and encouragement throughout the study. His personal example and quest for knowledge has indeed been stimulating.

A special acknowledgment is due the members of my committee: Dr. D. W. Hedrick, Mr. L. W. Kuhn, and Dr. C. T. Youngberg. The writer is especially indebted to Dr. C. T. Youngberg for field checking soil profiles and for assistance in interpreting the soil series.

Appreciation is extended to the Oregon State Game Commission for their financial support and for their progressive approach in recognizing the need for intensive synecological research prior to animal-plant relationship studies. Particular acknowledgment is due Dr. H. J. Rayner, chief, Research Division, and Mr. W. C. Lightfoot, chief game biologist. There were many stimulating discussions in the field and office with Messrs. G. L. Crouch and W. W. Hines at the Cedar Creek field station.

The Oregon State Board of Forestry supplied aerial photographs and maps. Assistance given by those not mentioned is appreciated.

A personal word of thanks is extended to my wife Ruth for her patience and constant encouragement throughout the study.

TABLE OF CONTENTS

Page

LIST OF FIGURES

LIST OF TABLES

CHARACTERIZATION OF SELECTED PLANT COMMUNITIES WITHIN THE TILLAMOOK BURN IN NORTHWESTERN OREGON

INTRODUCTION

A large contiguous area of northwestern Oregon coast range devastated by three forest fires between 1933 and 1945 has become known as the Tillamook Burn. An exceedingly severe crown fire in 1933 that burned 244,000 acres of old-growth *Pseudotsuga menziesii* (Mirb.) Franco has been documented by Morris (22), Cronemiller (4) and McArdle (18). Later fires were highly variable in intensity and pattern, missing some old burn and destroying more virgin forest, increasing the total burned area to 355,000 acres. A heterogeneous seral vegetation has resulted from the complex burn history and post-burn salvage logging.

Rapidly spreading early seral species and late seral plants from the old forest soon became established. Without a seed source, regeneration of *Pseudotsuga*, the most valuable timber species in the area, was very slow; Kallander (16) found only 12 percent of the Tillamook Burn adequately stocked. A concentrated effort has been made for more than a decade to restock the burn by hand planting and aerial seeding. Young, relatively shade-intolerant *Pseudotsuga* seedlings have had difficulty competing and surviving in the established seral plant communities, particularly during the dry summer months. Regeneration has failed in many areas due to injury to the young conifer seedlings before or during planting, or as a result of animal damage after planting. Poor planting procedures and planting of injured stock as well as overbrowsing by Columbian black-tailed deer (Odocoileus hemionus columbianus Richardson) and rodents have caused heavy losses. The early seral plant communities provided excellent habitat for deer and numbers increased after the fires (27). When populations increased beyond their winter food supplies or when heavy snows covered preferred browse plants, Douglas-fir was among the less desirable species used as emergency food.

The Oregon State Game Commission, in cooperation with the Oregon State Board of Forestry, initiated a project to investigate the deer-conifer damage problem. A small part of the Tillamook Burn was selected as a study area which was felt to be representative of the whole. Limited reconnaissance near the end of the author's project revealed that the vegetation of the selected area is probably representative of about one-half of the Tillamook Burn. The study area lies on a tributary of the Wilson River enclosing much of the Cedar Creek drainage at 45°35' to 45°37' north latitude and 123°35' to 123° 37' west longitude.

The purpose of the research reported in this thesis was to characterize seral plant communities, to determine the vegetation-soil relationships and to infer possible habitat types of the area selected by the Game Commission for deer-conifer damage investigations. *Pseudotsuga* is not preferred browse and is utilized heavily only during winter when preferred plants are unavailable. The presence of critical winter food plants is limited to certain plant communities and their abundance varies within each community. Since available deer forage varies among plant communities and conifer damage is linked to deer forage availability, an adequate synecologic interpretation of vegetation and vegetation-soil relationships must be made for stratification of vegetation into ecologic units before investigations into the deer-conifer damage problem are initiated. Failure to stratify deer-conifer damage data on a plant community basis may lead to either erroneous interpretations or to the failure to detect significant differences. A key purpose of synecologic research is to improve and enhance the value of other investigations. Other important objectives were to estimate abundance of winter deer forages by plant community and to quantitatively document change in abundance of deer foods with plant successional advance.

CLIMATE, PRISTINE VEGETATION AND FIRE

The moderate climate of western Oregon is controlled by westerly winds and the North Pacific Drift (11). The cooling effect of the coast on warm, eastward moving low pressure areas from the Pacific Ocean causes nearly all precipitation (11, 10). Coast range mountains have the highest annual precipitation in the state (Glenora averaged 130 inches over 25 years); winters are wet and cool, summers are dry and warm. Monthly values for maximum temperature and precipitation are presented in Figure 1 for Glenora (35), a weather station that operated three miles east of the study area. Temperatures are moderate throughout most of the year, the lowest monthly maximum is 41 °F in January (Figure 1) and the highest monthly maximum is 79°F in August. Precipitation peaks at 25 inches in November but is slightly over one inch per month during July and August. Temperature and evapotranspiration are highest when precipitation is low. During July and August, eight or nine inches are evaporated monthly from a free-water suface when precipitation is very low (9, Figure IV-4). Droughty conditions in surface horizons are prevalent during summer and soil moisture sometimes falls below the wilting point (17). High annual precipitation misrepresents the actual growing season soil-moisture relationships, a limiting factor in survival

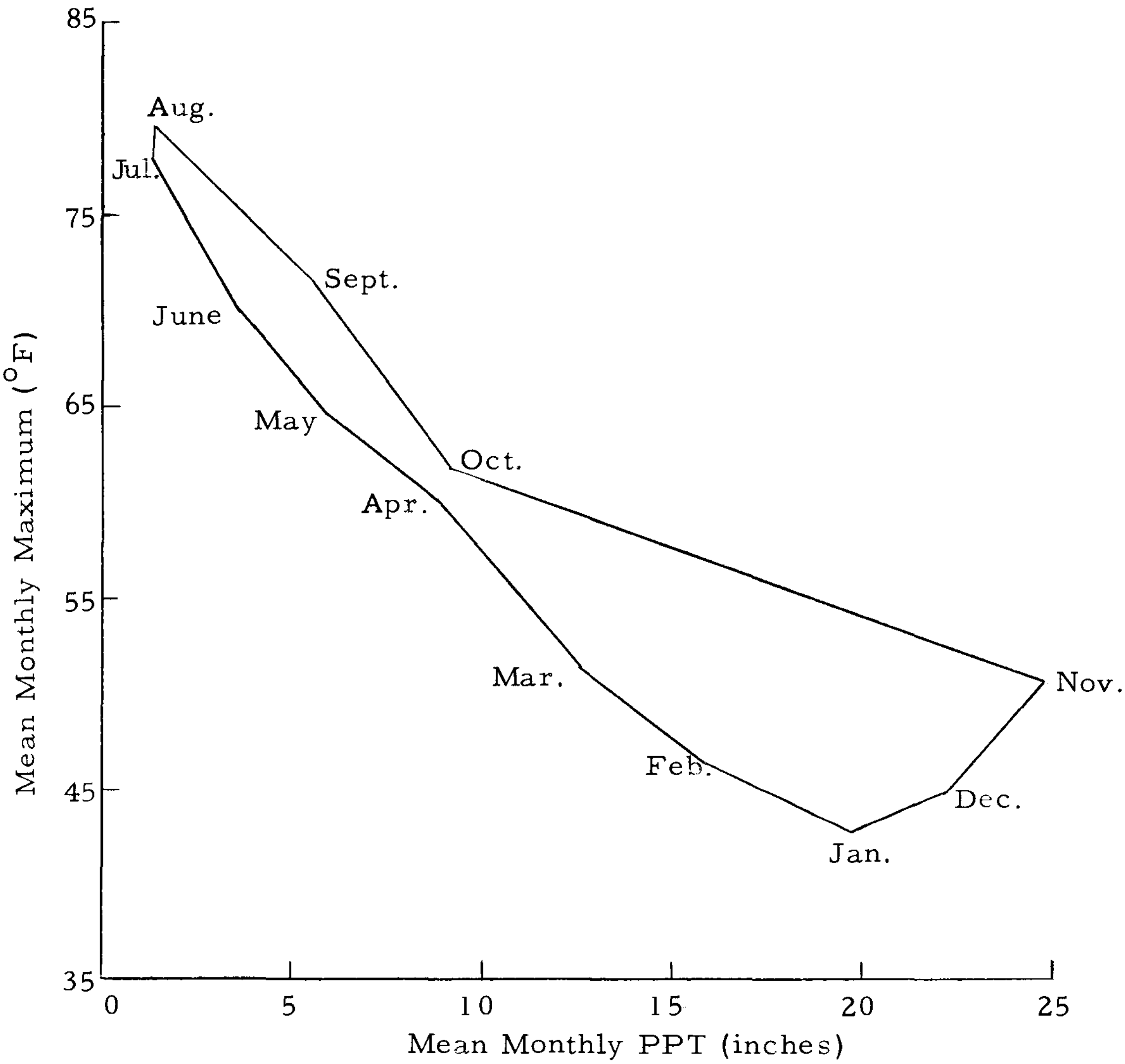

Figure 1. A hythergraph comparing maximum temperature and precipitation for Glenora (25 year record, three miles east of study area).

of many plants including young Pseudotsuga menziesii. Precipitation is high from September to June but the supply is limited during critical summer months.

Climate has been relatively stable the past 4,000 years (11, 10). This would seem to be an adequate length of time for plant species adapted to present climatic conditions to invade, become established, and to sort themselves according to the local effective environment. The coast range forest falls into Daubenmire's Thuja plicata province and into the Pacific conifer forest of Oosting (26, p. 312). Climax dominants are Tsuga heterophylla, Thuja plicata and several Abies species. Common understory species include Gaultheria shallon, Polystichum munitum, Achyls triphylla, Oxalis oregana, Trillium ovatum, and Vancouveria hexandra. Important seral species include Pseudotsuga menziesii, Alnus rubra, Rubus ursinus, Pteridium aquilinum and Rubus parviflorus.

Fire has been an intimate part of the environment for centuries. Heusser (11) studied bogs along the wet coastal belt of North Pacific, North America and discovered that Devils Lake in northwestern Oregon had six charred layers in a 6,000 year old bog, while Seaview bog in southwestern Washington had three charred layers. Climax and late seral plant communities have been destroyed by fire time and again, changing physical properties of surface soil horizons (8) and altering succession. The complex pattern of fires allowed perpetuation of shade-intolerant species well-adapted to survival in early successional stages. Seral plants were also perpetuated within old-aged stands in openings left by fallen trees. Many seral species remain in stands, under the forest canopy, for centuries and may actually never be eliminated. Nieland (25, p. 661) found no fire scars in the forest remnant she investigated several miles south of the present study area. Although age data were not presented, diameter measurements of Douglas-fir (25, p. 664) are similar to stump diameters in the author's study area that ranged from 320 to 440 years old. Seral species that Nieland found in the forest in small amounts include Rubus ursinus, Rubus spectabilis, Luzula parviflora, Campanula scouleri, Xerophyllum tenax, Galium oregana and Trillium ovatum. A tall shrub important in the author's seral communities and also abundant in Nieland's forest is Acer circinatum.

Fires have occurred so frequently that climax stands are rare. Species have had time to develop adaptations to fire in order to populate devastated areas quickly. Shade-intolerant species could exist in some burns for many years. Individual trees of the shade-intolerant Pseudotsuga ranged from at least 320 to 440 years old in the virgin forest. Between 1550 A. D. and 1670 A. D., shade-intolerant species could have survived and reproduced. Nieland (25, p. 666) found some of these seral species still growing in the forest.

The Tillamook Burn is unusual because of repeated burning of three fires over the same area within a 12 year period. Most seral species have had to have some adaptations to survive forest fires over the past centuries and are apparently little affected by repeated burning. Limited reconnaissance into other parts of the northern coast range has shown strong similarities between plant communities of the thrice burned study area and communities that developed after one forest fire.

GEOLOGY, PHYSIOGRAPHY AND SOILS

The northern Oregon coast range has a complex geology (1, 10, 36). During several million years in middle Eocene, submarine lava flows and breccia accumulated intermittently, while tuff was deposited during and following the periods of active vulcanism. Depression of the land surface in upper Eocene permitted the sea to encroach and form an archipelago. Since Eocene, uplifting, erosion, folding, warping and trenching has occurred. Warren (36) named this complex of basaltic lava, breccia and tuff the Tillamook volcanic series. The Wilson River approximates the boundary between two major parts of this geologic formation. All the northern part and the western edge of the Tillamook Burn is underlain by dark-greenish gray aphanitic to porphyritic basalt flows and breccia with occasional interbedded tuffaceous shales and siltstones. The south and eastern parts of the burn are underlain by dark-grey tuffaceous shale, siltstone and thin-bedded sandstone with interbedded dark-grey amygdaloidal porphyritic basalt and andesite. Miocene dikes and sills of diorite and gabbro intruded periodically into this formation. Diorite and gabbro became more extensive in the extreme southeastern part.

The study area is near the coast-range crest on generally westerly-facing slopes. Rapid erosion on the western side has shifted coast-range passes east of the present mountain crest. Basaltic lavas constitute the upper slopes and ridges in the study area while tuffaceous siltstones predominate colluvial flats and lower slopes. Mountains are highly dissected with narrow ridges, a complex pattern of slopes, and narrow valleys; slopes are 60 to 80 percent and range from 500 to 1500 feet long.

A reference applicable to the soils of the Cedar Creek drainage is the Soil Survey, Tillamook Burn Area, Tillamook County, Oregon (33), a 32,000 acre survey several miles west of the study area. The soils are in the Sol Brun Acides great soil group. They are well-drained, strongly acid and have highly water-stable aggregates very resistant to erosion.

Deep permeable soils have developed on the more gentle topography but stony, shallow lithosols occupy the ridges. Surface horizons are fine and granular, dark to reddish-brown silt loams while B horizons vary between parent materials. The presently recognized soil series are Astoria, Trask, Hembre and Kilchis.

The Astoria series is weathered from tuffaceous shales and siltstones, it is the most productive soil with a site index for _Pseudotsuga_ ranging from 160 to 200 depending upon soil depth, drainage and slope exposure. Surface horizons are dark brown, friable, fine granular silt loams with strong brown to yellowish-brown, firm and subangular blocky B horizons.

The lithosolic associate of Astoria is the Trask series, it is similar to the Astoria series but shallower, with many shale fragments throughout the profile.

Clay content generally increases with depth in soils developed from weathered basalt, but the Hembre soils, which are underlain by basalt, have silt loam B horizons. Deposition of loess or volcanic ash on basalt in the geologic past may account for the silt loam texture of B horizons.[1/] The site index for Pseudotsuga is 161 to 196 depending upon drainage, depth and slope exposure. Surface horizons are fine granular, dark brown silt loams with few to many shot concretions.

The lithosolic associate of Hembre is the Kilchis soil series. This shallow soil is prevalent on ridges and steep upper slopes and has many coarse fragments throughout the profile.

1/ Youngberg, C. T., Professor of Forest Soils, Oregon State University. Personal interview, March 12, 1963.

METHODS

Reconnaissance

The investigator whose main objective is to characterize important plant communities needs to become familiar with synecologic and physiographic properties of the plant populations prior to collection of quantitative data. This was accomplished through field reconnaissance in the winter of 1961-62. Homogeneity of the vegetation was interpreted on the basis of dominance and species composition. The scientific method was strictly followed to interpret vegetation as it occurs on the ground. Reconnaissance is essential for stratification of vegetation into relatively homogeneous units and to provide tentative hypotheses that can be objectively and quantitatively investigated.

Samples of similar populations can always be grouped, but if dissimilar populations are grouped prior to a study and the groupings are lost track of, the resulting confounded data is impossible to interpret. Stands were purposely classified into homogeneous units in reconnaissance rather than risk aggregating different plant communities. If species dominance and composition of a stand was different from the usual, it was assumed to be a different population until quantitative analysis data revealed otherwise.

A 5 by 25 meter plot was located near the center of homogeneous stands free from recent soil and vegetation disturbance. Since the objective was to characterize post-burn plant communities, atypical stands whose species composition and dominance had been altered noticeably by logging, deer, rodents, or soil slumping, were excluded from the study. Overstory dominants and tall shrubs were observed from one location but winter herbs were examined at several places in the plot. Canopy coverage was estimated by species into seven classes as described in the quantitative analysis section. Physiographic information recorded at each site included elevation, slope direction, drainage direction, percent slope, and position on slope.

Seven plant communities were tentatively defined from the coverage and physiographic data taken at 92 reconnaissance sites. The validity of the reconnaissance classification was tested by quantitative analysis as outlined in the following section.

Quantitative Analysis

Vegetation. The purpose of quantitative analysis was to test the validity of tentative hypotheses developed in reconnaissance and to adequately characterize the seral plant communities. The method needed to be rapid, relatively accurate, free of bias and of proven merit. Synecological methods suitable for adaptation to seral forest communities were needed but steep mountainous topography limited amount of equipment. The canopy coverage method selected is a modification of Daubenmire (5, 6) and Poulton (30). Definition of terms follow Tansley (34) and Daubenmire (5). The classification unit for seral plant communities is the associes, the successional equivalent of the association.

A vertical projection of a polygon drawn around the maximal aerial extent of an individual plant provides the basis for estimating its coverage. Coverage values expressed as a percentage of ground area may be used to index a plant's influence in the ecosystem. When estimates are made in broad cover classes, the method is rapid yet accurate enough for current, detailed wildland synecological investigations. Weight or volume measurements would be more accurate but are far too time consuming for many synecological studies.

The canopy coverage method is best suited to measure plants with the same height to width ratio. When tall, narrow, and short, wide plants are measured together, the influence in the ecosystem is probably underestimated for tall, narrow plants and overestimated for short, widespreading plants. The method as described by Daubenmire (6) is not suited for measuring vines or creeping plants.

The coverage estimation technique was modified for the creeper, *Rubus ursinus*, and the vine, *Marah oregana*, because a polygon drawn around the peripheral aerial parts of these widespreading plants would grossly overestimate their influence on the ecosystem. Instead, a polygon was drawn around the vertical projection of aerial parts of individual stems as they occurred in the observation plot.

A 5 by 25 meter macroplot was laid out downslope in the center of each selected stand. Macroplots were divided into five 1 by 25 meter strip transects and two transects were selected for sampling from a table of random numbers. The upper right corner of the macroplot and both ends of the sample transects were marked with orange cedar stakes. Beginning one-half meter from the upslope transect stake, twenty-five, 2 by 5 dm. observation plots, spaced one meter apart, were examined. Canopy coverage was recorded by species in each observation plot using the seven class system of Table 1. After both transects had been sampled, the macroplot was thoroughly examined to record species not found in the 50 observation plots. An illustration of the sampling design is presented in Figure 2.

A panchromatic and a kodachrome photograph were taken of the vegetation in each macroplot to record distinctive overstory and understory features of the plant communities.

Table 1. Canopy coverage classes and midpoints

Class	Percentage of observation plot	Midpoint
1	0-1	0.5
2	1-5	3
3	5-25	15
4	25-50	37.5
5	50-75	62.5
6	75-95	85
7	95-100	97.5

Quantitative information was collected in July, 1962 from 42 macroplots. Six stands were sampled in each of the seven tentatively recognized plant communities. Representative homogeneous stands studied during field reconnaissance, including some with reasonable variations, were selected for analysis. The environment as reflected in the vegetation was similar among stands and emphasis was placed upon understanding the usual expression of each community. Each plant species in a community has its own ecologic amplitude. The degree of environmental change from one stand to another is reflected in species composition and dominance. Stands with minor variation in species composition and dominance were prevalent and were included in the study. However, unusual expressions of a seral burn community were avoided. Other stands excluded were excessively disturbed by soil slumping, salvage logging or burrowing rodents. Vegetation and soil disturbance causes are explained in more detail in the Discussion and Results section.

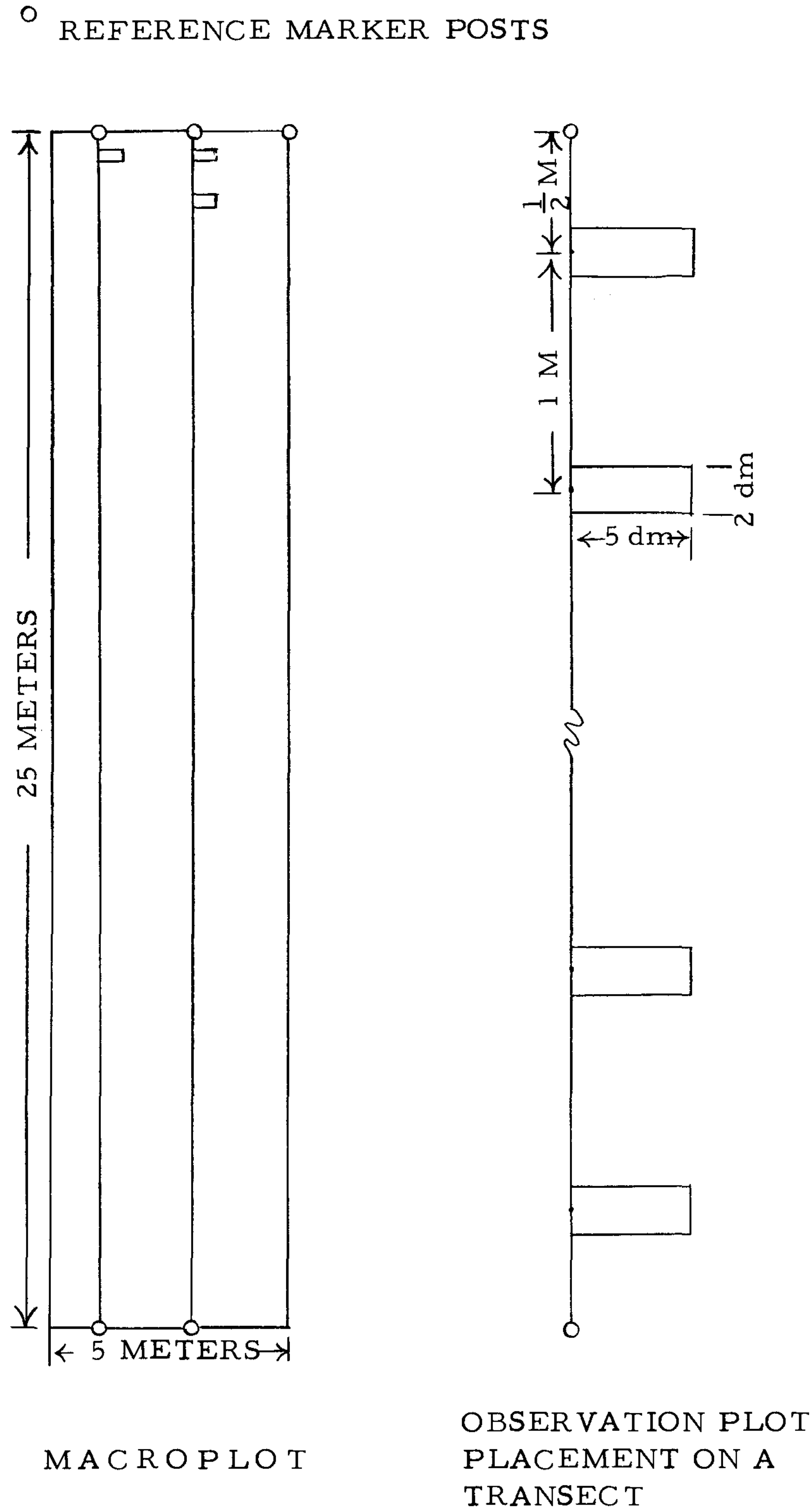

Figure 2. Macroplot sampling design.

Midpoints of cover classes were used to calculate species coverage in the observation plots. Average canopy coverage by species was based on 50 observation plots per macroplot. Constancy is the number of macroplots in which a species occurs, six being the maximum. It measures species frequency of occurrence among stands of a community. Frequency is suggestive of the species distribution pattern within a stand. Coverage, frequency, and constancy together estimate a species influence on its ecosystem more adequately than any single measurement.

Range in species dominance among stands was expressed by the lowest and highest macroplot averages for frequency and canopy coverage instead of subjecting the data to statistical tests. Since stands reasonably different from the modal stands were included, lowest and highest values reveal the expected species variation among stands of a plant community as adequately as time-consuming statistical tests. Association tables were constructed to reveal similarities and differences among plant communities.

Soils and Physiography. Soils are a major component of the environment under which plants develop. Plants are dependent upon soil for rooting media, nutrients and water. Vegetation-soil relationships strengthen the understanding of the environment and supplement synecologic data in characterizing the community.

A soil profile was dug near the macroplot boundary and procedures used in the field description follow the U. S. Department of Agriculture, Soil Survey Manual (31). The following characteristics were recorded for each soil horizon: depth, lower boundary, moist color, dry color, texture, structure, consistence, root abundance, stoniness and pH. Origin of partly weathered rocks in each horizon was noted, as was the parent material of the profile. pH of saturated soil paste was measured by a glass electrode pH meter in the laboratory.

Physiographic location has an important environmental influence on seral vegetation in the study area. Microclimate and soils change abruptly in the rough, mountainous terrain. Physiographic properties recorded at each macroplot include elevation, drainage direction, aspect, percent slope, position on slope, and slope form. Units of measurement are presented in Table 2.

Table 2. Units used to measure physiographic characters.

Physiographic property	Limits
Elevation	100 foot intervals
Drainage direction	8 compass divisions
Aspect	16 compass divisions
Percent slope	to nearest 5 percent
Position on slope	top: upper one-third middle: middle one-third bottom: bottom one-third
Slope form	ridgetop convex concave swale

Aging Procedure. Early seral plant communities are sometimes relatively heterogeneous due to a diverse recent past history and the dominating microclimatic control. Field reconnaissance revealed that overstory dominant trees and shrubs were homogeneous within stands but variable among stands. Frequently, the shrubs and trees were taller and denser in deep swales and valleys, areas naturally protected from fire. The study area was burned three times but fire intensities and patterns were unknown. The purpose of the aging procedure was to attempt to determine the fire history of the macroplots. Burning intensity seems to have been severe in the first two fires but light in the 1945 fire. Local intensity and pattern were largely controlled by the amount of flammable material, topography, and immediate weather conditions.

The different woody plant species have varying resistances and adaptations to fire. Some plants are highly susceptible to fire injury while others have only their aboveground parts killed and resprout soon after fire from the live root.

Age of a stand since the last fire was determined at each macroplot site and any indication of previous fires was noted. A preliminary study was made on only one species, _Alnus rubra_, to investigate the validity of using xylem rings as an age indicator. Increment-boring of 34 alder trees on two known-aged logging skid-trails revealed no double rings and an age for each stem younger than the skid-trail age. Woody plants aged in addition to Alnus rubra include Acer circinatum, Acer macrophyllum, Corylus californica, Pseudotsuga menziesii and Vaccinium parvifolium. Three reference points used to validate the assumption that the species grew one xylem ring per annum were the fire years 1933, 1939 and 1945.

Woody species recorded in each macroplot were aged within the stand but outside the macroplot. Stems were cut or increment bored within one foot of ground level and xylem rings were counted. Ages were recorded for five large plants of the dominant or codominant species and for two plants of each subordinate species. Preliminary studies revealed that the largest stem of multistemmed species was not always the oldest but the two largest stems revealed the maximum age with about 90 percent accuracy. The two largest stems of multistemmed species were aged. Shrub and tree height was estimated in feet.

RESULTS AND DISCUSSION

Soils

Soils in the coast range crest area have developed under the influence of high annual precipitation and dense conifer forest. Certain properties common to all soils of the study area that reflect primarily the influence of climate and vegetation include the following: strong acid reaction, rapid permeability and aggregates that are highly water stable. Soils on the 20 to 85 percent mountain slopes have been influenced by colluvium. The proportion of coarse fragments in the solum is related to colluvial activity. Surface horizons are granular loams or silt loams and are darker than B horizons.

Profiles of the Astoria, Trask, Kilchis and Meda soil series are adequately described by Swanson, *et al.* (33). However, the Hembre soil series was found to be classified too broadly. For the purposes of the present investigation the original Hembre series has been tentatively separated into two new series. Hembre I soil series is differentiated from Hembre II soil series primarily on the basis of physiographic position, amount of coarse fragments in the solum and structure and consistence of the B horizons.

Meda Soil Series. The Meda soil series is an immature soil developed on alluvial outwash fans. A profile description is in Appendix 1. The series is recognized by its alluvial parent material, a weakly developed structure in B horizons and the abundance of gravels and rounded coarse fragments throughout the solum. Three profiles were examined on the same large alluvial fan. The A horizon is very friable, black to dark reddish brown 5YR 2/1.5 moist, changing to a 10YR hue when dry. Dry colors become lighter with depth but remain in the 10YR hue, moist colors frequently become yellower with increasing depth. Clay content increases with depth and roots remain abundant throughout the solum. Roots may be restricted to the solum because igneous sands gravels and cobbles of the underlying D horizon are a poor growth medium. Meda soils have a low moisture-holding capacity because of the abundant coarse fragments but profiles examined during August, the driest month, were very moist. Meda soils on north-facing, lower slopes seem to have a constant nutrient and moisture source provided by lateral seepage from upslope.

Astoria Soil Series. The Astoria soils have developed from tuffaceous shales and siltstones deposited during the Eocene Epoch. The nine profiles examined occurred on lower slopes from 700 to 1100 feet elevation. A typical profile is illustrated in Figure 3 and a profile description is in Appendix 1. Astoria soils ranged from

30 to 45 inches to the C or D horizon. Depth of weathering varied among profiles and a C horizon was found in deeply weathered soils, while shallower profiles rested upon shale D horizons. The profiles described are generally on 70 to 80 percent slopes. Shale coarse fragments are common throughout the profile, a result of downslope colluvial movement. The A horizons are about a dark brown 7.5YR 3/2 when moist and a dark greyish brown 10YR 4/2 dry color. Moist horizon colors become yellower with increasing depth but dry color remains in the 10YR hue. The moist color for B horizons is frequently a dark brown 7.5YR 4/4 to 10YR 3/3 changing to brown to light yellowish brown 10YR 4/3-6/4 when dry. Clay content increases with depth, from a silt loam A horizon to a silty clay loam B horizon and to a clay loam C horizon. The A horizons are friable and granular while B horizons are sticky and plastic, firm and subangular blocky. As in all profiles examined, roots are abundant in the A horizons, decreasing to common in B horizons and to few in C or D horizons.

Astoria soils have a high moisture-holding capacity. In addition, lateral seepage provides many favorably located lower slope soils with a continuous supply of moisture and nutrients.

Trask Soil Series. The Trask soils are lithosolic associates of the Astoria series. A shallow solum developed from shales and siltstones is characteristic of the Trask series. The B horizons were always absent in the four profiles described. A photograph in Figure 4 and a profile description in Appendix 1 illustrate a typical Trask soil profile. Like the Astoria series, Trask soils are on lower slopes. The A horizon ranges from 8 to 18 inches deep. It is a black to dark reddish brown 5YR 2/1.5 moist color changing to a very dark greyish brown to dark brown 10YR 3/2-4/3 dry color. This friable, granular silt loam textured horizon has abundant roots and shale fragments. The D horizon is composed of loosely or tightly packed unweathered sedimentary rock. Roots are rare in the unweathered rock. These shallow soils have a very limited moisture-holding capacity but productivity is also dependent upon physiographic location. Trask soils on lower, north-facing slopes have a vegetation indicative of favorable growing conditions while similar soils on south-facing ridgetops have a vegetation adapted to more xeric conditions.

Hembre I Soil Series. The range of characteristics of the original Hembre soil series as described by Swanson, *et al.* (33) is extremely wide. The series is too broad for the purposes of either land management or basic synecological research. Two series, Hembre I and Hembre II soil series have been tentatively proposed after an examination and description of 21 profiles that fall into the original Hembre series. The dominating influence of colluvium on soil development has been the main criterion used to separate the tentatively designated Hembre II soil series from the Hembre I series. Colluvium is becoming recognized to have an important influence on soil development. A recent soil survey in the Alsea Basin used colluvial parent materials as a criterion for separation at the series level (3).

Hembre I series has comparatively few coarse fragments, is deeply weathered, and is formed in place on basalt. Figure 5 shows a typical profile and a profile description is provided in Appendix 1. The surface horizon is about a dark brown 7.5YR 3/2 moist color changing to a dry dark greyish brown 10YR 3/2 color while B horizons have a dark brown 7.5YR 3/4 moist color changing very little when dry to 7.5YR 4/4. The C horizon is a dark brown 7.5YR 4/4 color when moist becoming yellower when dry, a light yellowish brown 10YR 6/4. The solum is subangular blocky throughout except for the occasional granular surface horizon. Structure tends towards massive in lower B horizons and is frequently massive in the C horizon. The A horizons are friable, B horizons are firm. Roots are abundant in surface horizons and decrease with depth but a few are present at 60 inches. Horizon boundaries become less distinct with increasing depth.

The Hembre I profiles described are on middle and upper slopes ranging from 20 to 60 percent slope and 1600 to 2000 feet elevation. They are on nearly all slope directions. The soils are generally located where lateral seepage would contribute little to the supply of available moisture. These deep, stone free soils probably have a high moisture-storage capacity and are the most productive, higher elevation soils studied.

Hembre II Soil Series. The soils have silt loam to loam textures throughout the solum, and their development has been strongly influenced by colluvial igneous rock and occasionally by sedimentary rock. Figure 6 is a photograph of a Hembre II soil and a profile description is provided in Appendix 1. Thirteen profiles were described and their solum depth ranged from 20 to 57 inches. The A horizon is usually friable and fine granular with an abundance of roots while B horizons are friable, weak subangular blocky and have common or abundant roots. Moist color usually is black to dark reddish brown 5YR 2/1.5 changing to very dark brown 10YR 2/2 when dry while B horizon has a dark brown 7.5YR 3/4 moist color changing to a brown 10YR 4/3 dry color. Shallower soils have a D horizon of loose or tightly packed igneous rock at 20 to 30 inches. A C horizon is present as the lower horizon in deeply weathered soils, it is lighter colored than B horizons but has many similar characteristics.

Most Hembre II profiles examined are on steep, middle and lower slopes ranging from 800 to 2100 feet elevation. The 60 to 80 percent slopes were in a position to benefit from downslope lateral seepage. The abundance of coarse fragments reduces moisture-storage capacity of Hembre II soils but productivity is at least comparable with Hembre I soils because of the generally favorable location in relation to lateral seepage.

Kilchis Soil Series. Kilchis series is the lithosolic associate of the Hembre soil series described in the Soil Survey, Tillamook Burn Area (33). Kilchis soils are common on slopes above 1800 feet. The soils have abundant coarse fragments throughout the profile due to the very slow weathering of basalt parent material and geologic erosion. Color change is frequently great between moist and dry soils going from 5YR to the 10YR hue. The friable, granular silt loam A horizon generally has a black to dark reddish brown 5YR 2/1.5 moist color changing to very dark greyish brown 10YR 3/2 when dry, roots and igneous chert are abundant. The B horizon colors vary considerably. The friable silt loams have a weak, subangular blocky structure, roots and igneous cherty basalt are abundant. The D horizon consists of tightly packed unweathered or loosely packed shattered basalt. Roots penetrate deeply into the shattered

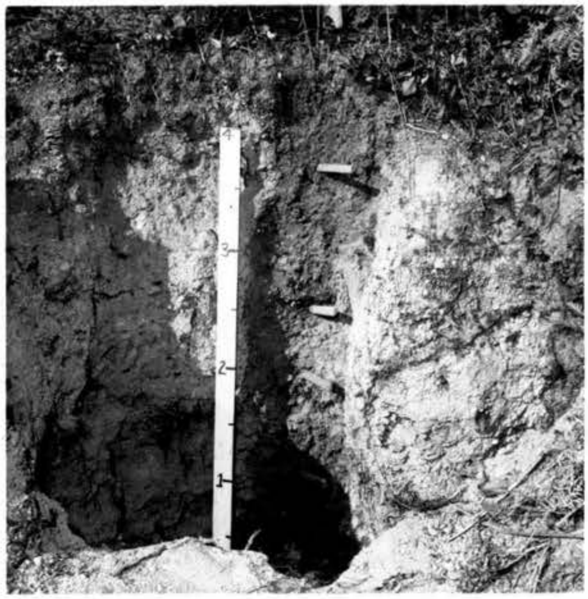

Figure 3. A typical profile of the Astoria soil series, macroplot 13, (scale marked in feet).

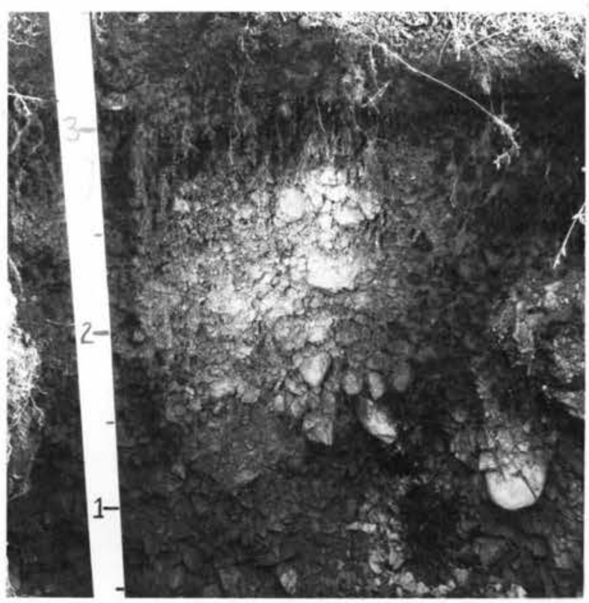

Figure 4. A typical profile of the Trask soil series, macroplot 10, (scale marked in feet).

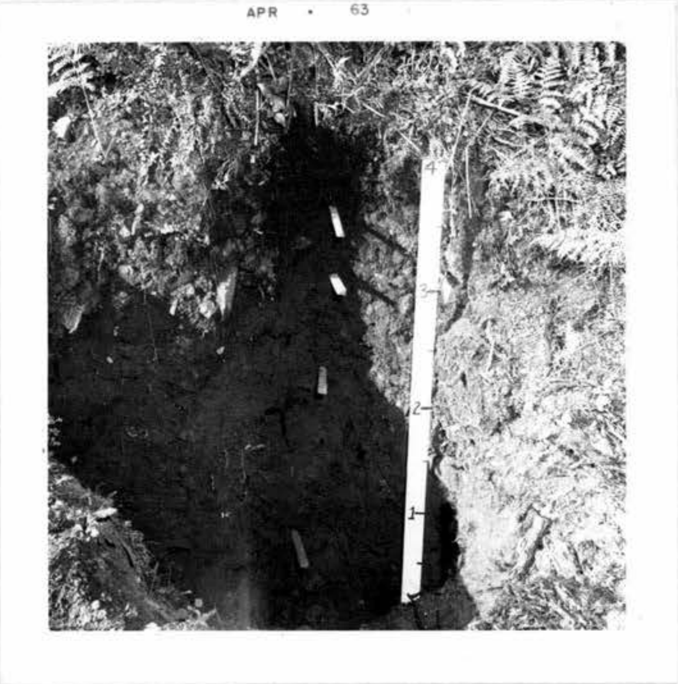

Figure 5. A typical profile of Hembre I soil series, macroplot 28, (scale marked in feet).

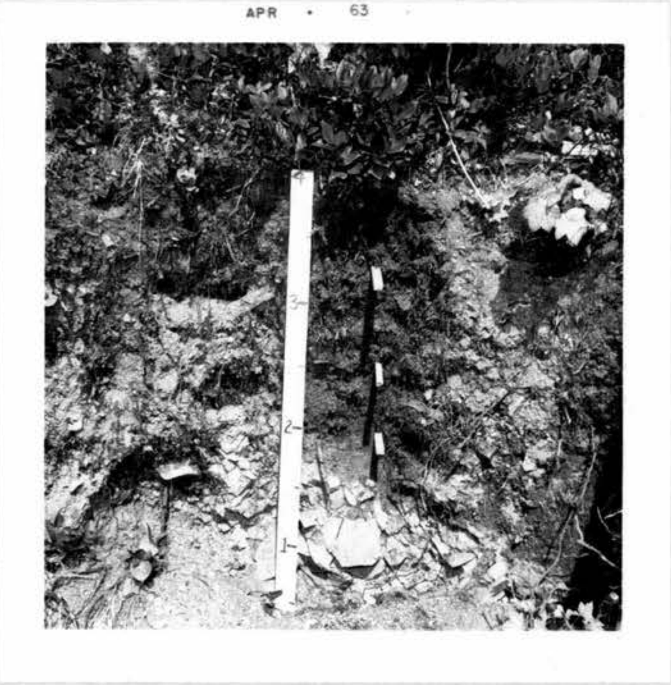

Figure 6. A typical profile of Hembre II soil series, macroplot 26, (scale marked in feet).

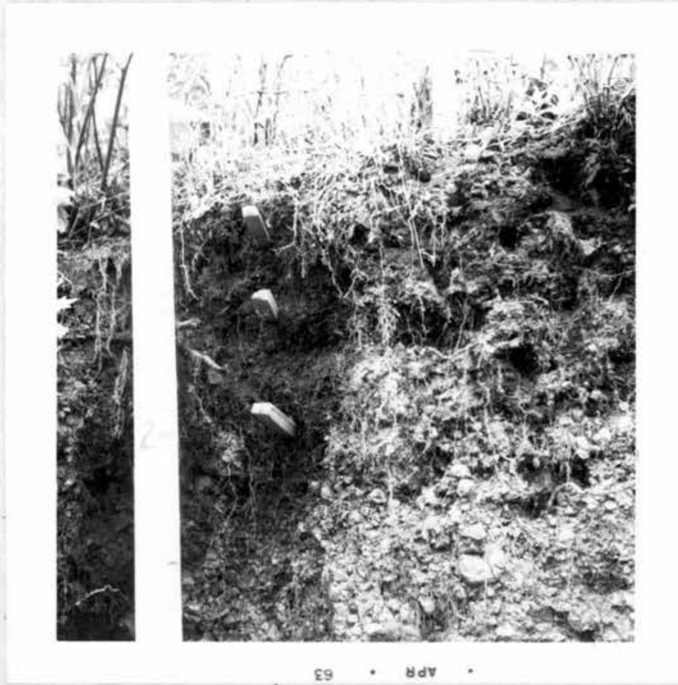

Figure 7. A typical profile of the Kilchis soil series, macroplot 33, (scale marked in feet).

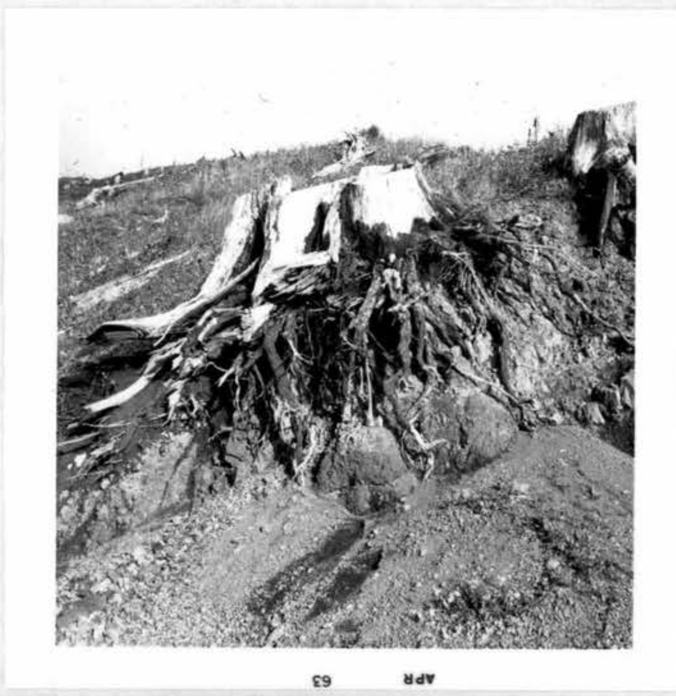

Figure 8. Deeped rooted Pseudotsuga menziesii on Kilchis soil series.

Figure 9. An example of the Alnus rubra/Polystichum munitum associes, macroplot 4, (two meter scale marked in dm.).

Figure 10. An example of the Alnus rubra-Acer circinatum associes, macroplot 30, (two meter scale marked in dm.).

Figure 11. The usual expression of the Acer circinatum-Corylus californica associes, macroplot 31, (two meter scale marked in dm.).

Figure 12. A dense stand of Acer circinatum-Corylus californica associes, macroplot 9.

Figure 13. An example of the Rubus parviflorus/Trientalis latifolia associes, macroplot 32, (one meter scale marked in dm.).

Figure 14. An example of the Pteridium aquilinum/Lotus crassifolius associes, macroplot 20, (two meter scale marked in dm.).

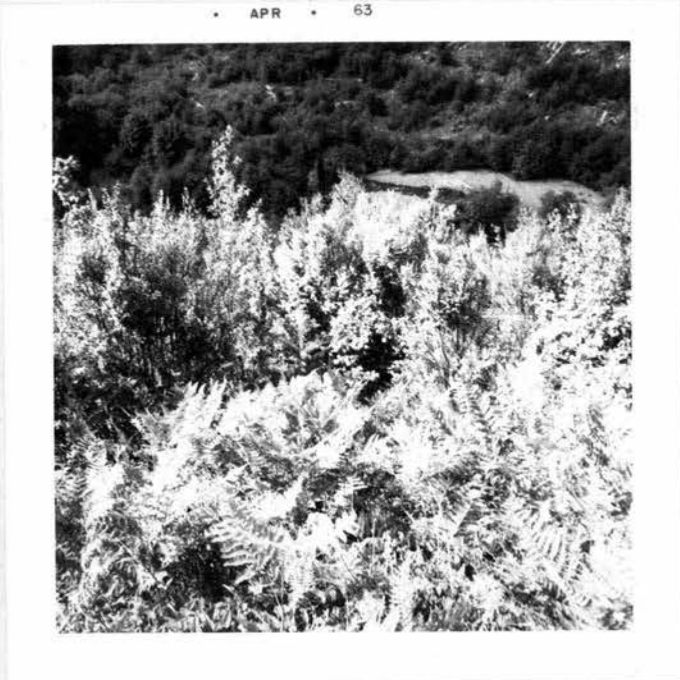

Figure 15. An example of the Vaccinium parvifolium/Gaultheria shallon associes, macroplot 13.

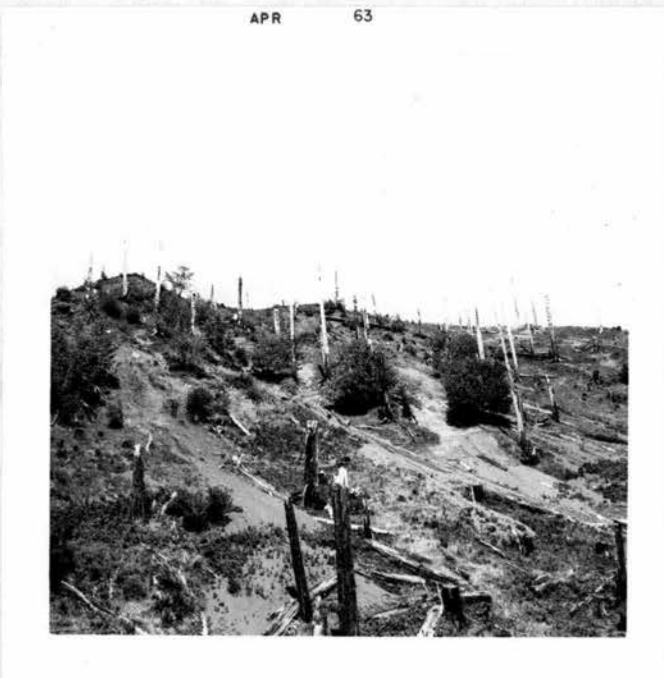

Figure 16. An example of the Acer macrophyllum/Symphoricarpos mollis associes.

Figure 17. An example of the Acer macrophyllum-Alnus rubra associes (two meter scale marked in dm.).

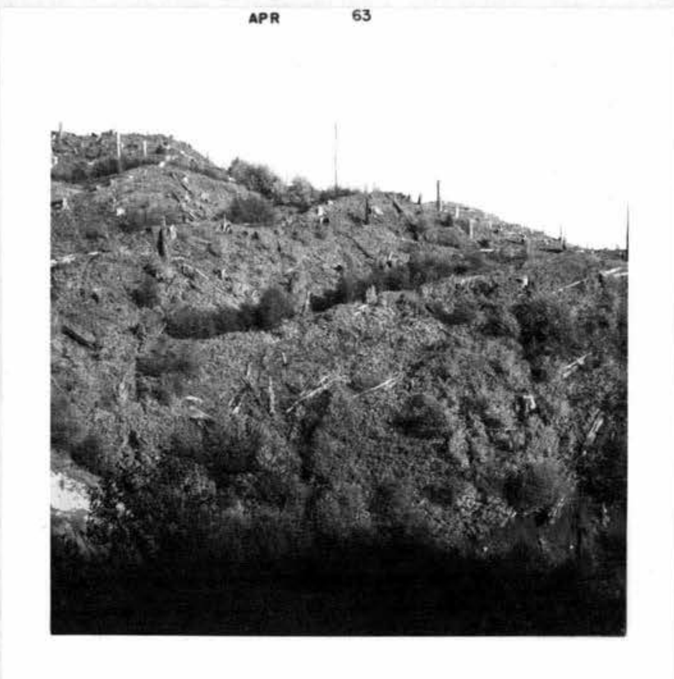

Figure 18. Alnus rubra growing on a logging skidroad in a stand of the Acer-Corylus associes.

rock (Figure 8) but few penetrate the unweathered basalt. Figure 7 is a photograph of a typical Kilchis soil, a profile description is presented in Appendix 1.

Kilchis soils are located on ridgetops or upper slopes where there is little chance of lateral seepage carrying additional moisture and nutrients into the soil. The amount of moisture available to plants during the dry summer season is dependent upon the moisture-holding capacity of the soil. Soils are shallow and the abundance of basalt coarse fragments further reduces moisture-storage capacity. Kilchis soils seem to have a limited productivity since *Rubus parviflorus* is two to three feet high on this soil series but is four or five feet high on lower elevation soils.

Vegetation

Alnus rubra/Polystichum munitum Associes. Mesic, low elevation, north-facing bottom slopes are occupied by the *Alnus rubra/Polystichum munitum* associes. All stands studied were last burned in 1945. Coverage and frequency values for characteristic species are presented in Table 3. The associes is characterized by a 40 foot high closed overstory canopy of *Alnus rubra* and a dense understory cover of *Polystichum munitum*. The only other overstory tree is the occasional *Acer macrophyllum*. *Acer circinatum* and *Corylus californica* are 15 to 20 feet high. Each is present in about

Table 3. Characteristic species of the Alnus rubra/Polystichum munitum Associes (Alru/Pomu).

Species	Constancy n = 6	Average Coverage Frequency	Range in Coverage	Range in Frequency
TREES				
Alnus rubra	6	97/98	92-98	94-100
HERBS AND SHRUBS				
Vaccinium parvifolium	5	4/6	(0)+-17**	(0)+-20
Polystichum munitum	6	64/78	40-81	60-86
Montia siberica	6	33/69	14-63	32-98
Rubus parviflorus	6	31/45	+-83	+-92
Oxalis oregana	6	14/24	1-50	6-44
Rubus ursinus	6	8/23	2-15	10-54
Maianthemum bifolium	6	6/46	2-11	14-66
Galium aparine	6	5/15	0. 4-14	4-34
Festuca subuliflora	6	4/11	0. 05-10	2-26
Disporum smithii	6	3/19	0. 1-5	4-30
Stellaria crispa	6	3/10	0. 6-4	4-14
Stachys mexicana	6	1/9	0. 5-3	2-18
Luzula parviflora	6	1/7	0. 3-3	2-16
Rubus spectabilis	5	24/29	(0)3-61	(0)8-70
Pteridium aquilinum	5	7/10	(0)2-31	(0)2-42
Viola sempervirens	5	0. 4/2	(0)+-1	(0)+-6
Trientalis latifolia	5	0. 2/4	(0)0.1-0.7	(0)4-6
Galium trifolium	5	0. 2/4	(0)+-0. 4	(0)+-8
Senecio sylvaticus	5	0. 08/5	(0)0.02-0.3	(0)2-16
OTHER CHARACTERISTICS				
Litter	6	80/97	65-89	94-100
Epigynous - Cryptogams	6	9/40	2-22	8-68
Logs	6	6/10	0. 4-14	2-22
Bare Ground	6	4/13	0. 8-9	2-26

**Constancy 5/6, species absent from one macroplot; plus (+) indicates presence in macroplot but not recorded in 50 observation plots.

Table 3 (Continued)

Species with a constancy of 3/6 or 4/6 in Alru/Pomu.

Adiantum pedatum	Rosa gymnocarpa
Acer circinatum	Smilicina sessilifolia
Campanula scouleri	Struthiopteris spicant
Corylus californica	Trillium ovatum
Epilobium watsonii	Vancouveria hexandra
Melica harfordii	

Species important in other associes but absent in Alru/Pomu.

Aira carophyllea	Elymus glaucus
Anaphalis margaritacea	Epilobium angustifolium
Berberis nervosa	Epilobium minutum
Cerastium viscosum	Galium oreganum
Crepis capillaris	Hypericum perforatum
	Lotus crassifolius

one-half the stands. *Vaccinium parvifolium*, a shrub about seven feet high, is usually present in small amounts. Four to six foot *Rubus parviflorus*, *Pteridium aquilinum*, and *Rubus spectabilis* are nearly always present but their coverages vary within stands, increasing greatly in sun spots. Herbaceous species highly indicative of the associes are listed in Table 3. Decaying leaves and twigs cover the ground surface and bare ground and stone cover are low. Species with wide ecologic amplitudes rare in the associes include *Collomia heterophylla*, *Festuca rubra*, *Hieraceum albiflorum* and *Luzula campestris*.

Alnus rubra-Acer circinatum Associes. Another community dominated by *Alnus rubra* occurs on middle and lower north-facing slopes generally on slightly higher, steeper, convex slopes than the *Alnus rubra/Polystichum munitum* associes. The stands were burned in 1945 as indicated by the maximum *Alnus rubra* age of 17 years. *Alnus* is 30 to 35 feet high and has a variable cover ranging from 50 to 100 percent. A tree with an even more variable coverage than *Alnus* is the 20 foot *Acer circinatum*. *Corylus californica* and *Vaccinium parvifolium* are nearly always present. The associes is relatively heterogeneous among stands and both overstory and understory species occur in extremely variable amounts.

The dominant understory species (Table 4) are *Rubus*

Table 4. Characteristic species of the Alnus rubra-Acer circinatum Associes (Alru-Acci).

Species	Constancy n = 6	Average Coverage/ Frequency	Range in Coverage	Range in Frequency
TREES				
Alnus rubra	6	76/81	52-98	58-100
HERBS AND SHRUBS				
Acer circinatum	6	17/57	0. 6-98	4-100
Vaccinium parvifolium	5	3/5	(0) +-12	(0)+-16
Rubus parviflorus	6	75/86	36-98	60-100
Polystichum munitum	6	40/59	16-62	32-76
Rubus ursinus	6	12/43	3-25	20-60
Luzula parviflora	6	6/24	0. 7-16	8-54
Montia siberica	6	2/17	1-4	12-24
Oxalis oregana	6	2/15	+-5	+-32
Anaphalis margaritacea	6	2/15	+-6	+-16
Trientalis latifolia	6	1/17	0. 4-2	8-32
Galium triflorum	6	1/6	0. 01-6	2-20
Adiantum pedatum	6	1/6	+-5	+-20
Disporum smithii	6	0. 8/8	+-3	+-20
Senecio sylvaticus	6	0. 6/19	0. 1-2	6-40
Collomia heterophylla	6	0. 6/6	+-2	+-18
Elymus glaucus	6	0. 5/3	0. 05-1	2-6
Pteridium aquilinum	5	6/11	(0)0. 3-25	(0)2-42
Campanula scouleri	5	0. 6/7	(0)0. 01-2	(0)2-22
OTHER CHARACTERISTICS				
Litter	6	56/95	36-79	88-100
Epigynous-Cryptogams	6	18/35	0. 5-77	18-58
Logs	6	8/17	0. 3-12	4-30
Bare Ground	6	7/18	0. 6-20	8-28

Other important species with a constancy of 3/6 or 4/6:

Anemone oregana
Berberis nervosa
Corylus californica
Cystopteris fragilis
Dentaria tenella
Epilobium angustifolium
Epilobium watsonii
Festuca subuliflora
Hieracium albiflorum
Lotus crassifolius
Luzula campestris
Maianthemum bifolium
Rosa gymnocarpa
Rubus spectabilis
Stellaria crispa
Trillium ovatum
Vancouveria hexandra

parviflorus, Polystichum munitum, Rubus ursinus, Luzula parviflora and Montia siberica. Moss and litter cover are high and bare ground and stone cover are low.

Species that have wide ecologic amplitudes but are rare in the associes are Festuca rubra and Viola sempervirens.

The Alnus rubra/Polystichum munitum and Alnus rubra-Acer circinatum associes are the only two intensively studied plant communities having an overstory dominated by Alnus. Alnus is present in other associes but usually only on areas disturbed by logging or on soil slumps. The two communities occupy low elevation, north-facing slopes where soil moisture is abundant. Species with moderate to high constancy and coverage values in the two Alnus associes but uncommon in all other associes are Adiantum pedatum, Disporum smithii, Galium triflorum, Maianthemum bifolium, Oxalis oregana and Vancouveria hexandra.

Acer circinatum-Corylus californica Associes. The Acer circinatum-Corylus californica associes occurs on west, south and east-facing bottom and middle slopes at elevations ranging from 800 to 2100 feet. The associes is extremely variable and was tentatively separated into two distinct plant communities from reconnaissance data but quantitative analysis on 12 macroplots revealed no important differences between the communities. Stands in the associes may be separated into phases, the drier phase occurring on convex, low elevation, south-facing slopes and the mesic phase being mostly on concave slopes. The associes occupies approximately 40 percent of the study area.

The fire history in Acer circinatum-Corylus californica associes stands is difficult to understand because Acer circinatum and Corylus californica, the two most abundant overstory dominants, are both resistant to fire injury and can survive a low intensity burn. Acer and Corylus plants had their stems killed in the 1939 fire but root sprouted soon afterwards; most plants survived the light 1945 burn.

The overstory is usually dominated by 12 to 16 foot Acer circinatum, canopy coverage is extremely variable and ranges from present (+) to 89 percent. Corylus has a somewhat erratic distribution and seldom occurs higher than 1800 feet. Other overstory trees are Acer macrophyllum, Alnus rubra and Rhamnus purshiana. Alnus grows very rapidly on moist Acer circinatum-Corylus californica sites but only occasional trees can become established unless there is considerable soil surface disturbance, most frequently caused by soil slumping or logging operations.

Only five species have a constancy of 12/12 and the canopy coverage and frequency values are highly variable among macroplots.

Table 5. Characteristic species of the Acer circinatum-Corylus californica Associes (Acci-Coca).

Species	Constancy n = 12	Average Coverage/ Frequency	Range in Coverage	Range in Frequency
HERBS AND SHRUBS				
Acer circinatum	12	38/54	+-89	+-96
Corylus californica	10	22/26	(0)0.3-57	(0)2-72
Rubus parviflorus	12	49/72	6-90	18-100
Polystichum munitum	12	24/36	0.1-57	4-72
Rubus ursinus	12	20/42	0.3-87	2-100
Elymus glaucus	12	7/23	0.3-36	2-82
Senecio sylvaticus	12	1/19	+-2	+-34
Galium aparine	11	10/36	(0)1-38	(0)14-84
Anaphalis margaritacea	11	8/31	(0)0.7-29	(0)6-80
Luzula campestris	11	0.8/7	(0)+-4	(0)+-36
Lotus crassifolius	10	10/23	(0)+-25	(0)+-62
Epilobium watsonii	10	0.8/7	(0)+-1	(0)+-22
Cystopteris fragilis	10	0.1/2	(0)+-1	(0)+-6
OTHER CHARACTERISTICS				
Litter	12	81/99	70-91	96-100
Bare Ground	12	7/26	0.3-17	2-58
Logs	10	4/9	1-10	2-22
Epigynous-Cryptogams	10	3/23	0.4-11	4-58

Other important species with a constancy of 6/12 to 8/12:

Adiantum pedatum	Galium triflorum
Aira caryophyllea	Luzula parviflora
Campanula scouleri	Montia siberica
Carex rossii	Oxalis oregana
Collomia heterophylla	Pteridium aquilinum
Disporum smithii	Rubus spectabilis
Epilobium minutum	Stachys mexicana
Hieracium albiflorum	Trientalis latifolia

Rubus parviflorus is the usual understory dominant but its coverage is greatly reduced under dense Acer circinatum and Corylus. A litter cover of leaves and twigs is always high and bare ground is rare. The long list of species with a constancy of 6/12 to 8/12 (Table 5) testifies to the associes' variability. Species that are more abundant on drier sites include:

Agrostis exarata	Nemophila parviflora
Digitalis purpurea	Phacelia nemoralis
Festuca myuros	Rosa gymnocarpa
Galium aparine	Rubus ursinus
Lotus micranthus	Trientalis latifolia
Madia sativa	Vaccinium parvifolium

The species that prefer higher elevation, generally more mesic sites are:

Struthiopteris spicant	Melica geyeri
Oplopanax horridum	Tellima grandiflora
Osmaronia cerasiformis	Hydrophyllum tenuipes
Asarum caudatum	Adiantum pedatum

Rubus parviflorus/Trientalis latifolia Associes. Stands of the Rubus parviflorus/Trientalis latifolia associes are common at higher elevations on nearly all aspects. It is assumed that this associes developed after the 1945 fire, since slopes below the stands were burned then. Stems of the few woody plants in stands of Rubus/Trientalis are less than 17 years old. An identifying characteristic of the associes is the 80-100 percent canopy cover of Rubus parviflorus. Woody plants are rare, Prunus emarginata is occasionally

Table 6. Characteristic species of the Rubus parviflorus/Trientalis latifolia associes (Rupa/Trla).

Species	Constancy n = 6	Average Coverage/ Frequency	Range in Coverage	Range in Frequency
HERBS AND SHRUBS				
Rubus parviflorus	6	88/99	82-93	98-100
Elymus glaucus	6	29/65	9-60	42-88
Lotus crassifolius	6	25/63	17-48	22-88
Trientalis latifolia	6	19/85	12-25	72-94
Anaphalis margaritacea	6	15/52	11-19	40-58
Luzula parviflora	6	14/30	1-55	6-86
Campanula scouleri	6	13/53	0. 05-30	2-90
Viola sempervirens	6	7/31	0. 3-24	2-76
Polystichum munitum	6	6/20	0. 1-26	4-66
Hieraceum albiflorum	6	5/36	2-7	18-48
Epilobium minutum	6	5/30	0. 01-18	2-56
Luzula campestris	6	3/16	+-9	+-41
Carex rossii	6	2/12	0. 4-5	4-24
Epilobium angustifolium	6	2/8	+-4	+-18
Rubus ursinus	5	6/19	(0)1-23	(0)6-60
Festuca rubra	5	3/9	(0)3-5	(0)8-14
Festuca subuliflora	5	0. 8/2	(0)+-4	(0)+-6
Senecio sylvaticus	5	0. 4/13	(0)0. 06-1	(0)4-38
Hypochaeris radicata	5	0. 2/1	(0)+-0. 6	(0)+-4
OTHER CHARACTERISTICS				
Litter	6	72/95	60-81	90-100
Logs	6	15/33	9-31	8-62
Epigynous-Crytograms	6	13/27	0. 8-63	8-90
Bare Ground	6	4/7	0. 7-8	2-20
Stone Cover	5	1/9	0. 4-3	4-22

Other important species with a constancy of 3/6 or 4/6:

Aira caryophyllea
Collomia heterophylla
Disporum smithii
Epilobium watsonii
Galium triflorum
Pteridium aquilinum
Rosa gymnocarpa
Smilicina sessilifolia

present and in swales near ecotones with the Acer circinatum-Corylus californica associes, Acer circinatum increases in abundance. Elymus glaucus, a grass, has a coverage of about 30 percent and is as tall as Rubus parviflorus. Elymus markedly increases in abundance on shallow soils, particularly on sharply convex slopes where Rubus parviflorus coverage is lower. Decaying Rubus parviflorus leaves and twigs litter the ground and moss cover is frequently high.

Pteridium aquilinum/Lotus crassifolius Associes. The Pteridium aquilinum/Lotus crassifolius associes occupies most high elevation, gentle slopes of less than 55 percent. It is found on all aspects and is usually associated with the Rubus parviflorus/ Trientalis latifolia, Acer circinatum-Corylus californica, and Vaccinium parvifolium/ Gaultheria shallon associes.

The unique character of the associes is the dominance of two to five foot high Pteridium aquilinium and the virtual absence of woody species. Occasional woody plants encountered include Acer circinatum, Acer macrophyllum, Holodiscus discolor, Salix sp. and Vaccinium parvifolium. Alnus rubra establishes on more mesic localized situations after logging soil surface disturbance. The associes is relatively homogeneous and the many species that occur in all stands are listed in Table 7. Litter cover is higher

Table 7. Characteristic species of the Pteridium aquilinum/Lotus crassifolius Associes (Ptaq/Locr).

Species	Constancy n = 6	Average Coverage/ Frequency	Range in Coverage	Range in Frequency
HERBS AND SHRUBS				
Pteridium aquilinum	6	81/98	55-93	94-100
Lotus crassifolius	6	53/90	38-71	70-100
Rubus ursinus	6	47/81	13-77	34-100
Anaphalis margaritacea	6	16/63	9-32	52-72
Rubus parviflorus	6	15/36	1-46	8-92
Elymus glaucus	6	14/50	10-31	30-74
Campanula scouleri	6	13/62	3-26	22-96
Trientalis latifolia	6	8/47	1-17	14-72
Hieracium albiflorum	6	8/29	1-32	19-36
Viola sampervirens	6	5/26	0. 8-17	10-56
Luzula campestris	6	4/14	1-11	6-34
Carex rossii	6	3/15	1-7	4-36
Epilobium angustifolium	6	3/14	0. 1-7	4-22
Polystichum munitum	6	0. 8/4	+-2	+-10
Epilobium watsonii	6	0. 6/8	0. 05-3	2-20
Senecio sylvaticus	6	0. 03/2	+-0. 1	+-4
Festuca rubra	5	4/17	(0)0. 7-10	(0)6-42
Collomia heterophylla	5	2/22	(0)+-5	(0)+-48
Smilicina sessilifolia	5	0. 6/5	(0)0. 05-2	(0)2-14
OTHER CHARACTERISTICS				
Litter	6	86/98	74-93	94-100
Logs	6	9/13	1-16	4-24
Epigynous-Cryptogams	6	8/21	1-17	4-46
Stone Cover	5	0. 1/3	(0)0.05-0.5	(0)2-8
Bare Ground	2	1/4		

Other important species with a constancy of 3/6 or 4/6:

Aira caryophyllea
Disporum smithii
Epilobium minutum
Galium triflorum
Hypochaeris radicata
Luzula parviflora
Oxalis oregana
Rubus spectabilis
Vaccinium parvifolium

than in any other associes. Dead Pteridium aquilinum fronds are resistant to decay and a three inch mat frequently covers the ground. Bare ground and stones are rare because of the matted dead fronds.

The two most abundant associes between 1800 and 2500 feet are the Rubus parviflorus/Trientalis latifolia and Pteridium aquilinum/Lotus crassifolius associes. Each occupies about 10 percent of the study area. Stands of the associes are frequently adjacent and since each stand is usually small, a complex patchwork pattern develops. The complex pattern suggests that the vegetation cannot override the environmental controls on the associes.

Vaccinium parvifolium/Gaultheria shallon Associes. The Vaccinium parvifolium/Gaultheria shallon associes is common on south-facing sharply convex slopes and ridgetops from 900 to more than 1900 feet elevation. Stands of the associes are usually small but they occur so frequently that the associes occupies about 10 percent of the Cedar Creek drainage. The six stands intensively studied were burned in 1945, most Vaccinium roots and a few stems survived. Vaccinium parvifolium, a five to eight foot shrub, and one to two foot high Galtheria shallon are the two dominant species. Vaccinium has about 20 percent canopy coverage in lower elevation stands but above 1200 feet elevation its coverage is reduced considerably. Canopy coverage of Gaultheria is also highly variable

Table 8. Characteristic species of the Vaccinium parvifolium/ Gaultheria shallon Associes (Vapa/Gash).

Species	Constancy n = 6	Average Coverage/ Frequency	Range in Coverage	Range in Frequency
HERBS AND SHRUBS				
Gaultheria shallon	6	42/74	3-76	12-100
Rubus ursinus	6	36/85	15-66	60-100
Pteridium aquilinum	6	34/58	2-83	8-94
Lotus crassifolius	6	24/72	8-39	40-96
Vaccinium parvifolium	6	17/24	4-27	6-46
Rubus parviflorus	6	10/30	2-37	12-92
Anaphalis margaritacea	6	8/23	1-32	8-48
Luzula campestris	6	8/41	0.05-18	4-84
Trientalis latifolia	6	6/40	0.3-18	2-88
Elymus glaucus	6	5/24	0.05-13	2-58
Hieracium albiflorum	6	3/23	0.1-6	6-40
Epilobium minutum	6	1/22	+-4	+-46
Aira caryophyllea	5	6/21	(0)+-20	(0)+-68
Collomia heterophylla	5	3/22	(0)0.4-7	(0)8-60
Rosa gymnocarpa	5	2/8	(0)0.1-6	(0)2-20
Viola sempervirens	5	1/9	(0)0.01-4	(0)2-32
OTHER CHARACTERISTICS				
Litter	6	61/79	30-90	90-100
Bare Ground	6	11/45	0.3-24	6-80
Logs	6	5/14	0.6-17	2-34
Stone cover	6	0.4/10	0.01-2	2-18
Epigynous-Cryptogams	4	3/12		

Other important species with a constancy of 3/6 or 4/6:

Acer circinatum
Carex rossi
Campanula scouleri
Epilobium angustifolium
Festuca rubra
Hypochaeris radicata
Polystichum munitum

among stands. A few woody species occasionally present are Acer circinatum (particularly in stands below 1200 feet elevation), Acer macrophyllum and a Salix species. Alnus rubra occasionally becomes established on soils disturbed during logging operations. Cover of Gaultheria is sometimes high enough to suppress many herbaceous species. The associes has much bare ground and a low litter cover.

Several species are most abundant at high elevations in this associes, the Rubus parviflorus/Trientalis latifolia associes and Pteridium aquilinum/Lotus crassifolius associes. They include the following: Campanula scouleri, Festuca rubra, Viola sempervirens, Luzula campestris, Trientalis latifolia and Hieraceum albiflorum.

Acer macrophyllum-Alnus rubra Associes. Stream floodplains are occupied by the Acer macrophyllum-Alnus rubra associes. Quantitative data were not collected from the associes. The severe burn of 1933 missed narrow, protected streambottoms. Scars on Alnus reveal that stands were lightly burned in 1939 and 1945 but the fires did not kill the overstory trees. Alnus and Acer each have a 70 percent canopy coverage in the 90 foot overstory. Alnus trees are about 65 years old but Acer is perpetuating itself, ages recorded ranging from nine to 212 years. Acer circinatum and Vaccinium parvifolium are noticeably absent from the floodplain community. Approximately six foot high Rubus spectabilis dominates the understory. Commonly occurring species in the associes are listed below:

Cirsium edule	Oplopanax horridum
Dryopteris arguta	Oxalis oregana
Epilobium angustifolium	Polystichum munitum
Heracleum lanatum	Ranunculus bongardii
Hydrophyllum tenuipes	Rubus ursinus
Maianthemum bifolium	Senecio sylvaticus
Melica harfordii	Stachys mexicana
Mimulus dentatus	Stellaria crispa
Montia parvifolia	Tellima grandiflora
M. siberica	Rubus parviflorus

Conifer reproduction in the associes is limited to Tsuga heterophylla and Thuja plicata.

Acer macrophyllum/Symphoricarpos mollis Associes. Stands of the Acer macrophyllum/Symphoricarpos mollis associes are on steep, south-facing rock slopes below which are both active and stabilized talus slopes. Erosion has been severe since the forest fires. Reconnaissance data were collected from stands of the associes. Acer macrophyllum is a root sprouter and was last burned in the 1945 fire. Acer is the dominant on igneous rock slopes. Two species adapted to this xeric site and rare in all other associes are Symphoricarpos mollis and Ceanothus sanguineus. Two distinct parts of the community are upper bare igneous rock slopes, and below, active and stabilized talus. Species in the following list primarily grow on stabilized talus:

Aira caryophyllea	Epilobium minutum	Phacelia nemoralis
Anaphalis margaritacea	Festuca myuros	Rubus leucodermis
Berberis nervosa	Galium triflorum	R. parviflorus
Cirsium edule	Hieracleum albiflorum	Senecio sylvaticus
Corylus californica	Holodiscus discolor	Vaccinium parvifolium
Crepis capillaris	Hypericum perforatum	
Digitalis purpurea	Lotus micranthus	
Elymus glaucus	Madia sativa	

Vegetation-Environment Relationships

Plants, by their growth characteristics, are phytometers of their environment. Species presence and canopy coverage usually records the environmental change critical for plants more accurately than any combination of physical measurements. One cannot presently summate all environmental factors and predict the probable plant community occupying the site. However, by first studying and comparing areas of relatively homogeneous vegetation, one can speculate upon the major environmental factors responsible for repetition of plant communities from stand to stand. No single environmental component controls vegetation distribution. The environmental parts are linked together in a complex. When one component changes, it sets off a chain reaction altering the influence of many environmental factors.

Distribution of the plant communities in the study area is related to physiographic and soil characters. The physiographic properties influencing distribution most are position on slope, aspect, percent slope, elevation and slope form. Soil series apparently influence the distribution of several communities. The effect of a soil and underlying unweathered rock on vegetation distribution seems to be frequently modified by factors related to lateral seepage and evapotranspiration.

Many lower mountain slopes benefit from water that has percolated through upper slope soil and geologic formations. This water, called lateral seepage, accumulates water soluble nutrients and frequently stimulates growth in lower slope vegetation (7, p. 41). Soils in the study area have developed under an annual precipitation exceeding 100 inches. These soils may be highly leached and water soluble nutrients probably affect plant distribution and growth. Certain plant communities may be restricted in their distribution to slopes that have a favorable nutrient supply. Mueller-Dombois, in forest ecology investigations on Vancouver Island, (23) found significantly greater amounts of calcium and magnesium in B horizons of several lower slope plant communities than in ridgetop B horizons.

Two major causes of moisture loss in soils with a moisture regime below field capacity are evaporation and transpiration. Most associes studied have a dense overstory vegetation and a litter cover that protects the soil surface from evaporation losses. However, high daytime summer temperatures (average maximum for August is 79°F) promote high transpiration rates on exposed slopes (21). Leaf temperatures and transpiration rates are generally greater on slopes at right angles to the sun than on protected slopes. Soil moisture losses through transpiration on southwest to southeast slopes are felt to be critical enough to limit the vegetation to those species capable of surviving summer soil moisture regimes near the permanent wilting point. Lowry and Youngberg (17, p. 380) in the summer of 1953, found the surface horizons of several Astoria soils below the permanent wilting point.

Vegetation growing on a soil not benefiting from lateral seepage must rely on the solum and underlying material to provide moisture and nutrients. Soils differ in their capacity to provide plants with the essentials for growth. A few criteria apparently important in the soils examined include solum depth, depth of weathering below the solum, rooting depth, amount of coarse fragments, texture, structure and maturity of profile. Information about the moisture and nutrient status in the soils investigated is scanty. Stonefree, deeply weathered soils with increased clay content in the B horizon may be expected to be relatively fertile. The Astoria and Hembre I soil series have deep solums, usually deeply weathered C horizons, silty clay loam B horizons and are relatively stonefree. The other four soil series, Kilchis, Trask, Meda and Hembre II series are either so shallow over an unweathered rock D horizon or have such a high volume of coarse fragments in the solum that the nutrient supply and moisture storage capacity is extremely limited. However, other sources of moisture and nutrients temper the influence an underlying soil has on its vegetation. If rooting depth is adequate and there is an abundant supply of lateral seepage, a very productive community will grow on shallow, immature Meda and Hembre II soils.

Lateral seepage, aspect, elevation and soil series seem to be the major influences related to distribution of plant communities. Relationships of the quantitatively sampled communities to soils and physiography are presented in Figures 19 and 20 and in Tables 9 and 10. Distribution of each associes as it is affected by environment is discussed below.

Alnus rubra/Polystichum munitum Associes. The plant community is on well-drained, usually steep, north-facing lower slopes. The stands are on lower elevation, bottom slopes positioned to benefit from lateral seepage (Table 10). Steep, north-facing slopes probably protect the stands from high summer soil moisture losses through transpiration. The associes is not limited to any one soil series but rooting depth seems to influence growth. *Alnus* was 5 to

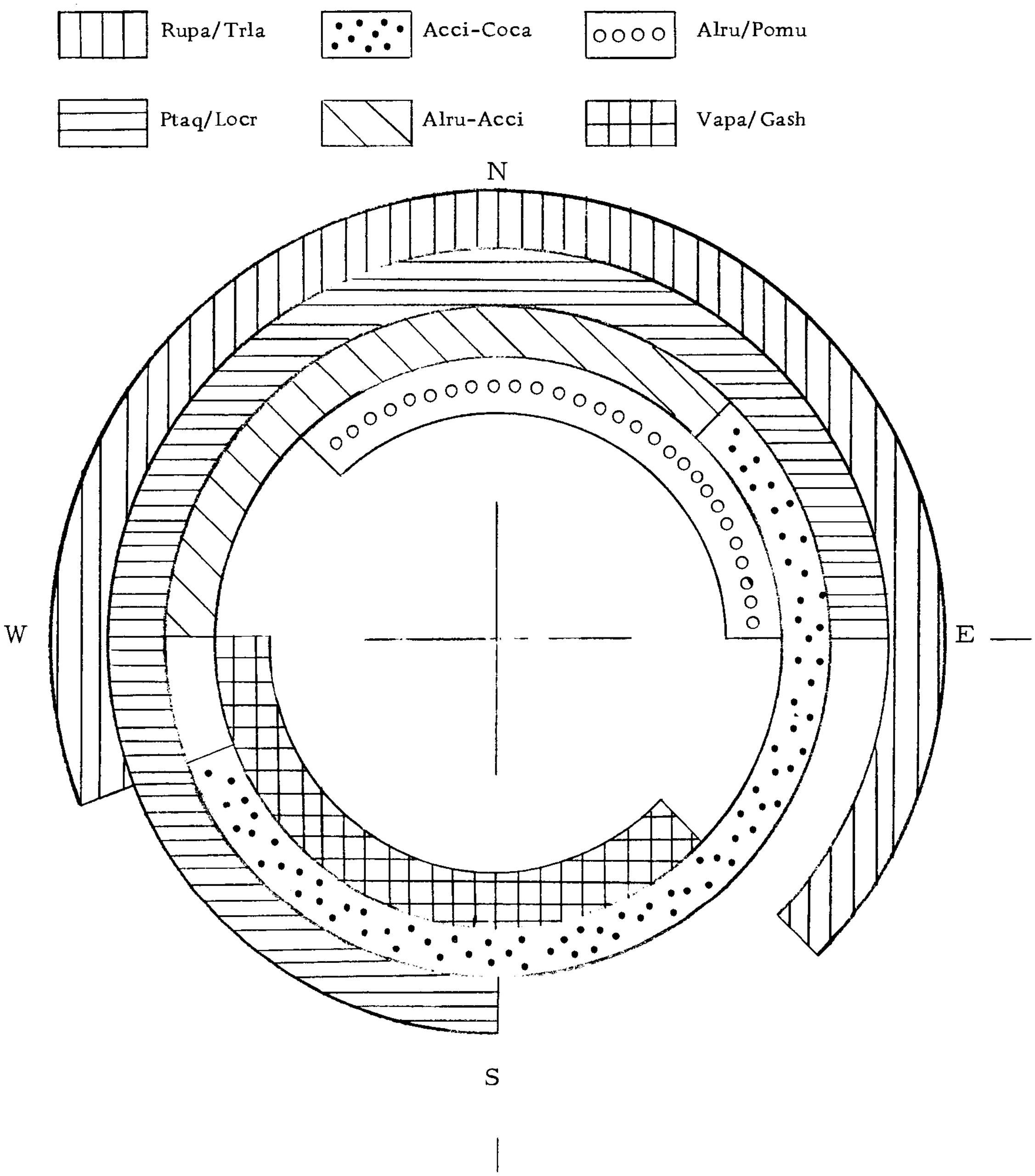

Figure 19. Range in aspect direction of plant associes.

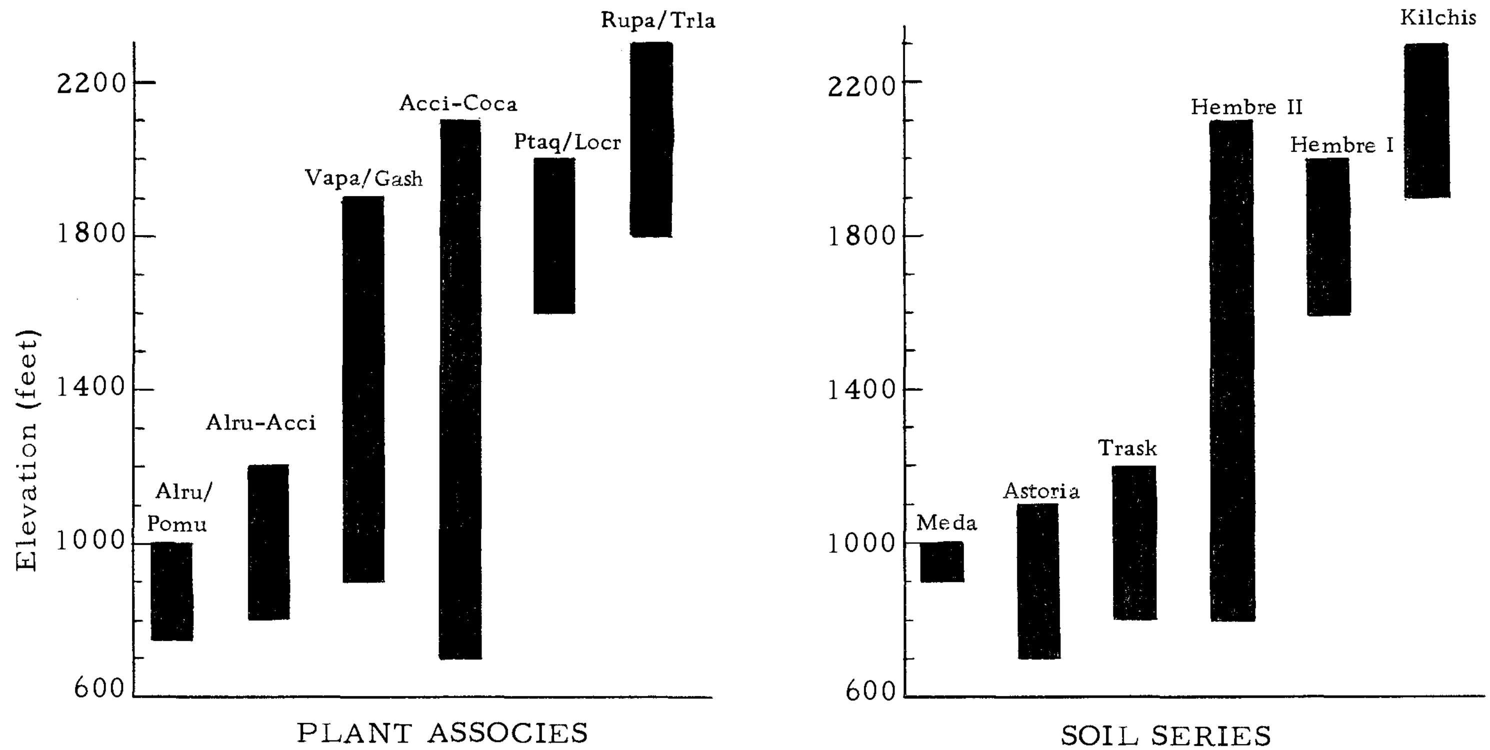

Figure 20. Elevational ranges of plant associes and soil series as recorded at 42 macroplot sites.

Table 9. Distribution of stands intensively studied on the six soil series.

Soil Series	Alnus/Polystichum n = 6	Alnus-Acer n = 6	Acer-Corylus n = 12	Vaccinium/Gaultheria n = 6	Rubus/Trientalis n = 6	Pteridium/Lotus n = 6
Meda	3					
Astoria	2		5	2		
Hembre II	1	4	6		1	
Trask		2	1	1		
Hembre I				3		6
Kilchis					5	

Table 10. Range in selected physiographic properties.

Associes	Position for lateral seepage	Position on slope	Aspect direction	Percent slope	Elevation (feet)	Slope form
Alnus/Polystichum	yes	bot	NW-E	30-80	700-1000	convex-concave
Alnus-Acer	yes	mid-bot	W-NE	65-85	800-1200	convex-flat
Acer-Corylus	yes	mid-bot	WSW-S-ENE	20-80	800-2100	convex-swale
Rubus/Trientalis	no to possibly	top-mid	WSW-S-NW	60-75	1800-2300	convex-concave
Pteridium/Lotus	possibly	top-mid	NNW-S-NE	20-55	1600-2000	convex-concave
Vaccinium/Gaultheria	no to possibly	top-mid	W-SE	50-75	900-1900	ridgetop-convex

10 feet shorter in a macroplot underlain by a shallow Hembre II soil (Table 9). Most macroplots studied are on Astoria or Meda soil series. The associes occupies an apparently very productive site.

Alnus rubra-Acer circinatum Associes. The _Alnus rubra-Acer circinatum_ associes is at somewhat higher elevations, on usually convex, north-facing slopes that have shallower soils and are apparently slightly less productive than the _Alnus rubra/Polystichum munitum_ community. The associes is restricted to very steep 65 to 85 percent slopes (Table 10). The Trask and Hembre II soil series that support the associes are in a position for lateral seepage. However, the volume of seepage is probably less than in the _Alnus/Polystichum_ community. Abundant coarse fragments limit moisture-holding capacity in the profiles examined.

Acer circinatum-Corylus californica Associes. Stands of the _Acer-Corylus_ community occur on several aspects but are usually south-facing. The soils are predominantly deep Astoria or Hembre II series. One stand, on a Trask soil, is on a bottom slope that is positioned for very favorable lateral seepage. Although the associes ranges from 800 to 2100 feet, stands are always positioned to benefit from lateral seepage. Stands on upper slopes are restricted to drainage ways and swales. Transpiration rates on the south-facing slopes must be very high in the hot, dry summer. The vegetation probably must be able to utilize soil moisture near the permanent wilting point. Water-soluble nutrients brought from upslope soils by lateral seepage may be more critical to this seral community than the additional moisture because of the apparent summer drouth conditions. The many large Pseudotsuga menziesii stumps reveal the site as highly productive.

Rubus parviflorus/Trientalis latifolia Associes. The Rubus/Trientalis associes is restricted to elevations above 1800 feet and occurs on most slope directions. The stands are rarely in a position to benefit from lateral seepage. This lack of additional growth factors is the apparent cause for the short height (about two feet) of Rubus parviflorus. It is about five feet high in the three communities that benefit from lateral seepage. The steep slopes have shallow Kilchis or Kilchis-like soils. These lithosols are deeper in drainage ways. Five macroplots were located on typical Kilchis soils but the sixth macroplot, in a narrow drainage way, was underlain by a 31 inch solum of Kilchis-like soil. Since the Kilchis series is separated from the old Hembre series by physical, rather than by ecological factors, this profile was too deep to be in the Kilchis series. It was classified into the Hembre II soil series although its profile characteristics resembled the Kilchis series. The Kilchis soils upon which the Rubus/Trientalis associes grows is probably less productive for Pseudotsuga since most stumps were smaller than in other associes.

Pteridium aquilinum/Lotus crassifolius associes. This associes is restricted to the Hembre I soil series and occurs on most aspects between 1600 and 2000 feet. The Hembre I series was formed in place and necessarily occupies the gentle, 20 to 55 percent, higher elevation relief (Table 10). Lateral seepage is possible, but its influence is probably minor since the series is mostly on upper slopes. The soils are deep and have a high moisture-holding capacity. Stumps are large and close together, indicating a productive site for Pseudotsuga.

Vaccinium parvifolium/Gaultheria shallon associes. The Vaccinium/Gaultheria associes is a ridgetop community. It occupies south-facing ridgetops and convex slopes at all elevations in the study area. The six macroplots were on three different soil series (Table 9). Solum depth ranged from 8 to 43 inches. The associes occupies many different topographic positions but the one thing in common all seem to possess is their position for good or excessive drainage. Vaccinium is about five feet high and averages about five percent cover in higher elevation stands. It is about eight feet high and averages about 30 percent cover in lower elevation stands.

Lateral seepage may be the cause for the increased Vaccinium coverage and height but part of it probably is lost through transpiration during summer. Soil moisture may be at or below the permanent wilting point during the late summer of many years. Site productivity as revealed by diameters of Pseudotsuga stumps is quite variable but appears to generally decrease with increase in elevation.

Acer macrophyllum/Symphoricarpos mollis associes. Many casual observations but no quantitative and little reconnaissance data were taken in the associes. The Acer/Symphoricarpos associes is restricted to very steep, bottom and middle slopes of igneous rock and talus. It is in a position for excessive drainage and extreme evapotranspiration rates. Acer macrophyllum apparently survives through deep root penetration into the rock where it obtains an adequate moisture and nutrient supply. Productivity of the site is probably extremely limited.

Acer macrophyllum-Alnus rubra associes. The Acer-Alnus associes was described only by reconnaissance data. The soils were not studied. Aspect has little influence on the associes, but the stands are restricted to the lower elevation, larger streambottoms. A watertable in the rooting zone is probably present during the winter rainy season. Flooding seems to be common, particularly adjacent to the stream channels.

Homogeneity of plant communities. Plant communities vary in their degree of homogeneity among stands. Constancy expresses species variation from stand to stand in a community. Homogeneous communities have a relatively large compliment of species present in all stands and a greater proportion of species that occur in only some stands. Table 11 demonstrates homogeneity of the communities intensively studied. Homogeneous plant communities in the study area have approximately twice as many species with a constancy greater than 82 percent than species with a constancy of 50 to 81 percent. The Acer circinatum-Corylus californica and Alnus rubra-Acer circinatum associes are more heterogeneous among stands than the other four associes. The Acer-Corylus associes is highly variable. The table also reveals that the Vaccinium/Gaultheria associes, located on the more xeric sites, has fewer mid to high constancy species than other associes.

Table 11. Homogeneity of plant communities.

Number of Species	Plant Associes					
	Alru/ Pomu	Alru- Acci	Acci- Coca	Rupa/ Trla	Ptaq/ Locr	Vapa/ Gash
Constancy greater than 82%	20	19	11	19	19	16
Constancy 50 to 81%	11	17	16	8	9	7
Total	31	36	27	27	28	23

Plant Succession

The rapid establishment of hand planted Pseudotsuga menziesii seedlings over much of the Tillamook Burn has increased the rate of succession. Pseudotsuga has been successfully established in many stands of the Rubus/Trientalis, Pteridium/Lotus and Vaccinium/Gaultheria associes. The trees are currently about two to six years old and are just beginning to have a noticeable effect on the ecosystem. Many stands of these three associes will be dominated by Pseudotsuga in 10 to 20 years. Pseudotsuga is relatively shade-intolerant and has had difficulty becoming established and making satisfactory growth in the three associes with a tree overstory. Partial success has been attained in the Acer-Corylus stands that have a sparse tree overstory. Establishment and growth are apparently both unsatisfactory in the Alnus/Polystichum and Alnus-Acer associes. A heavy stocking rate of large Pseudotsuga stumps reveals that the species is very productive on these sites. However, Pseudotsuga seems to have little chance of succeeding unless Alnus is removed. A few shade-tolerant Tsuga heterophylla and Thuja plicata seedlings and saplings seem to be growing satisfactorily. If the present successional trends were allowed to continue, Tsuga and Thuja would probably eventually become the dominants in the Alnus/Polystichum and Alnus-Acer associes, rather than

Pseudotsuga.

As conifers become the overstory dominants, shade intolerant species will be reduced or eliminated. Many species recorded in this investigation were also found by Nieland (25, p. 666-668). Species Nieland observed only in the burn or in the forest and burn have been appropriately marked in Appendix 3. Of the 51 species common to both studies, Nieland found 26 of them restricted to the burn. These are mostly early seral, rapidly spreading species that readily establish on burned-over areas. The 25 remaining species are mostly shade-tolerant, late seral or climax species that either survived the fires or have since re-established.

Under pristine conditions, the only conifer seed source would have been the few mature trees that survived the fires. Rate of succession would have been much slower. Re-establishment of a conifer overstory would have taken many years. Without the changes soon to be brought about by handplanted Pseudotsuga, succession in most associes would be slow.

The dominants in the Rubus/Trientalis and Pteridium/Lotus associes are seral (25, p. 666-667). Since there is no evidence for woody species other than Pseudotsuga becoming dominant, under conditions of natural succession, these associes would be near a state of equilibrium. The early seral, late seral and climax species present, probably have had time to approach a state of dynamic equilibrium in the 17 years since the last burn.

Two near-climax forest species, Vaccinium parvifolium and Gaultheria shallon (25, p. 666), dominate the Vaccinium/Gaultheria associes. Table 12 reveals that some Vaccinium plants were in the forest before the 1933 fire. All five plants examined survived at least two forest fires. The species is a root sprouter. The stems are not resistant to fire since very few survived the light 1945 burn. Since few new Vaccinium plants are establishing and lateral growth is slow on the old plants, overstory coverage in the Vaccinium/ Gaultheria associes will slightly change the undergrowth. However, Gaultheria coverage is low in some stands and it may spread, crowding out less competitive species.

Table 12. Year of establishment of Vaccinium plants (from age of root crown) and age of oldest stem cut 12 inches above ground level. Stand was burned in 1933, 1939 and 1945. (plants near macroplot 12).

	PLANT NUMBER				
	1	2	3	4	5
Year oldest stem sprouted	1944	1947	1945	1946	1945
Year plant established	1933	1934	1926	1936	1929

The Acer-Corylus associes is extremely variable in species composition and coverage primarily due to the variable tree overstory cover. A three to six foot canopy of Rubus parviflorus predominates where overstory tree cover is low. Acer circinatum and Corylus californica are not only root sprouting forest species but the stems are fire resistant. The 1939 fire destroyed Acer and Corylus stems but most stems survived the light 1945 burn. Acer and Corylus are slowly spreading within stands over areas they do not presently occupy. As the tree overstory becomes more dense, species composition and coverage of shade-intolerants will be reduced. A marked difference was noted in species composition of macroplots with a dense overstory of Acer and Corylus. Successional relationships of some species are noted below.

Species absent from stands with dense tree overstories.

Aira caryophyllea
Cerastium viscosum
Collomia heterophylla
Epilobium minutum
Hypericum perforatum
Lotus micranthus
Lupinus sp.
Madia sativa
Phacelia nemoralis

Species with greatly reduced coverages in stands with dense tree overstories

Anaphalis margaritacea
Digitalis purpurea
Elymus glaucus
Lotus crassifolius
Nemophila parviflora
Pteridium aquilinum
Rubus parviflorus
Trientalis latifolia

Species common in dense tree overstory stands but rare or absent in sparse tree overstory stands

Festuca subuliflora	Polystichum munitum
Hydrophyllum tenuipes	Rubus spectabilis
Oxalis oregana	Viola sempervirens

The species absent in stands with a dense overstory of Acer and Corylus are seral species that apparently cannot tolerate shading. The number of species and herbaceous cover is greatly reduced in stands with a dense tree overstory. Most species that increased under shade are also present in the forest communities (25, p. 666-668). The Acer-Corylus associes vegetatively resembles the more advanced successional stage described by Corliss and Dyrness (3) as the vine maple-sword fern community.

The Alnus/Polystichum and Alnus-Acer associes will have a continued decrease in shade-intolerant, early seral species. Forest species will gradually increase. The six species that increased under dense shade in the Acer-Corylus associes will probably also increase in the two Alnus associes. Rubus spectabilis dominates the understory in the Acer macrophyllum-Alnus rubra associes and increases in dense shade in the Acer-Corylus associes. Rubus spectabilis will probably become the understory dominant in the two Alnus associes at the expense of Rubus parviflorus. The Alnus/Polystichum and Alnus-Acer associes are vegetatively very similar to the salmonberry-sword fern and sword fern communities described in the Alsea Basin by Corliss and Dyrness (3).

Adequacy of Sampling

The primary purpose of the study was to characterize the major post-burn plant associes in order to use vegetation as a basis for stratification of data in conifer-animal damage investigations. Constancy and coverage were used to characterize the six communities intensively sampled. Two communities that occupy a very small part of the study area were described only with reconnaissance data. These two communities are restricted to such characteristic physiographic locations that they are readily recognized.

A sampling plan adequate to characterize the most variable community will also adequately characterize more homogeneous communities. Species-area curves in Figures 21 and 22 demonstrate sampling adequacy. A typical macroplot in the *Acer*-*Corylus* associes (Figure 21) reveals that about 30 observation plots adequately characterize a stand. Five macroplots sufficiently characterize the associes (Figure 22). Stands varying from the modal stand were purposely selected to measure variation within each plant community. Since 50 observation plots per macroplot and six macroplots were used to sample each associes (with the

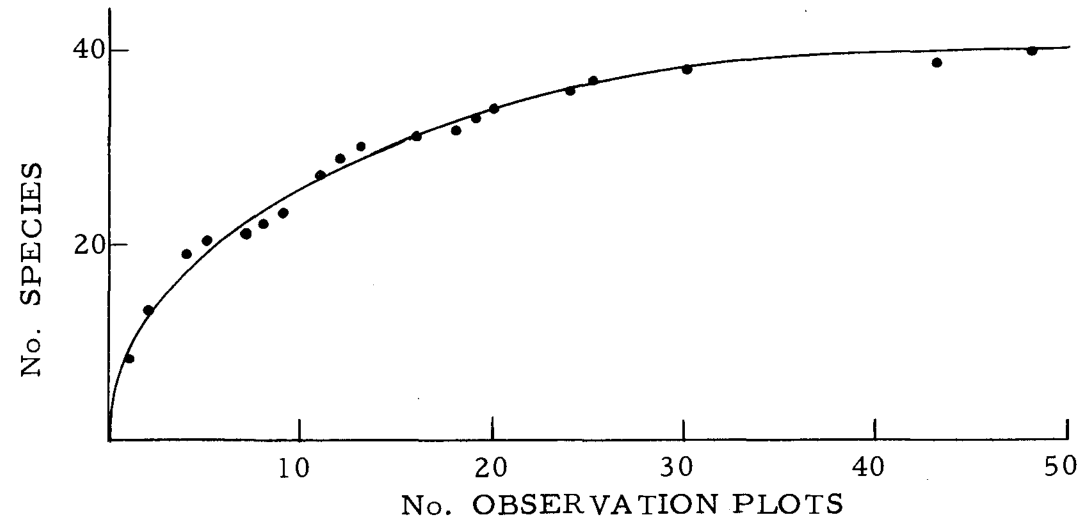

Figure 21. Species-area relationship in observation plots of a typical macroplot.

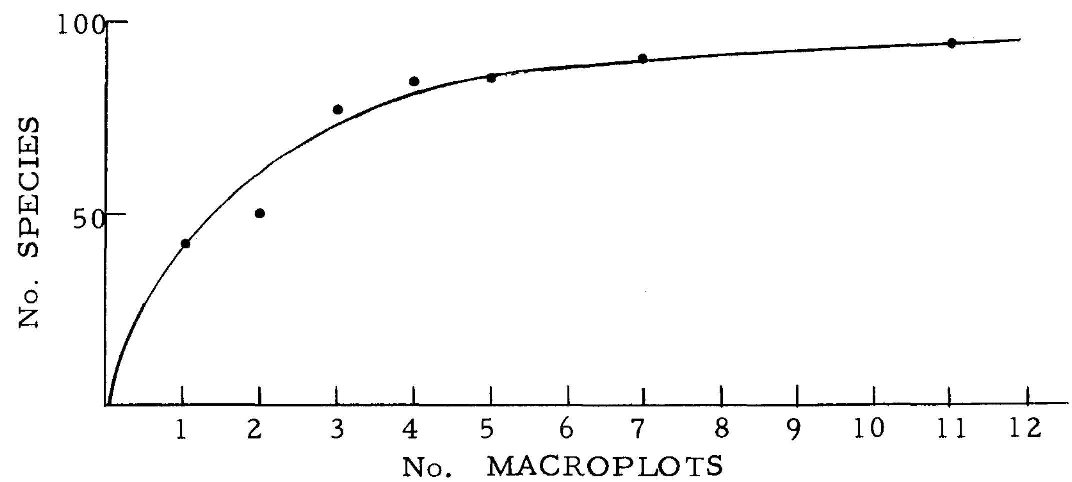

Figure 22. Species-area relationship for macroplots in the *Acer circinatum-Corylus californica* associes.

exception of the 12 macroplots in the Acer-Corylus associes), normal variation within associes has been measured.

The primary objective, to characterize the important post-burn plant communities, has been realized. However, there are other communities in the study area that were not characterized. These communities have developed as a result of extreme post-burn soil and vegetation disturbance. They were not a part of the study and were intentionally avoided.

Environmental Influences Increasing Vegetation Heterogeneity

As previously mentioned, the 1933 burn was quite severe. It apparently burned all the study area except a few protected Acer macrophyllum-Alnus rubra stands. The 1939 fire also burned most of the area. Many stems of Acer circinatum, Acer macrophyllum, Corylus californica and a few stems of Vaccinium parvifolium survived the apparently light 1945 fire. However, except for a few mature trees that escaped the first burn, no Alnus rubra or Pseudotsuga menziesii survived the 1945 fire. Burning intensity was variable from place to place in all fires depending upon amount of flammable material, topography and local climatic conditions. Present vegetation heterogeneity is due in part to the variable fire intensities and patterns.

Acer circinatum, Acer macrophyllum, Corylus californica and Vaccinium parvifolium are root sprouters. Root crowns have been observed that were much larger and apparently very much older than the stems. Although the stems were frequently killed, many plants survived the fires and sprouted soon afterwards. These species must have been a part of the primeval forest and their present distribution is strongly influenced by past forest history. Since the four species are present in the overstory of at least one associes studied, abundance and distribution of understory species is also affected by past forest history.

Species composition and dominance has been noticeably influenced in some stands by deer and mountain beaver (Aplodontia rufa Rafinesque). Deer have overbrowsed the highly palatable Ceanothus sanguineus and Rhamnus purshiana, reducing or eliminating them from several plant communities. Trampling by deer and elk (Cervus canadensis roosevelti Merriam) on key, low elevation, south-facing wintering slopes, has increased canopy coverage of several species, particularly Rubus ursinus, Crepis capillaris, Hypochaeris radicata and Madia sativa.

Mountain beaver, a burrowing animal, disturbs vegetation and soil adjacent to the colony. Soil overcast from diggings, roots cut underground and severe cropping of preferred species contribute to a distinct modification of stands. The colonies seem to be most abundant in the Acer circinatum-Corylus californica associes. The animals are rare in the Rubus/Trientalis and the Pteridium/Lotus associes probably because of the lack of woody browse.

Marketable logs, from snags killed by the 1933 fire, were removed between 1946 and 1958. Two systems, tractor and high-lead cable logging, were used to salvage the timber. Tractor logging disturbed much surface soil on flats and gentler slopes. Old skid trails and log landings are still very much in evidence. At least 30 to 50 percent of the area logged by this method has a vegetation different from the expected plant community. Most change was brought about by soil removal, overcast and compaction. Inadequately planned and constructed roads have created huge landslides that removed the soil mantle and presently support little vegetation. High-lead cable logging was less commonly used and was restricted to very steep slopes. Since logs were dragged directly from the stump to the loading area, less soil surface was disturbed.

Vegetation removal three times in 12 years might be expected to precipitate a severe erosion problem in a 130 inch annual rainfall area. However, periodic fires have occurred at least since pleistocene times and climate has changed little. The soils that developed are stable. Slumps on imperfectly-drained slopes and landslides initiated by logging are common but sheet erosion has been low. All profiles examined have a distinct, dark A horizon which suggests that sheet erosion has been low.

The vegetation that developed as a result of these many disturbances is quite complex. However, the two major causes of vegetation change are logging and soil slumping. Soil slumping, or logging soil disturbance in the Alnus/Polystichum and Alnus-Acer associes results in the establishment of a dense stand of even-aged Alnus rubra. There is a characteristic understory vegetation but it has not been recorded. When the soil surface is disturbed in moist stands of the Acer-Corylus associes, a dense stand of Alnus rubra develops. The xeric phase of the Acer-Corylus associes has an extremely variable vegetation on soil disturbed areas. Bare ground may be either absent or prevalent. Elymus glaucus or Holcus lanatus are the usual dominants. Other species present in variable amounts include Rubus ursinus, Phacelia nemoralis, Digitalis purpurea, Solidago canadensis and Collomia heterophylla. The Rubus/Trientalis, Pteridium/Lotus and Vaccinium/Gaultheria associes have quite a similar heterogeneous vegetation on soil disturbed areas. There is generally much bare ground. Species frequently present include Elymus glaucus, Rubus ursinus, Crepis capillaris, Anaphalis margaritacea, Carex rossii and Carex californica.

Significance of Results to Big Game Management

Eight plant communities were recognized in the study. Each community has its own distinct environment. Distribution of species used by wildlife for food or cover are limited to communities that have an environment favorable for their survival and growth. For this reason, an adequate synecological study is a necessary prerequisite to any intensive wildlife investigation. This study has been an essential preliminary part of conifer-deer damage investigations in the Tillamook Burn.

Available deer forage is low during winter but there apparently is an adequate supply in the growing season. Plant associes studied have different amounts of winter forage. A few species provide almost all the winter deer food (Table 13). Deer can only be as abundant as their available food supply will permit. Populations in the Tillamook Burn are apparently limited by winter food supply.

Trailing blackberry (Rubus ursinus) is the most abundant, preferred winter browse. The species has a creeping vine life-form and is readily covered by snow. Mortality is highest during severe winters (27, p. 7) apparently because snow covers trailing blackberry for unusually long periods. Without trailing balckberry, winter food supply is scanty (since Salal (Gaultheria shallon) is not a preferred browse, Table 13). Aspect and elevation are critical.

Table 13. Canopy coverage of available winter deer forage in six plant communities.

Species	Rubus/ Trientalis	Alnus/ Polystichum	Alnus- Acer	Acer- Corylus	Pteridium/ Lotus	Vaccinium/ Gaultheria
Rubus ursinus (trailing blackberry)	6	8	12	20	47	36
Gaultheria shallon (salal)	+ *	+	+	+	+	42
Vaccinium parvifolium (red huckleberry	4	3	+	+	+	17
Alnus rubra (red alder)		u**	u	u		u
Berberis nervosa (Oregon grape)		4	+	4		2
Corylus californica (hazelnut)		u	u	u		
Acer circinatum (vine maple)		u	u	u		u
Osmaronia cerasiformis (Indian plum)		u		u		
Holodiscus discolor (ocean spray)				+		+
Rhamnus purshiana (cascara)			u	u		
Total coverage of available forage	10	15	12	24	47	97

* Less than one percent canopy coverage

** Species has less than 10 percent of forage within reach of deer (browse considered unavailable if higher than four feet).

Snow is most frequent and stays the longest above 1600 feet. The Pteridium/Lotus associes has an abundant supply of trailing blackberry but since the associes is mostly above 1600 feet, it is snow-covered when deer most need food. The low elevation, south-facing slopes, occupied by the Vaccinium/Gaultheria and Acer-Corylus associes have the shortest periods of snow cover. Both associes have an abundant cover of trailing blackberry (Table 13) and provide the most winter forage during the critical periods of heavy snows. Trailing blackberry is relatively shade-intolerant and is abundant in the more open xeric phase of the Acer-Corylus associes. Drier stands of this associes occupy many lower elevation, south-facing slopes. Coverage of trailing blackberry is much higher in these stands than Table 13 indicates.

Approximately 20 to 40 percent of the study area is heavily disturbed and has vegetation differing from the little disturbed post-burn plant communities. Logging and other influences previously described have disturbed the soil surface and vegetation. Disturbance vegetation can usually be identified with the expected post-burn plant associes by physiographic location and by vegetation indicators in surrounding undisturbed stands. Later investigators can easily describe the disturbance communities common to each associes adequately for animal studies and game management. One or a few distinct and recognizeable disturbance communities are common to each post-burn associes. Since an early seral vegetation develops on the disturbed areas, winter deer food is frequently more abundant on these areas than in the undisturbed, post-burn plant associes.

This study has established a basis for inventorying and mapping game habitat. Canopy coverage can be used to rapidly index amount of available deer forage. A much smaller sample than that used in this research project would provide an estimate adequate for most game management purposes.

Examples of the need for mapping game ranges by plant communities can be illustrated in Table 13. The south-facing, lower elevation slopes are generally occupied by stands of the _Acer-Corylus_ and the _Vaccinium/Gaultheria_ associes. They have the shortest periods of snow cover. The stands have comparatively high amounts of winter deer forage. The extent of these areas to a great degree determines the possible size of the wintering deer population. The other associes are either above 1600 feet or are on protected slopes where snow remains longer and winter forage is unavailable when most needed. Since wintering deer apparently tend to congregate in the lower elevation stands of _Acer-Corylus_ and _Vaccinium/Gaultheria_ for food, the conifer damage problem may be acute in these associes. A cover map of the lower elevation stands of the two associes may not only reveal the best winter deer habitat but also reveal an acute conifer-deer damage area.

Each associes has a characteristic cover of overstory species. Visability is extremely limited in those associes with a dense tree or tall shrub overstory. Deer are much more difficult to see in the *Acer-Alnus*, *Alnus/Polystichum*, *Alnus-Acer* and *Acer-Corylus* associes than in the *Vaccinium/Gaultheria*, *Rubus/Trientalis* and *Pteridium/Lotus* associes. Maps of the associes reveal the areas easiest to hunt or to use for sight census methods.

Hypotheses to be Clarified by Future Investigations

Daubenmire (5, p. 302-303) describes a community as *climax*:

> . . . if it appears to be self-regenerating and there is no concrete evidence that it is followed by a different subsequent community . . . . The term *association* is applied only to climax communities . . . . The collective area which one association occupies or will occupy as succession advances, is called a *habitat type*.

There are two types of successional routes to climax that vegetation may follow. A rapid re-establishment of the forest species may occur on the habitat-type and a single, distinctive seral community will develop that slowly advances towards climax. Sometimes environmental differences of a minor nature in the climax community so dominate the seral vegetation that two or more successional communities develop on a single habitat-type. As succession advances, the forest overstory apparently moderates the controlling environmental effect and one climax association develops. Either or both successional routes to climax may be present in the area studied. Few climax associations have been characterized in the Oregon and Washington coast range. Becking (2) and Corliss and Dyrness (3) have described a number of seral and a few climax communities. Studies on Vancouver Island by McMinn (19), Mueller-Dombois (23) and Spilsbury and Smith (32) may apply in part. Several major environmental changes have been noted in the study area that may represent the boundaries of different habitat-types.

The *Acer macrophyllum*/*Symphoricarpos mollis* associes is restricted to south-facing, extremely steep, rock and talus slopes. The site seems to be highly unfavorable to growth. No similar environmental situation has been found in the study area. *Pseudotsuga menziesii* and *Acer macrophyllum* apparently dominated the overstory before the 1933 fire. The slopes are about 100 percent and a deep soil profile probably could not have developed. Accelerated erosion since the fires has removed most of the soil mantle. The *Acer*/*Symphoricarpos* associes probably occupies a habitat type. The climax association could be dominated by *Pseudotsuga* and *Acer* macrophyllum since the site appears to be too dry for Tsuga heterophylla.

The Acer macrophyllum-Alnus rubra associes is on narrow floodplains of major streams. The site is apparently the only one that has a water table in the rooting zone for part of the year. Soils are alluvial and moisture status is probably always good. Acer macrophyllum is perpetuating itself, Alnus is even-aged. The only conifers observed were Tsuga heterophylla and Thuja plicata. The Acer-Alnus associes probably is on a habitat type whose climax forest association would be dominated by Thuja, Tsuga and at least some Acer macrophyllum.

The Rubus parviflorus/Trientalis latifolia and Pteridium aquilinum/Lotus crassifolius associes occur above 1200 feet elevation. The Pteridium/Lotus community is confined to the deeply weathered Hembre I soil series that has a high stocking rate of large Pseudotsuga stumps. The Rubus/Trientalis associes is nearly always on the lithosolic Kilchis soil series and productivity of Pseudotsuga seems to have been lower. Soils, topography and forest species present reveal that there are many differences as well as many similarities between sites occupied by the Rubus/Trientalis and Pteridium/Lotus associes. Each associes may occupy a habitat type, or the environment created by the forest community may possibly modify the present environmental factors to the extent that the seral associes develop into the same climax association.

The *Vaccinium parvifolium/Gaultheria shallon* associes occupies specific xeric, topographic situations. There seems to be little relationship between soil characters and distribution of the associes. Species in this associes apparently must be able to utilize moisture near the permanent wilting point during dry summers. *Vaccinium* and *Gaultheria* are forest species. Nieland (25, p. 666) found their abundance to be nearly constant between the burn and forest communities. The species probably occupy the same areas they did before the burn. The high coverage of the two dominants and the absence of several moisture requiring forest species in only this associes (*Maianthemum bifolium, Oxalis oregana, Disporum smithii*) leads to the conclusion that this associes may also represent a single habitat-type.

The *Alnus/Polystichum*, *Alnus-Acer* and *Acer-Corylus* associes, are restricted to sites favorably located for lateral seepage. The *Acer-Corylus* associes is on south-facing slopes where soil moisture may be limiting to growth during summer due to moisture loss through excessive transpiration. The two *Alnus* associes are on north-facing slopes which probably have more favorable summer soil-moisture relationships. The three associes may each occupy a habitat type or all may be on one habitat type. The environmental influences controlling distribution of the three seral communities may or may not be so modified that one climax forest association will develop. The two *Alnus* associes are vegetatively and environmentally quite similar. The *Acer*-*Corylus* associes also has many similarities to the two *Alnus* associes. These three associes have a similar shade-tolerant species composition that differs from the *Rubus*/*Trientalis*, *Pteridium*/*Lotus* and *Vaccinium*/*Gaultheria* associes. The similarities and differences are revealed in Table 14.

The habitat types in the Oregon coast range are presently unknown and the hypotheses and tentative conclusions discussed in this section can be substantiated or refuted only after a thorough synecological investigation of the forest associations.

Table 14. Average percent canopy coverage of some shade-tolerant species demonstrating similarities and differences in the associes.

Species	Alnus/ Polystichum	Alnus-Acer	Acer-Corylus	Rubus/ Trientalis	Pteridium/ Lotus	Vaccinium/ Gaultheria
Adiantum pedatum	2	1	+*			
Corylus californica	21	2	22			
Festuca subuliflora	4	+	1	+	+	
Oxalis oregana	14	2	2	+	+	
Maianthemum bifolium	6	+	+	+	+	
Rubus spectabilis	24	+	10		1	+
Polystichum munitum	60	40	24	6	+	1
Acer circinatum	5	17	38	+	+	2
Vancouveria hexandra	5	+	+	+	+	+
Viola sempervirens	+	+	+	7	5	1
Campanula scouleri	+	+	1	13	13	2
Trientalis latifolia	+	1	1	19	8	6

* plus (+) indicates less than one percent average canopy coverage.

SUMMARY

The purpose of the study was to characterize post-burn plant communities in a restricted part of the Tillamook Burn. The vegetation-environment relationships are discussed.

Seven plant communities were tentatively defined from reconnaissance data taken in 92 stands. Quantitative vegetation information was recorded on six 5 by 25 meter macroplots for each tentatively defined plant community. Canopy coverage was recorded by species in 50, two by five dm. observation plots per macroplot. Physiographic information and a soil profile description were made at each macroplot. Burning pattern and history were evaluated by aging woody species beside every macroplot.

About five macroplots and 30 observation plots per macroplot adequately characterize the seral plant communities. Since six macroplots and 50 observation plots were used, it is felt that an adequate sample has been made of the normal variation within each community. Two plant associes are more variable than the other four intensively sampled. The _Acer circinatum-Corylus californica_ associes is most variable.

Five soil series previously described were examined. The Meda, Astoria, Trask and Kilchis soil series were recognizeable

and adequately characterized. The Hembre soil series was found to be classified too broadly for synecological or land management purposes. For the purposes of this investigation, the series was divided into the Hembre I and the Hembre II soil series. The Hembre I soil series formed in place on gentle, higher elevation slopes. A deeply weathered C horizon, increasing clay content with depth, and few stones in the solum, are characteristics of the series. The Hembre II soil series formed from colluvium on generally steep slopes. The loam or silt loam texture in the B horizons and an abundance of coarse fragments throughout the solum are characteristic.

Association tables constructed after compilation of the quantitative information demonstrate that there are six major plant associes in the study area. They are listed below:

Alnus rubra/Polystichum munitum
Alnus rubra-Acer circinatum
Acer circinatum-Corylus californica
Rubus parviflorus/Trientalis latifolia
Pteridium aquilinum/Lotus crassifolius
Vaccinium parvifolium/Gaultheria shallon

The Acer macrophyllum-Alnus rubra and Acer macrophyllum/Symphoricarpos mollis associes occupy a small part of the study area and were described from reconnaissance information. Physiographic position adequately characterized them for the purposes of this study.

The Alnus rubra/Polystichum munitum associes usually has a 100 percent overstory cover of Alnus and about a 60 percent understory cover of Polystichum. The associes is on several soil series. It is on lower elevation, north-facing slopes where lateral seepage is probably high and evapotranspiration rates are low.

The Alnus rubra-Acer circinatum associes has a variable tree cover of Alnus rubra and Acer circinatum. The understory is dominated by Rubus parviflorus. The plant community is on convex, very steep, north-facing slopes at slightly higher elevations than the Alnus/Polystichum associes and volume of lateral seepage is probably not as great. The Alnus-Acer associes is usually on the Trask or Hembre II soil series.

The Acer circinatum-Corylus californica associes was tentatively recognized as two plant communities from reconnaissance information. Quantitative data revealed a xeric and mesic phase of the same community. The associes is characterized by a sparse to dense overstory of Acer circinatum. Corylus californica is usually present. Aspect range is quite wide but most slopes are south-facing. Although the elevational range is wide, all stands examined are in a topographic position to benefit from lateral seepage. Summer transpiration rates are high on south-facing slopes and soil moisture is probably frequently near the permanent wilting point. The associes is generally on deep Astoria or Hembre II soils.

Stands of the Rubus parviflorus/Trientalis latifolia associes are common at higher elevations. They are characterized by a dense cover of Rubus parviflorus and the virtual absence of woody species. The community is on steep slopes and on nearly all slope directions. The associes is generally on the Kilchis soil series which has a low moisture-storage capacity and probably a low nutrient status.

The Pteridium aquilinum/Lotus crassifolius associes is at higher elevations on Hembre I soils. The community has very few woody species and a high cover of Pteridium aquilinum. The associes is on gentle slopes and on most slope directions. Lateral seepage is probably low but the soils are deeply weathered and are apparently quite productive.

The Vaccinium parvifolium/Gaultheria shallon associes is dominated by two forest species. The associes is usually on south-facing ridgetops or convex slopes and is little influenced by soil series or solum depth. The stands are well to excessively drained and summer evapotranspiration rates are likely high. Many stands probably must utilize soil moisture near the permanent wilting point during late summer.

The Acer macrophyllum-Alnus rubra and Acer macrophyllum/

Symphoricarpos mollis associes can be recognized by physiographic characters. The Acer-Alnus associes is on floodplains of larger streams. A water table is in the rooting zone part of the year. The Acer/Symphoricarpos associes is on extremely steep, south-facing, bottom and middle slopes of igneous rock and talus.

Possible habitat types in the area studied are discussed. The ideas presented can be neither substantiated nor refuted until the forest associations in the coast range have been thoroughly studied.

The plant communities have both shade-intolerant, early seral species and shade-tolerant, late seral or climax species. The early seral species are less common under dense overstories where shade-tolerant species are more prevalent. Several species apparently present in the mature forest are adapted to fires. Acer circinatum, Acer macrophyllum, Corylus californica and Vaccinium parvifolium are root sprouters that apparently grew new sprouts from the living crown after each fire. Some of these species have stems capable of surviving a low intensity fire. Stems of young Alnus rubra and Pseudotsuga menziesii cannot tolerate even light burns.

Hand planted Pseudotsuga has been successfully established on much of the area. As Pseudotsuga becomes dominant in 10 to 20 years, shade-intolerant species will decrease and there will be an increase in forest species. Herbaceous cover will be lower and the stands will be taxonomically poorer than at present. *Pseudotsuga* is generally not growing satisfactorily under dense tree overstories and *Tsuga heterophylla* and *Thuja plicata* may eventually dominate these stands if the overstories are permitted to remain.

Several influences have increased vegetation heterogeneity. Fire pattern and intensity have been variable from place to place. Past history of the forest species influences their present distribution. Animals have over-utilized some preferred species altering their distribution pattern.

It was demonstrated that the study not only provides a basis for stratifying the plant communities but it also indexes available deer forage. The importance of *Rubus ursinus* as a winter deer food was demonstrated. The *Vaccinium parvifolium*/*Gaultheria shallon* and *Acer circinatum*-*Corylus californica* associes apparently provide most deer forage during the critical periods of winter snow.

As succession advances, the coverage of *Rubus ursinus* will be reduced and the area will be able to support fewer deer.

Table 15 . A key to eight seral plant communities in the Cedar Creek drainage of the Tillamook Burn.

A. Tree or tall shrub overstory
  B. Overstory dominated or codominated by *Acer macrophyllum*
    C. On generally south-facing slopes about or greater than 100 percent, mostly igneous rock and talus.

Acer macrophyllum/Symphoricarpos mollis

    CC. Not on steep, south-facing slopes, on floodplains of streambottoms.
      High constancy species:
        Rubus spectabilis
        Hydrophyllum tenuipes
        Oplopanax horridum
        Ranunculus bongardii

Acer macrophyllum-Alnus rubra

  BB. Overstory not dominated by *Acer macrophyllum*
    D. *Alnus rubra* dominant or codominant.
      E. Canopy coverage of *Alnus rubra* greater than 90 percent, coverage of *Acer circinatum* less than 25 percent. Coverage of *Rubus parviflorus* usually less than 50 percent, below 1400 feet.

Alnus rubra/Polystichum munitum

      EE. Canopy cover of *Alnus rubra* 50 to 100 percent, *Acer circinatum* coverage 1 to 100 percent, *Rubus parviflorus* coverage 30 to 100 percent, below 1400 feet.
      Species usually present (low coverage) but absent from *Alnus/Polystichum*:
        Anaphalis margaritacea
        Elymus glaucus
        Berberis nervosa
        Epilobium angustifolium
        Lotus crassifolius

Alnus rubra-Acer circinatum

DD. Alnus rubra not dominant except on some soil disturbed areas.
Acer circinatum always present, Corylus californica usually present, and dominant or codominant. If tree overstory sparse, sometimes dense cover of Rubus parviflorus. In positions to benefit from lateral seepage, all elevations.

Acer circinatum-Corylus californica

AA. Little or no tree or tall shrub overstory

F. Canopy coverage of shrubs, Vaccinium parvifolium: five to 40 percent, Gaultheria shallon: to 80 percent coverage. Usually on south-facing ridgetops or convex slopes.

Vaccinium parvifolium/Gaultheria shallon

FF. Canopy coverage of Vaccinium parvifolium less than two percent.

G. Pteridium aquilinum dominant, Rubus parviflorus canopy coverage up to 50 percent, above 1200 feet.

Pteridium aquilinum/Lotus crassifolius

GG. Pteridium aquilinum not dominant, Rubus parviflorus dominant, may be codominant with Elymus glaucus on shallow ridgetops. Pteridium aquilinum up to 25 percent canopy coverage, above 1200 feet.

Rubus parviflorus/Trientalis latifolia

BIBLIOGRAPHY

1. Baldwin, Ewart M. Geology of Oregon. Ann Arbor, Edwards Bros. 1959. 136 p.

2. Becking, Rudolf W. Site indicators and forest type classification of the Douglas fir region in western Washington and Oregon. Ph. D. thesis. Seattle, University of Washington, 1954. 159 numb. leaves. (Microfilm)

3. Corliss, John F. and C. T. Dyrness. Alsea Basin area soil and vegetation survey general and technical information for use in the final review. Corvallis, 1961. unnumb. (Oregon State University. Dept. of Soils) (Mimeographed)

4. Cronemiller, L. F. Oregon's forest fire tragedy. American Forester 39:487-490, 523. 1933.

5. Daubenmire, R. Forest vegetation of northern Idaho and adjacent Washington, and its bearing on concepts of vegetation classification. Ecological Monographs 22(4):301-330. 1952.

6. ________________. Canopy coverage method of vegetation analysis. Northwest Science 33(1):43-64. 1959.

7. ________________. Plants and environment. 2d ed. New York, Wiley, 1959. 422 p.

8. Dyrness, C. T. The effect of logging and slash burning on certain physical properties of forest soils. Master's thesis. Corvallis, Oregon State University, 1956. 85 numb. leaves.

9. Forest Soils Committee of the Douglas-Fir region. An introduction to forest soils of the Douglas-fir region of the Pacific Northwest. Portland, Western Forestry and Conservation Association, 1957. 14 chapters.

10. Hansen, H. P. Post glacial forest succession, climate, and chronology in the Pacific Northwest. Transactions of the American Philosophical Society 37(1):1-130. 1947.

11. Heusser, Calvin J. Late Pleistocene environments of North Pacific North America. New York, American Geographical Society, 1960. 308 p. (Special Publication no. 35)

12. Hitchcock A. S. Manual of the grasses of the United States. Rev. ed. 1950. 1051 p. (U. S. Dept. of Agriculture. Miscellaneous Publication no. 200, Revised by Agnes Chase)

13. Hitchcock, C. Leo, et al. Vascular Plants of the Pacific Northwest, Part 5. Seattle, University of Washington Press, 1955. 343 p.

14. ________________. Vascular Plants of the Pacific Northwest Part 4. Seattle, University of Washington Press. 1959. 510 p.

15. ________________. Vascular Plants of the Pacific Northwest Part 3. Seattle, University of Washington Press. 1961. 614 p.

16. Kallander, R. M. Problems of rehabilitating the Tillamook Burn. Master's thesis. Corvallis, Oregon State University, 1953. 85 numb. leaves.

17. Lowry, G. L. and C. T. Youngberg. The effect of certain site and soil factors on the establishment of Douglas-fir on the Tillamook Burn. Soil Science Society of America Proceedings 19(3):378-380. 1955.

18. McArdle, R. E. The Tillamook fire. U. S. Forest Service Bulletin 17(21):1-2. 1933.

19. McMinn, Robert G. Water relations and forest distribution in the Douglas-fir region on Vancouver Island. Ottawa, 1960. 71 p. (Canada. Dept. of Agriculture. Publication 1091)

20. McNab, James A. Biotic aspection in the Coast Range Mountains of Northwestern Oregon. Ecological Monographs 28(1):21-54. 1958.

21. Meyer, Bernard S., D. B. Anderson and R. H. Bohning. Introduction to plant physiology. Princeton, Van Nostrand, 1960. 541 p.

22. Morris, W. G. The Tillamook Burn--its area and timber volume. Pacific Northwest Forest and Range Experiment Station, Research Notes 18:2-4. 1936.

23. Mueller-Dombois, Dieter. The Douglas-fir forest associations on Vancouver Island in their initial stages of secondary succession. Ph.D. thesis. Vancouver, University of British Columbia, 1959. 570 numb. leaves.

24. Munger, Thornton T. The cycle from Douglas-fir to hemlock. Ecology 21(4):451-459. 1940.

25. Neiland, Bonita J. Forest and adjacent burn in the Tillamook Burn area of Northwestern Oregon. Ecology 39(4):660-671. 1958.

26. Oosting, H. J. The study of plant communities. 2d ed. San Francisco, Freeman, 1956. 440 p.

27. Oregon. State Game Commission. Game Division. Annual report. Portland, 1959. 177 p.

28. Peck, Dallas L. Geologic map of Oregon west of the 121st meridian. Salem, State of Oregon, Dept. of Geology and Mineral Industry, 1961. 1 sheet.

29. Peck, Morton E. A manual of the higher plants of Oregon. Portland, Binfords and Mort, 1941. 866 p.

30. Poulton, Charles E. Ecology of the non-forested vegetation in Umatilla and Morrow Counties, Oregon. Pullman, Washington State University, 1955. 166 numb. leaves. (Microfilm)

31. Soil Survey Staff. Soil survey manual. Rev. ed. Washington, 1951. 503 p. (U.S. Dept. of Agriculture. Handbook no. 18)

32. Spilsbury, R. H. and D. S. Smith. Forest site types of the Pacific Northwest: A preliminary report. Victoria, 1947. 45 p. (British Columbia Dept. of Lands and Forests. Forest Service Technical Publication T30)

33. Swanson, Richard C., et al. Soil Survey, Tillamook Burn Area, Tillamook County, Oregon. Portland. 1957. 33 p. (Oregon State Board of Forestry, Soil Conservation Service and Oregon State University cooperating) (Mimeographed)

34. Tansley, A. G. The use and abuse of vegetational concepts and terms. Ecology 16(4):284-307. 1935.

35. U. S. Weather Bureau. Climatic summary of the United States from the establishment of stations to 1930, inclusive. Western Oregon. Washington, D. C., 1936. 48 p.

36. Warren, W. C., Hans Norbisrath and Rex Grivetti. Geology of Northwestern Oregon, west of the Willamette River and north of latitude 45°15'. U. S. Geological Survey Oil and Gas Inventory, Preliminary Map 42. Washington, D. C., 1945. 1 sheet.

APPENDIX

APPENDIX 1

Typical Profiles of Soil Series Investigated

Meda Soil Series

Macroplot 2

Aoo	1-0	Litter of dry and partly decomposed leaves and twigs.
A1	0-10	Dark brown to dark reddish brown (8.75YR 3/2; (5YR 2/1.5 moist) gravelly loam; weak, medium subangular blocky breaking to moderate fine granular; very friable, slightly sticky and slightly plastic; roots abundant; abundant igneous pea stones and fine gravels; strongly acid (pH 5.2); clear, smooth lower boundary.
B1	10-24	Brown to dark brown (10YR 4/3; 7.5YR 3/2 moist) gravelly loam; weak, medium subangular blocky; friable, slightly sticky and slightly plastic; roots abundant; abundant fine gravels; strongly acid (pH 5.1); clear, smooth lower boundary.
B2	24-32	Brown to dark yellowish brown (10YR 5/3; 10YR 4/4 moist) gravelly clay loam; weak, medium subangular blocky; friable, sticky and plastic; roots common; very abundant fine gravels and few igneous chert; strongly acid (pH 5.2); clear, smooth lower boundary.
D	32	Light yellowish brown to yellowish brown coat (10YR 6/4; 10YR 5/8 moist) igneous sands, gravels and cobbles; roots common.

Astoria Soil Series

Macroplot 3

Aoo	1-0	Litter of dry and partly decomposed leaves and twigs.
A11	0-10	Dark greyish brown to dark brown (10YR 4/2; 7.5YR 3/2 moist) silt loam; weak, medium subangular blocky breaking to strong, very fine granular; very friable, non-sticky non-plastic; roots abundant; common pea stones and cherty sedimentary rocks; very strongly acid (pH 5.0); clear, smooth lower boundary.
A12	10-15"	Brown (10YR 4/3; 7.5YR 4/4, moist) silty clay loam; weak, medium subangular blocky; friable, sticky and plastic; roots abundant; common pea stones and cherty sedimentary rocks; very strongly acid (pH 5.0); abrupt wavy lower boundary.
B21	15-25"	Yellowish brown to strong brown (10YR 5/4; 7.5YR 5/6 moist) silty clay loam; moderate, medium subangular blocky; firm, sticky and plastic; roots common; few pea stones and cherty sedimentary rocks; very strongly acid (pH 5.0); abrupt, wavy lower boundary.
B22	25-37"	Dark yellowish brown to dark brown (10YR 4/4; 10YR 3/3 moist) silty clay loam; moderate, medium subangular blocky; firm, sticky and plastic; roots common; few pea stones and cherty sedimentary rocks; strongly acid (pH 5.2); diffuse, smooth lower boundary.
C	37"	Light yellowish brown to yellowish brown (10YR 6/4; 5/6 moist) clay loam; moderate, medium subangular blocky; firm, sticky and plastic; roots few; few stones; strongly acid (pH 5.2).

Trask Soil Series

Macroplot 10

Aoo	$\frac{1}{2}$-0	Dry leaves and twigs, amount and depth irregular.
A11	0-8	Very dark, greyish brown to dark reddish brown (10YR 3/2; 5YR 2/1.5 moist) silt loam; strong, fine granular; friable, slightly sticky and slightly plastic; roots very abundant; very abundant small shale fragments; very strongly acid (pH 4.8); abrupt, wavy lower boundary.
D	8	Light yellowish brown to brown coat (2.5Y 6/4; 7.5YR 4/4) loosely packed shale and siltstone; roots common.

Kilchis Soil Series

Macroplot 27

Aoo	2-0	Litter of dead leaves and twigs.
A1	0-3	Very dark greyish brown to dark reddish brown (10YR 3/2; 5YR 2/1.5 moist) silt loam; strong, fine granular; friable, slightly sticky, slightly plastic; roots very abundant; abundant igneous chert; strongly acid (pH 5.2); abrupt, smooth lower boundary.
B1	3-7	Dark greyish brown to dark brown (10YR 4/2; 7.5YR 3/2 moist) silt loam; weak, fine subangular blocky; friable, slightly sticky and slightly plastic; roots very abundant; abundant igneous chert; strongly acid (pH 5.1); abrupt, smooth lower boundary.
B2	7-19	Brown to yellowish red (10YR 4/3; 5YR 4/8 moist) silt loam; weak, fine subangular blocky; friable, slightly sticky and slightly plastic; roots abundant; abundant igneous chert; very strongly acid (pH 4.9); diffuse, wavy lower boundary.
D	19	Cherty basalt, tightly packed, roots few.

Hembre I Soil Series

Macroplot 20

Aoo	2-0	Litter of dead fronds.
A1	0-4	Very dark greyish brown to dark brown (10YR 3/2; 7.5YR 3/2 moist) silt loam; moderate medium subangular blocky; friable, slightly sticky and slightly plastic; roots very abundant; few coarse fragments; very strongly acid (pH 4.9); abrupt, smooth lower boundary.
B21	4-12	Dark brown to dark reddish brown (7.5YR 4/4; 5YR 3/3.5 moist) silty clay loam; moderate medium subangular blocky; friable, sticky and plastic; roots abundant; few coarse fragments; very strongly acid (pH 4.9); clear, smooth lower boundary.
B22	12-24	Dark brown (7.5YR 4/4; 7.5YR 4/3 moist) silty clay loam; weak medium subangular blocky; friable, sticky and plastic; roots common; few coarse fragments; very strongly acid (pH 4.7); clear, wavy lower boundary.
C	24	Light yellowish brown to dark brown (10YR 6/4; 7.5YR 4/4 moist) clay loam; weak medium subangular blocky; firm, sticky and plastic; roots common; few coarse fragments of basalt; very strongly acid (pH 5.0).

Hembre II Soil Series

Macroplot 41

Aoo	2-0	Decaying leaves and twigs.
A11	0-4	Very dark brown to dark reddish brown (10YR 2/2; 5YR 2/1.5 moist) silt loam; strong, very fine granular; very friable, non-sticky and non-plastic; roots very abundant; abundant igneous and sedimentary chert; strongly acid (pH 5.2); abrupt, wavy boundary.
B21	4-14	Dark greyish brown to dark brown (10YR 4/2; 10YR 3/3 moist) silt loam; weak medium subangular blocky; friable, non-sticky and non-plastic; roots abundant; abundant igneous and sedimentary chert; very strongly acid (pH 4.9); diffuse, wavy boundary.
B22	14-27	Brown to dark brown (10YR 4/3; 7.5YR 3/4 moist) silt loam; weak, medium subangular blocky; friable, non-sticky and non-plastic; roots abundant; abundant igneous and sedimentary chert; strongly acid (pH 5.1); clear, wavy boundary.
C	27	Yellowish brown to strong brown (10YR 5/4; 7.5YR 5/6 moist) silt loam; weak, medium subangular blocky; friable, slightly sticky and slightly plastic; roots common; abundant igneous and sedimentary chert; strongly acid (pH 5.1).

Appendix 2. Difference between Hembre I and Hembre II soil series.

Characteristic	Hembre I soil series	Hembre II soil series
parent material	residuum from igneous rock	colluvium from igneous and sometimes sedimentary rock
coarse fragments	few	abundant
B horizon texture	silty clay loam	silt loam or loam
B horizon structure	subangular blocky	usually granular
B horizon consistence	friable to firm, sticky and plastic	friable, slightly sticky and slightly plastic
B horizon rooting	common	abundant
horizon below solum	C horizon	C or D horizon
elevational range	1600' - 2000'	800' - 2100'
slope range	20-60%	20-80%
position on slope	middle to top	bottom to top
position for lateral seepage	possibly	yes
plant communities	<u>Pteridium</u>/<u>Lotus</u>, <u>Vaccinium</u>/<u>Gaultheria</u>	<u>Alnus</u>-<u>Acer</u>, <u>Acer</u>-<u>Corylus</u>, <u>Rubus</u>/<u>Trientalis</u>, <u>Vaccinium</u>/<u>Gaultheria</u>

Appendix 3. Constancy and average canopy coverage for all species recorded in six intensively sampled plant associes.

SPECIES LIST	PLANT ASSOCIES					
	Alnus rubra/ Polystichum munitum (Alru/Pomu) n = 6	Alnus rubra- Acer circinatum (Alru-Acci) n = 6	Acer circinatum- Corylus californica (Acci-Coca) n = 6[b]	Rubus parviflorus/ Trientalis latifolia (Rupa/Trla) n = 6	Pteridium aquilinum/ Lotus crassifolius (Ptaq/Locr) n = 6	Vaccinium parvifolium/ Gaultheria shallon (Vapa/Gash) n= 6
Thuja plicata Donn	1[a] +					
Tsuga heterophylla (Raf.) Sarg.	1 +					
Delphinium troliifolium Gray	1 +					
Scoliopus hallii Wats.	1 +					
**Menziesia ferruginea Smith[c]	1 +					
Ranunculus bongardii Greene	2 +	1 +				

a/ For each species. upper row of figures is constancy, lower row is average canopy coverage, plus (+) indicates canopy coverage less than one percent.

b/ Twelve macroplots were sampled in this associes. but for the purposes of comparison with constancy values in other associes, constancy for the Acci-Coca associes is divided by two.

c/ Asterisks indicate species were also recorded by Nieland (25). ** indicates she recorded species in the forest and burn or only in the forest. *species was recorded by Nieland only in the burn.

	(Alru/Pomu)	(Alru-Acci)	(Acci-Coca)	(Rupa/Trla)	(Ptaq/Locr)	(Vapa/Gash)
Dentaria tenella Nutt.	2 +	3 +				
Cardamine oligosperma Nutt.		1 +				
Dentaria californica Nutt.		1 +				
**Oplopanax horridum (J.E. Smith) Miq.		1 +	1 +			
Corydalis scouleri Hook		2 +	.5 +			
*Sambucus cerulea Raf.		1 +	1 +			
*Osmorhiza chilensis H. and A.			.5 +			
Tellima grandiflora (Pursh) Dougl.			1.5 +			
Hydrophyllum tenuipes Heller			1.5 2			
Botrychium virginianum (L.) Sw.			.5 +			
**Asarum caudatum Lindl.			.5 1	1 +		

	(Alru/Pomu)	(Alru-Acci)	(Acci-Coca)	(Rupa/Trla)	(Ptaq/Locr)	(Vapa/Gash)
Eriophyllum lanatum (Pursh) Forbes			.5 +		1 +	
Viola glabella Nutt.			.5 +		1 +	
Agrostis tenuis (Parnell) Druce			1.5 +			1 +
Heracleum lanatum Michx.			.5 +			
Erigeron annuus (L.) Pers.			.5 +			
Silene antirrhina L.			.5 +			
Prunus emarginata (Dougl.) ex Hook.				1 +		
*Deschampsia elongata (Hook) Munro ex Benth.					1 +	
*Ribes sanguineum Pursh					1 +	
Achillea millefolium L.					1 +	
*Senecio vulgaris L.					1 +	

	(Alru/Pomu)	(Alru-Acci)	(Acci-Coca)	(Rupa/Trla)	(Ptaq/Locr)	(Vapa/Gash)
*Frageria vesca L.						1 +
Philadelphus lewisii Pursh						1 +
Senecio jacobea L.						1 +
Castilleja Mutis				2 +		2 +
*Carex californica Bail.				3 +	2 3	2 +
*Hypochaeris radicata L.				5 +	3 +	3 3
Festuca myuros L.			1.5 +	1 +	1 +	2 +
Holcus lanatus L.			.5 +		2 +	2 +
Hypericum perforatum L.			3 +	1 +	3 2	3 +
Agrostis grandiflora (Nutt.) Greene			1 +	2 +	1 +	2 +
Crepis capillaris (L.) Wallr.			2 +	1 +	2 +	4 +

	(Alru/Pomu)	(Alru-Acci)	(Acci-Coca)	(Rupa/Trla)	(Ptaq/Locr)	(Vapa/Gash)
Rumex acetosella L.			1	1	3	2
			3	+	+	3
Carex rossii Boott.			3.5	6	6	4
			+	2	3	5
*Lupinus L.			2.5	3	2	2
			+	2	+	+
**Galium oreganum Britt.			1.5	3	4	
			+	+	2	
*Adenocaulon bicolor Hook.			.5	1		
			+	+		
Cerastium viscosum L.			.5	1		4
			+	+		+
Gnaphalium purpureum L.			1			3
			+			+
Cirsium vulgare (Savi) Airy-Shaw			1			1
			+			+
Madia sativa Mol. Sagg.			2.5		1	1
			3		+	+
*Agrostis exarata Trin.			1		4	
			+		+	

	(Alru/Pomu)	(Alru-Acci)	(Acci-Coca)	(Rupa/Trla)	(Ptaq/Locr)	(Vapa/Gash)
Solidago canadensis L.		1	1. 5			3
		+	+			+
Holodiscus discolor (Pursh) Maxim.		1	1		1	1
		+	+		+	+
**Berberis nervosa Pursh		4	1. 5	4		4
		4	+	4		2
**Achlys triphylla (Smith) D. C.		1	1. 5		2	1
		+	+		+	+
*Epilobium angustifolium L.		3	2	6	6	3
		+	+	2	3	+
Lotus micranthus Benth.		1	3. 5	1	1	2
		+	1	+	+	1
Aira caryophyllea L.		1	4	4	4	5
		+	6	2	2	6
Epilobium minutum Lindl. ex Hook		2	4. 5	6	3	6
		+	4	5	+	1
*Lotus crassifolius (Benth.) Greene		3	5	6	6	6
		+	10	25	53	24
*Anaphalis margaritacea (L.) B. and H.		6	4. 5	6	6	6
		2	8	15	16	8
Elymus glaucus Buckl.		6	5	6	6	6
		+	7	29	14	5

	(Alru/Pomu)	(Alru-Acci)	(Acci-Coca)	(Rupa/Trla)	(Ptaq/Locr)	(Vapa/Gash)
*Maianthemum bifolium D. C.	6	4	2	1	1	
	6	+	+	+	+	
*Stachys mexicana Benth.	6	2	4. 5	1	1	
	1	+	6	+	+	
*Oxalis oregana Nutt.	6	6	3. 5	2	3	
	14	2	2	+	+	
Festuca subuliflora Scribn.	6	4	2	5	1	
	4	+	1	+	+	
Galium aparine L.	6	2	5. 5	1	2	
	5	+	10	4	+	
**Disporum smithii (Hook.) Piper	6	6	3. 5	3	3	
	3	+	+	3	+	
*Galium triflorum Michx.	5	6	3. 5	3	4	
	+	1	1	3	5	
Digitalis purpurea L.	1	2	4	2	1	
	+	+	4	+	+	
Phacelia nemoralis Greene	1	1	3	2	1	
	+	+	+	+	+	
*Montia siberica L.	6	6	4. 5	1		
	33	2	4	+		
*Stellaria crispa C. and S.	6	3	2	1		
	3	+	+	+		

	(Alru/Pomu)	(Alru-Acci)	(Acci-Coca)	(Rupa/Trla)	(Ptaq/Locr)	(Vapa/Gash)
Cystopteris fragilis (L.) Bernh.	2	4	5	1		
	+	+	+	+		
Corylus californica (A. DC.) Rose	4	4	5			
	21	2	22			
Rhamnus purshiana DC.	3	1	2			
	+	1	1			
Dicentra formosa (Andr.) DC.	4	2	1.5			
	1	+	+			
Adiantum pedatum L.	4	6	3			
	2	1	+			
Osmaronia cerasiformis (T and G.) Greene	1		1			
	2		1			
Dryopteris arguta (Kaulf.) Watt.	2		1			
	+		1			
Marah oreganus (T. and G.) Howell	3		.5			
	+		5			
Tolmiea menziesii (Pursh) T. and G.	1		1.5			
	+		+			
*Cirsium edule Nutt.	2		1.5		1	1
	+		+		+	+
Stellaria borealis Bigel.	1		3	3	2	1
	+		+	+	+	+

	(Alru/Pomu)	(Alru-Acci)	(Acci-Coca)	(Rupa/Trla)	(Ptaq/Locr)	(Vapa/Gash)
**Clintonia uniflora (Schult.) Kunth.	1		.5	2	1	
	+		+	+	+	
Melica geyeri Munro	4		1			1
	1		+			+
Salix (Tourn.) L.	1			1	2	1
	+			+	+	+
Melica harfordii Boland.	2			1		
	+			+		
**Coptis laciniata Gray.	1			1		
	+			+		
Acer macrophyllum Pursh	1	2			1	1
	+	2			+	+
Smilicina sessilifolia (Baker) Nutt.	3	2	.5	3	5	1
	+	+	+	+	+	+
Anemone oregana Grey.	2	3	.5	1		1
	+	+	+	+		+
Actaea arguta Nutt.	2	1	1.5	1		
	+	+	+	+		
**Struthiopteris spicant (L.) Weis	4	1	1	2	1	
	+	+	+	+	+	
Carex (Rupp.) L.	2	2	3		1	2
	+	+	+		+	+

	(Alru/Pomu)	(Alru-Acci)	(Acci-Coca)	(Rupa/Trla)	(Ptaq/Locr)	(Vapa/Gash)
**Rubus spectabilis Pursh.	5	4	4		3	1
	24	+	10		1	+
Alnus rubra Bong.	6	6	2		1	2
	97	76	2		+	2
Nemophila parviflora Dougl. ex Benth.	1	1	4.5			1
	+	+	1			+
**Trillium ovatum Pursh.	4	3	2.5	2		2
	+	2	+	+		+
**Vaccinium parvifolium Smith	5	5	1	2	3	6
	4	3	+	+	+	17
**Gaultheria shallon Pursh.	1	1	.5	2	2	6
	+	+	+	+	+	42
*Pteridium aquilinum (L.) Kuhn.	5	5	4	4	6	6
	7	6	6	4	81	34
*Hieracleum albiflorum Hook.	1	4	4.5	6	6	6
	+	+	+	5	8	3
**Rubus ursinus Cham. and Schlecht.	6	6	6	5	6	6
	8	12	20	6	47	36
*Epilobium watsonii Barbey	3	4	5	4	6	2
	+	+	+	+	+	+
**Trientalis latifolia Hook.	5	6	4	6	6	6
	+	1	1	19	8	6

	(Alru/Pomu)	(Alru-Acci)	(Acci-Coca)	(Rupa/Trla)	(Ptaq/Locr)	(Vapa/Gash)
*Rubus parviflorus Nutt.	6	6	6	6	6	6
	31	75	49	88	15	10
**Polystichum munitum (Kaulf.) Presl.	6	6	6	6	6	4
	64	40	24	6	+	1
**Vancouveria hexandra (Hook.) Morr. and Dcne.	3	4	2	1	1	1
	5	+	+	+	+	+
**Luzula parviflora (Ehrh.) Desv.	6	6	3.5	6	4	1
	1	6	3	14	9	+
Senecio sylvaticus L.	5	6	6	5	6	6
	+	+	1	+	+	+
**Acer circinatum Pursh	3	6	6	1	2	3
	5	17	38	+	+	+
*Luzula campestris (L.) DC.	2	3	5.5	6	6	6
	+	+	+	3	4	8
**Rosa gymnocarpa Nutt.	4	3	2.5	3	1	5
	1	+	2	+	+	2
Collomia heterophylla Hook.	1	6	4.5	4	5	5
	+	+	6	5	2	3
Viola sempervirens Greene	5	2	1.5	6	6	5
	+	+	+	7	5	1

	(Alru/Pomu)	(Alru-Acci)	(Acci-Coca)	(Rupa/Trla)	(Ptaq/Locr)	(Vapa/Gash)
*Festuca rubra L.	2	1	2.5	5	5	4
	+	+	+	3	4	+
**Campanula scouleri Hook.	3	5	3	6	6	4
	+	+	1	13	13	2
Stone cover		4	3.5	5	5	6
		1	+	1	+	+
Litter cover	6	6	6	6	6	6
	80	56	81	72	86	61
Bare ground	6	6	6	6	2	6
	4	7	7	4	1	11
Log cover	6	6	5	6	6	6
	6	8	4	15	9	5
Epigynous-Cryptogams	6	6	5	6	6	4
	9	18	3	13	8	3
Total plant canopy coverage	349	265	283	281	307	233
Number of species	64	63	95	64	56	60