PHYTOSOCIOLOGY OF THE NASH CRATER LAVA FLOWS, LINN COUNTY, OREGON

by

ARCHIBALD WILSON ROACH

A THESIS

submitted to

OREGON STATE COLLEGE

in partial fulfillment of
the requirements for the
degree of

DOCTOR OF PHILOSOPHY

June 1951

APPROVED:

[redacted]

Professor of Botany

In Charge of Major

[redacted]

Head of Department of Botany and Plant Pathology

[redacted]

Chairman of School Graduate Committee

[redacted]

Dean of Graduate School

Date thesis is presented July 22, 1950

Typed by Leta Allis and Archibald Wilson Roach

ACKNOWLEDGMENTS

It seems difficult at the moment to specifically acknowledge all of the sources of information and help, both past and present, that have helped to form the mould of this thesis. My teacher and major professor, Dr. H. P. Hansen, Dean of the Graduate School, not only recognized and suggested the problem, but outlined many of its synecologic potentialities as well. Moreover, his experience and knowledge of many plant aggregations and other ecologic works helped to initiate the course of field procedure. For these reasons and for assistance in correcting the mechanics and ambiguous details of the context, this student gratefully acknowledges his debt.

Dr. Helen M. Gilkey, Curator of the Herbarium, corrected many taxonomic designations during the course of the field and taxonomic work, and later checked all collections. Also, Mr. Frank Nichol, Instructor in Botany, kindly keyed out and identified all of the mosses; and Dr. J. T. Howell of the California Academy of Sciences identified several species of *Carex*. In addition, both Professor Frank Beer of the General Science Department and Nathan Byrd, a graduate student in Botany, assisted in field and photographic work.

The writer is further indebted to the staff of the Willamette National Forest for their permission to work in the forests during fire season and to cut down a large Douglas fir for tree ring analysis. Mr. and Mrs. Emil Sandoz at the Santiam Junction Lodge kindly aided in the field work and through their hospitality alleviated many unpleasant camping periods in the lava.

The staff of the United States Regional Weather Bureau at Portland, Oregon graciously furnished their facilities and ten years of thermograph and precipitation records of the Santiam Junction Highway Weather Station for analysis and transcription of data. Also Mr. W. T. Frost, hydraulic engineer of the U. S. D. A. Soil Conservation Service and Chief of the Oregon Cooperative Snow Surveys provided records of the Santiam Junction Snow Course.

The help, encouragement, and concern of my wife, Leta A. Roach during the long period that this thesis was in preparation has made its completion possible.

TABLE OF CONTENTS

TABLE OF CONTENTS

PHYTOSOCIOLOGY OF THE NASH CRATER LAVA FLOWS, LINN COUNTY, OREGON

I. INTRODUCTION

A. THE NASH CRATER LAVA FLOWS, THEIR CHARACTER AND LOCATION.

Mantling the central and upper montane regions of Oregon's massive dimorphic volcanic complex, the Cascade Mountains are a series of forest aggregations quite different in intrinsic structure, social affinities, and syngenetic history. These coniferous forests vary from primeval remnants to primary and secondary sereclimax expanses. Moreover, their macro-mosaic is composed of an alternation of altitudinal or orographic bands which begin in the foothills of the Western Trough and extend upward to converge with the alpine nard of the high peaks.

At mid-altitudes this orographic continuity is altered. For here a superimposition of the Pleistocene High Cascade belt upon the eastern flank of the Miocene Western Cascade range has created a trough and thus a macro-climatic divergence. The more mesic entities of the upper montane forest found on the western slope of the Western Cascades are excluded by this slight rainshadow effect.

In addition, the community pattern is further sharply altered from normal correlation with this climatic effect by the nature of recent vulcanism. For along the western slopes of the high Cascades, the last period of vulcanism took place during the last millenium in the Santiam-McKenzie region, and created a series of quite different substrates.

Viscid basaltic magmas poured out from parasitic fissures and flowed west to the above-mentioned Western-High Cascade junction or McKenzie trough. The end stages were marked by mild explosions of ejecta which built up symmetric, presently undissected scoria and lapilli cones. Extensive ash and lapilli mantles were deposited to the lee of the crater by the prevailing northwest winds.

From the crest of the Western Cascades, dense climax forest extends down over weathered lavas, tuffs, and glacial tills, giving way sharply to thin developmental stands which are scattered out over these prilithoseric lavas and sterile ash flats.

The Santiam or northern portion of the McKenzie trough was chosen for study of this divergence in forest communities. Figure 1 locates its position in the mid-Cascades in the northeast part of the Willamette National Forest and in the east central portion of Linn County, Oregon.

The flows cover an area approximately ten square miles in extent (Figure 2). Their coordinates are 44° 28' north latitude and 121° 59' west longitude. A conspicuous check point is the junction of Oregon State Highway 222 and U. S. Highway 20, the North and South Santiam Highways respectively. Nash Crater lies just below the highway junction, and Little Nash Crater, which is not indicated on the map, is situated at the bottom of the Y formed by the two highways.

The western boundaries of the flows are marked by two

Figure 1. The location of the study area in the mid-Cascades of Oregon. The Nash Crater lava flows are approximately 90 miles east of Albany, Oregon on U. S. Highway 20. The foothills of the Western Cascades commence at Foster, Oregon, and the crest of the range is at Tombstone Summit. Clear Lake and McKenzie River mark the McKenzie trough. The crest of the High Cascades is represented by Santiam Pass.

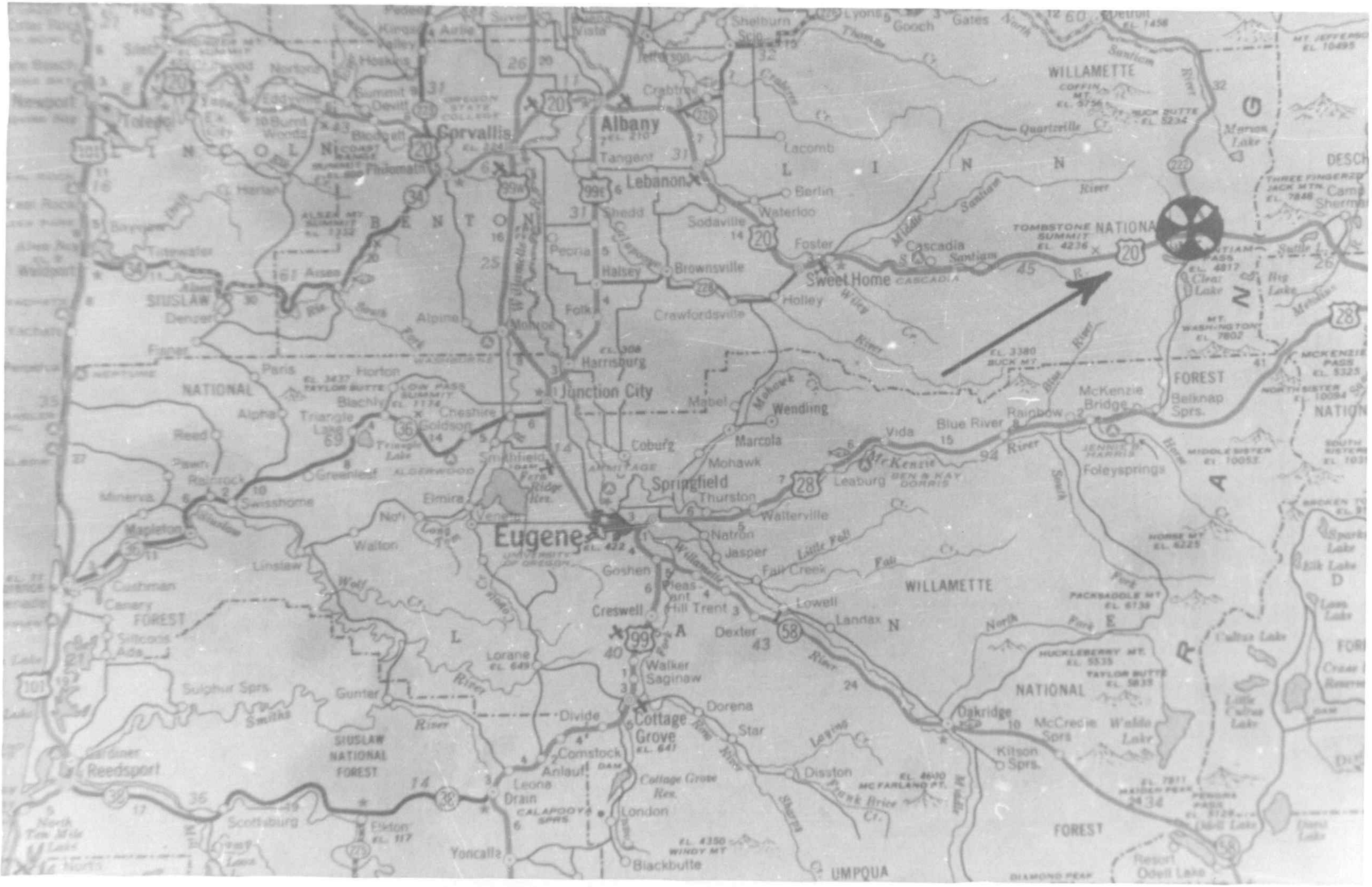
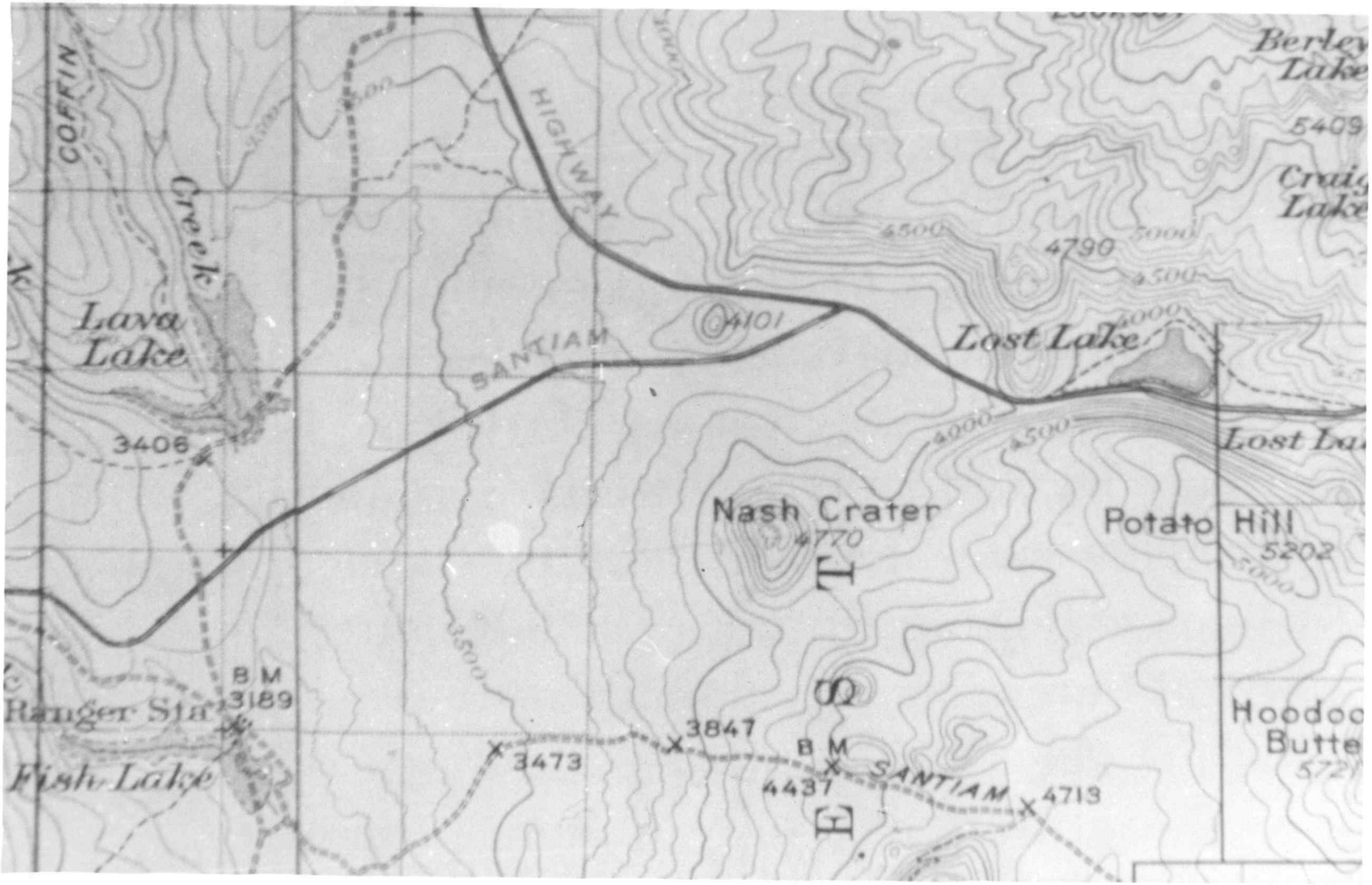

Newport
Toledo
Corvallis
Philomath
Albany
Tangent
Lebanon
Crabtree
Lacomb
Berlin
Waterloo
Sodaville
Foster
Cascadia
Sweet Home
Holley
Brownsville
Crawfordsville
Halsey
Shedd
Peoria
Harrisburg
Junction City
Monroe
Alpine
Alsea
Waldport
Siuslaw
Deadwood
Swisshome
Mapleton
Cushman
Canary
Florence
Reedsport
Gardiner
Scottsburg
Elkton
Yoncalla
Drain
Curtin
Cottage Grove
Saginaw
Walker
Creswell
Goshen
Eugene
University of Oregon
Springfield
Coburg
Marcola
Mohawk
Wendling
Mabel
Thurston
Walterville
Leaburg
Vida
Blue River
Rainbow
McKenzie Bridge
Belknap Sprs.
Foleysprings
Natron
Jasper
Fall Creek
Lowell
Dexter
Oakridge
Kitson Sprs.
McCredie Sprs.
Dorena
Disston
Star
Lorane
Veneta
Elmira
Noti
Walton
Cheshire
Blachly
Triangle Lake
Greenleaf
Alpha
Horton
Paris
Minerva
Linslaw
Sulphur Sprs.
Gunter
Divide
Comstock
London
Blackbutte
Cottage Grove Res.
Fern Ridge Res.
Lyons
Gooch
Gates
Detroit
Scio
Jefferson
WILLAMETTE
NATIONAL
FOREST
LINN
BENTON
LINCOLN
LANE
SIUSLAW NATIONAL FOREST
UMPQUA
Santiam Pass
Clear Lake
Big Lake
Tombstone Summit
Quartzville
Marion Lake
Odell Lake
Waldo Lake
Cultus Lake

Figure 2. The area of the Nash Crater lava flows indicated by the cross in Figure 1. The highway junction and the widely-spaced contour lines represent the ash-lapilli flats to the lee of Little Nash Crater. West from Little Nash and Nash Craters, the lavas are shown by the wavy, evenly-spaced contour lines which terminate at Lava and Fish Lakes. The scale is evident from the dotted section lines.


COFFIN
Creek
Lava Lake
3406
HIGHWAY
SANTIAM
4101
Lost Lake
4500
4790
5000
Berley Lake
5409
Craig Lake
4000
Lost La
Nash Crater
4770
Potato Hill
5202
3500
B M
3189
Ranger Sta
Fish Lake
3473
3847
B M
4437
SANTIAM
4713
Hoodoo Butte
T
E

intermittent lakes, Fish and Lava Lakes, at approximately 3200 feet elevation. The lavas then rise rapidly to their eastern boundary at 4200 feet elevation just beyond their point of origin where the ash flats to the lee of Nash Crater overlap with the deposits of the higher craters. The southern limits, continuous with the crater chain to the south, were arbitrarily placed at Sand Hill road. To the north the lavas of Little Nash terminate on an east-west line just beyond Fish Lake.

B. PURPOSE OF THIS STUDY

Phytosociologic studies imply a broad scope of synecologic interpretation as well as descriptive analysis. The quantitative, qualitative, and synthetic values of phytosociologic floristics fix and define a community as to its structure, as to its variation within its extent, and as to its progressive stages of development to a stable terminus. The characters of the community or communities, thus defined, are then explained by an analysis of the environmental factor complex which control or cause such effects.

The intent of this present paper is to separate the developmental communities on the lavas, to signify the structural floristics of each, to classify the whole on a basis of its present composition, and to attempt to explain sociologic variation and difference through an interpretation of the environmental controls. In addition, the ecology of these units will be compared with that of the climax forest bordering the periphery of the flows.

II. METHODS

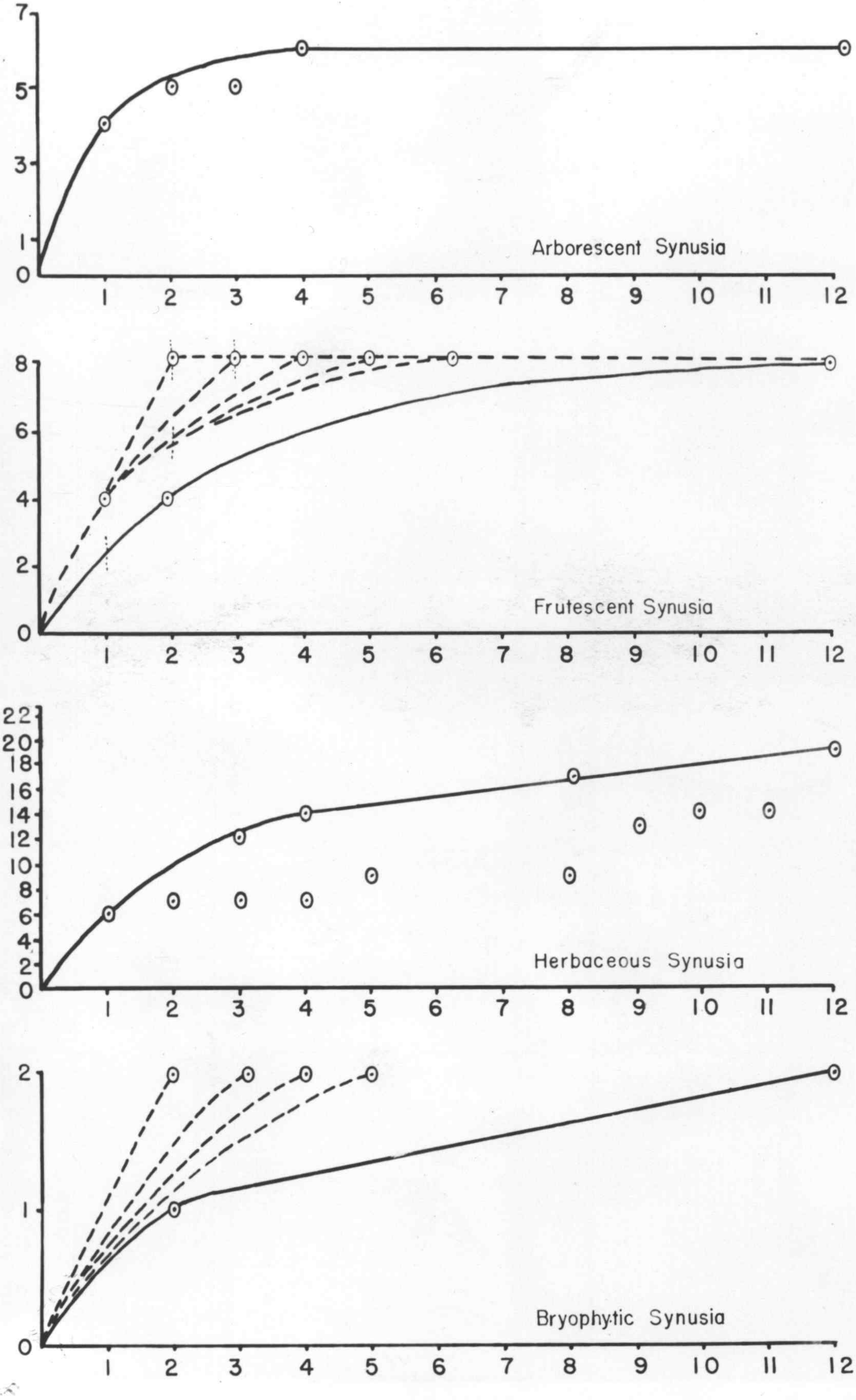
The field work was started in the latter part of May and continued through the growing season of 1949 into the last part of September. In the beginning, phenologic and taxonomic studies were initiated on the prevernal forms, and community delineation reconnaissance made.

During the first part of June, sampling areas were laid out in the six distinct developmental associations of the flows and the adjoining climax forest. Sampling techniques included three widely separated stations or stands in each entity. At each stand nested quadrats were laid out at 100 meter intervals along transects. To simplify and standardize technique, to cover this number of vegetational units in one season, uniform-sized quadrats were employed as follows: for the aboreal stratum 100 square meters; for the frutescent stratum 16 square meters; and for the bryophytic layer 1/4 of a square meter.

At the time, the pressing problem in this sampling seemed to be an accurate determination of number of such samples so as to adequately portray the structural quantitative values. The modified logistic curve or species:number curve used by many investigators failed to give results commensurate with apparent structure.

An example of the inadequacy of this method is illustrated by Figure 3. These species:number curves are based on 12 quadrats for each synusia of the climax forest. The curves of the frutescent

Figure 3. Species:number curves for the synusiae of the Pseudotsugetum taxifoliae tsugosum association. The y-axis represents the number of species of the layer and the x-axis the number of quadrats used in the sampling. The dotted curves indicate potential curves which depend upon the arrangement of the quadrats. The vertical dotted lines show the resulting minimum number of quadrats.



Arborescent Synusia
0 1 3 5 7
1 2 3 4 5 6 7 8 9 10 11 12
Frutescent Synusia
0 2 4 6 8
1 2 3 4 5 6 7 8 9 10 11 12
Herbaceous Synusia
0 2 4 6 8 10 12 14 16 18 20 22
1 2 3 4 5 6 7 8 9 10 11 12
Bryophytic Synusia
0 1 2
1 2 3 4 5 6 7 8 9 10 11 12

layer vary according to the sequence of quadrat plotting, yielding a different minimum number of quadrats for each sequence. Oosting (19, pp.46-47) depicts minimum number curves without qualification of order plotted. Any random movement of his points would create new curves.

Inspection of the bryophytic plot more clearly reveals this discrepancy. Two species of moss were encountered in the climax forest and in the sampling. The points at the end of the dotted lines show the nature of the curves which would result, depending upon the quadrat number of the first of the two species plotted on the x-axis. If the minimum number of two quadrats was used as is manifest by the solid line curve, the first species would have a frequency of 50 percent and the second one of 0 percent. The twelve quadrats, however, yielded frequencies of 8 percent for both which were more indicative of their homogeneity.

Other investigators have apparently encountered this same difficulty for Cain (6, p.243), in employing sampling methods of alpine vegetation in Wyoming, explains his use of plot number as follows:

> "Although a strict adherence to the species-plot curve would indicate the minimum necessary number of plots to be small, it was decided to use twenty plots at each station in order to obtain adequate frequency and coverage statistics."

Likewise, Billings (1, pp.450-451) perceived that his minimum areas inadequately expressed apparent frequence and cover. In addition, he used an arbitrary number of samples without using species:number determinations.

After these initial attempts to discern a satisfactory number of samples in the different areas, the following set numbers were used as appeared to correctly portray disposition and arrangement of the species: for the climax forest and the peripheral ecotone community, 12 quadrats in each layer; for each of the four subclimax communities on the lavas, 50 quadrats in each synusia; and for three strata of the bog community, 16 quadrats each. The total number was 894.

The data from the quadrats at all stations were analyzed for abundance and percent of total abundance except for the bryophytic synusiae. Such values give for the first an index of amount, and the second, the relationship of such amounts of the species one to another. These figures also yield densities and frequencies. All four values for each plant in its respective layer indicate both its dispersion and aggregation at the particular station.

Space occupied was likewise expressed in absolute and percent of total values. For the arborescent species, basal areas were calculated from DBH measurements; for the shrubby and bryophytic species, crown interception in square meters measurements was taken. These data together with the dispersion and aggregation quantitative values, give each species its structural and degree of dominance position in its union in the stand. No coverage data were obtained for the scattered species of the herbaceous layers.

In addition, abundance of the species of the arborescent synusiae of the associations was noted throughout a series of arbitrarily set size classes. These were: reproduction, 1 1/2" to 2 1/2", 3" to 6", 6 1/2" to 12", 12 1/2" to 24", 24 1/2" and over. Such data are useful for both structural and syngenetic relationships.

The remaining floristic analyses embraced phenologic records of the Angiospermae, and prescence lists. The latter segregate out the constant species or indicator species that typify the association type.

The synonomy of all species is principally that of Peck (20). However, more recent interpretations by Gilkey (13) were substituted for several species. A collection of these species of this study (Appendix) was placed in the herbarium of Oregon State College.

The rather sharp delineation of community types with abrupt ecotones indicate that perhaps micro-edaphic control is primary. For this reason the greatest emphasis was placed on this factor group. Representative profiles were obtained and plotted and soil samples of the layers obtained for textural analysis. The increment of each sample retained on a 2 mm screen was noted as a percent of the total. The smaller size classes of the remaining portion were found by using a modified Buoyoucos hydrometer method (3). In addition, soil pH was determined for the profile strata by colorimetric indicators. And permanent wilting percentages were secured by multiplying the colloidal fraction of the soil -- grams in suspension at 15 minutes on the hydrometric curve -- times the constant 0.2835. However, objections have been raised as to the validity of this constant and the data must not be considered as completely trustworthy.

Two micro-climate stations were maintained, one in the open block lava and the other in the climax forest. Maximum and minimum temperatures and relative humidities were recorded twice daily at 8 A. M. and 8 P. M. Other environmental influences, such as the biotic and pyric factor groups, were regarded through observation and photography.

The community nomenclature followed in this paper is that which has been developed by the European Zurich-Montpellier school. It is a static or taxonomic discipline whose mechanics are explained in detail by Braun-Blanquet (4, pp.361-377). The unit of classification or association is that recommended by the Sixth International Botanical Congress of 1935. However, in more recent years, it has been further subdivided by several workers into strata or separate floristic units of the whole, the unions (11, p.288; 8, pp.392-393). These are not to be confused with the unions of the Scandanavian school of classification which considers synusiae or strata as separate associations.

Much controversy was raised when this system was but recently introduced into American ecology. A different basis for classification had arisen and had gained wide acceptance through the evolution of the Chicagoan and Nebraskan schools of influence. This disposition, the monoclimax system of classification, is dynamic rather than static and its categories are based upon the movement, through successive stages of replaceable floras, to a stabilized vegetation in harmony with their regional climates. Its tenets are simply stated by its greatest designer, Clements (24, pp.89-105), and more completely by Cain (5).

The European school and its followers have raised valid objections to the monoclimax system. Braun-Blanquet (4, pp.306-362) points out that many of the regional stabilized formation and association units have been replaced by developmental floras through disturbance that are stabilized by their disturbance factors. Likewise, he brings into relief its lack of category systematization. Conrad (10, p.3) further objects on the grounds -- and which is the main reason the European disposition was used by this author -- that one should work with the vegetation which is present rather than with one which is theoretic and may never manifest itself.

Phytosociologic studies in the Pacific Northwest are negligible if not entirely absent. Its forest associations are virtually all a part of one alliance socially tied together by the presence of Douglas fir (Pseudotsuga taxifolia) in their association lists. Likewise, the major part of the forest aggregations of the Rocky Mountain chain, though varying floristically from those of the west, are affiliated through the presence of Douglas fir. Together these form two large Pseudotsugions of the coniferous order of western North America. It is hoped that the floristic studies of this paper may serve as a focal point for a future recognition and eventual classification of the associations of these alliances.

III. GEOLOGY OF THE NASH LAVAS AND CENTRAL CASCADES

A. EARLY VOLCANIC HISTORY.

The geology of the Cascadian chain, and subsequent topography and climatic differentiation, is the ultimate *raison d'etre* for the present macro-aspection of mid-Cascadian forest types. Nowhere, perhaps, has there been a more tumultuous series of mountain building activities. Volcanic in origin, this chain is composed of a vast composite of magmatic products ejected in many different ways for an almost continuous activity during the past 60 million years. The volcanic history of Oregon has been compiled from many sources and simply told by Williams (27, pp.14-52). The following generalization of early continuity is largely taken from his narrative.

The Larimide revolution, which threw up the vast Rocky Mountain folded anticline at the end of the Cretaceous Period, was a far-reaching series of crustal movements which uplifted the western portion of the continent. These upheavals ushered in the prelude of far-western eruptions along a tremendous north-south fault line.

In middle and late Eocene, a few volcanoes began the rudiment of the Cascade belt. Most of the agitation took place to the west of the present line of Cascadian foothills beneath the oceans. This was a period of submarine outpourings and low relief to the east.

The scattered ancestral cones of the Cascades continued to increase their outpourings and by middle Oligocene their products of ashes, agglomerates, andesitic and basaltic lavas were piled up to depths as high as 10,000 feet. However, up to the great consolidation period of middle Miocene, these were coastal mountains and it was a period of rhythmic subsidence or settling of these aggradations. Also during this period, large flows from fissures piled one over the other. The range grew higher as heterogeneous fragmental ejecta from isolated cones were built up. At the same time to the east, hot fluid lavas spread out as horizontal sheets of great extent to form the Columbia Plateau.

At the end of the Miocene, folding and tilting earth movements lifted the Cascades _en masse_. For the first time maritime climatic influence was excluded from eastern Oregon; eastern Oregon streams were blocked from access to the ocean. These new heights formed many streams and a long cycle of down-cutting and erosion was initiated. A more significant effect of the uplift was an opening of a band of fissures along the eastern flank and near the crest of this single range. From them, and during the following period, the Pliocene, were evolved a second range, one of large shield volcanoes -- the High Cascades.

Whereas the Western Cascades were built from quiet effusive flows, the High Cascades in their final stages of growth became explosive. Parasitic cinder cones developed on the flanks of the shields burying them with ejecta. Also erosion and Pleistocene glaciation greatly dissected these shields into a series of radiating ridges and valleys. Yet in the Santiam region the more resistant lava fillings of their central vents stand up to preserve their identity as Three-Fingered Jack and Mount Washington.

Tremendous consolidation continued into the Pleistocene. The more conical cones of Mounts Shasta to the south and Hood and Jefferson to the north place them in this period. As they approached old age, they began to erupt basalt and cinders, rhyolite and dacite from parasitic vents in place of andesite. Some emitted vast quantities of frothy pumice.

The High Cascade range was mantled with thick mountain glaciers, advancing and retreating down its slopes during the glacial and interglacial stages of the Pleistocene. At times they reached out 20 miles or more attaining depths of more than 1000 feet.

Thayer (23, p.20) recognizes three stages of glaciation in the Santiam region. These are Mill City, Detroit, and Tunnel Creek. He correlates them with the Sherwin, Tahoe, and Tioga glacial stages of the Sierra Nevadas proposed by Blackwelder (2), who in turn believes that the latter correspond with the Kansan, Iowan, and Wisconsin continental glacial epochs respectively.

During the Pleistocene, the McKenzie and North Santiam river valleys were the only large outlets to the west for glaciers from the western slope of the High Cascades between Mount Jefferson and the Three Sisters (23, p.39). Thayer surmises then, that the North-South-Santiam-McKenzie trough must have been filled with ice during the Detroit and Mill City glacial stages. From the north-south Fish Lake divide in the study area, two glaciers were formed, one moving north and the other south.

A tabular comparison of the two Cascadian belts has been arranged by Hodge (17, p.3) which illustrates their differences in form, formation, and age. Most of this table is in complete harmony with William's findings.

He describes the Western Cascades as being 50 miles wide with an average elevation of 4,500 to 5000 feet. Topographically they are a maturely eroded range with narrow ridges and valleys showing little relation to past volcanic structure. Their formations are of Eocene rhyolites under Oligocene-Miocene Breitenbush tuffs which grade up into Miocene andesitic lavas. He further depicts them as being composed of folded rocks, intruded by diorite and uplifted probably near the end of the Miocene. The present elevations were essentially attained in mid-Pliocene.

In contradistinction, the High Cascades are 25 miles in width with an average elevation of 5000 to 7000 feet. A cross-section of their crestline resembles a steep-sided "A" with glaciated dip slopes and "U" valleys. Their erosional unconformities divide them into three formations: Outerson or oldest volcanoes, Minto and Battle Axe olivine basalts which comprise the bulk of the High Cascades, and Olallie lavas and Santiam basalts. The lavas of the entire range vary from olivine basalts to dacites. In addition, glacial and glacio-fluvial deposits are widespread.

Hodge ascribes their building to late Pliocene and early Pleistocene.

B. THE NASH CRATER LAVAS.

During the 25,000 years following the retreat of ice from the lower slopes and the McKenzie trough, vulcanism diminished, though a few High Cascade volcanoes have continued to erupt at intervals. The most recent activity occurred from a line of parasitic vents along the western flank of the old shield volcanoes at the Western-High Cascade juncture to the north in the Santiam region extending south to the McKenzie Pass area. Short sporadic flows of dark basalt poured out of these fissures and flowed west to the lowest part of the McKenzie trough. In the waning stages, underground differentiation took place and explosive ejectas were blown out to form small cinder cones of scoria and lapilli. To the lee of these cones deep mantles of ash and lapilli were deposited.

Nash and Little Nash Craters (Figure 4) are to the north end of this chain. Nash Crater stands 770 feet above its ash covered base as a symmetric cone. Absence of erosion marks its youthful age. It has a crescent-shaped crater about 100 feet deep; and its eastern rim is 150 feet higher than its western rim because of an accumulation of smaller-sized lapilli by the prevailing northwest winds. The flow lines of the lavas are evident in Figure 5, as is their westernmost penetration. Lava and Fish Lakes are illustrations of the blocking off of small

Figure 4. An aerial photograph of Nash and Little Nash Craters. Little Nash lies in the "Y" formed by the two highways. The grey texture delimits the extent of the Pinetum contorti lapillosum association which is found on the ash-lapilli mantle to the lee of the craters.

Figure 5. An aerial photograph of the lavas at their westernmost penetration. This view is below or to the west of Figure 4. Note the flow lines of the lava and the fan that dammed up local drainage to form Lava Lake. The difference in forest composition at the bottom of the figure defines the magnitude of substratal control.

25

streams that flowed into the McKenzie trough.

Little Nash Crater is a much smaller cone rising only 300 feet. Its crater is small and strewn with large red bombs and scoria. Excavations for highway material show the successive flows of scoria that poured out of its vent (Figure 6).

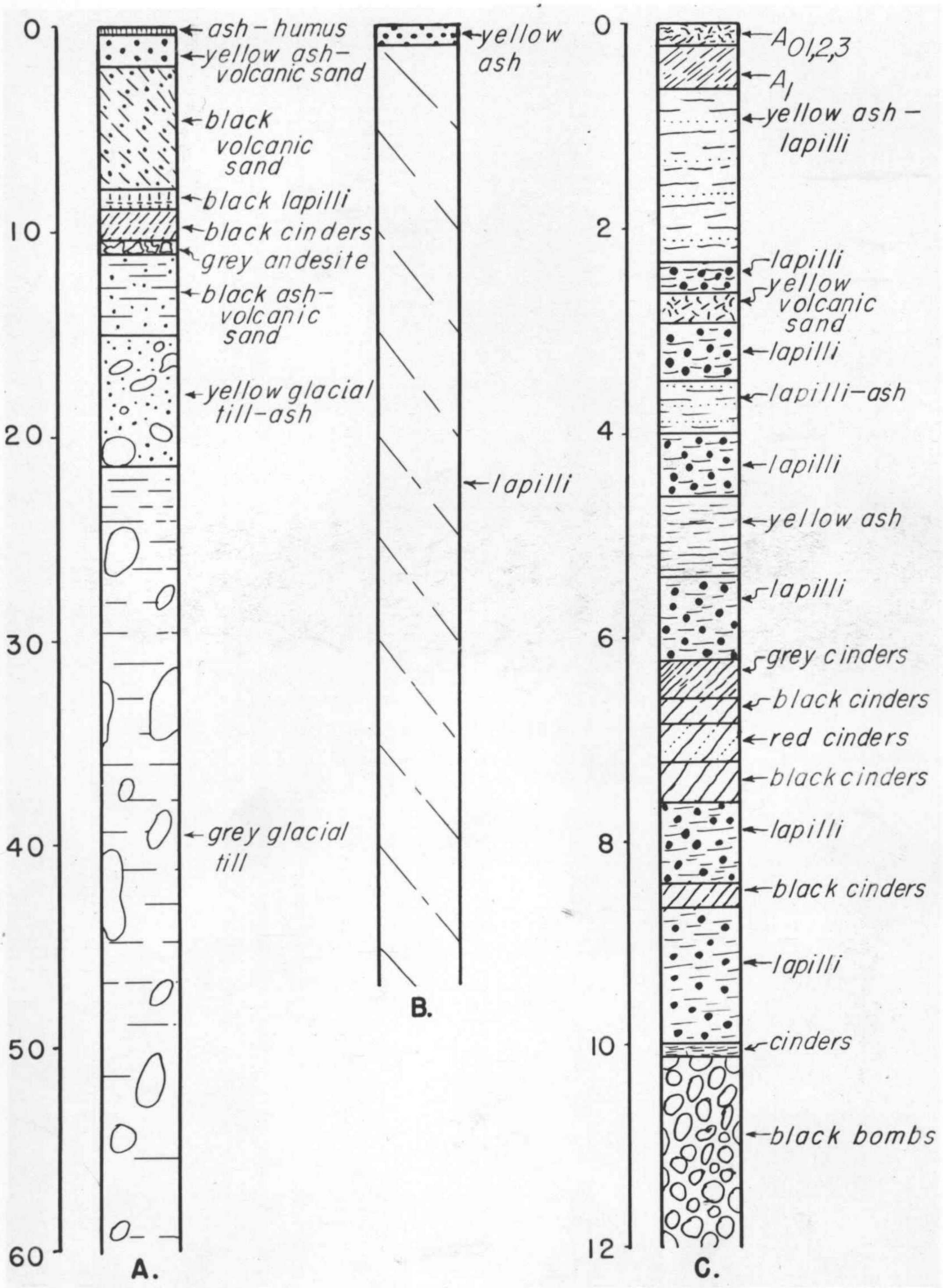
The basaltic lavas that moved west from Little Nash and Nash prior to formation of the cones are apparently of two compositions. One series is of greyer, less angular lava in which finer volcanic detritus is intermixed. Being scoriaceous it was probably very hot lava. Further away from the cones at lower elevations and at the outermost extensions, the second series of basalts is dark, less scoriaceous, and thus was relatively cooler. These flows are loosely broken up into a jumble of sharp edged blocks with large substratal interstices. Also, the gradient of flow of both series was rather steep, and the succession of waves with steep faces form a progression of benches (see elevation lines in Figure 2).

Undoubtably these lavas had a high viscosity and moved slowly. No evidences of ropy or obsidian lavas were found. Midway from Nash to the western or lowermost edge of the lavas there is the remains of a tunnel known as Sawyer's Cave. It is in the middle of the large deposition of the lighter, more scoriaceous, and thus hotter, basalts.

Figure 7 depicts graphic plots of the sequences of ejecta from Little Nash Crater. Profile B is a highway cut of its lee

Figure 6. A vertical cut into the west side of Little Nash Crater. Note the layering of the scoria cascades.

Figure 7. Diagrammatic sections of the differential volcanic composition of Little Nash Crater. Profile A depicts ejecta sequences overlying glacial till northeast of the crater. Profile B, taken from the lee side, is indicative of the composition of the cone's slopes as portrayed in Figure 6. Depths in feet are shown to the left of the profiles.


0
10
20
30
40
50
60
ash - humus
yellow ash-volcanic sand
black volcanic sand
black lapilli
black cinders
grey andesite
black ash-volcanic sand
yellow glacial till-ash
grey glacial till
A.
yellow ash
lapilli
B.
0
2
4
6
8
10
12
$A_{0 1,2,3}$
A_1
yellow ash - lapilli
lapilli
yellow volcanic sand
lapilli
lapilli-ash
lapilli
yellow ash
lapilli
grey cinders
black cinders
red cinders
black cinders
lapilli
black cinders
lapilli
cinders
black bombs
C.

base and is indicative of the composition of the ash and lapilli flats to the southeast. One foot of ash covers 46 feet of coarse yellow lapilli. Profile C is a 12 foot icon of the ejecta cascades down its slopes as previously portrayed in Figure 6. Profile A is of a highway cut of an old moraine 100 feet from its northeast base. Here 2 feet of ash overlie six feet of black volcanic sand. Beneath are three small strata of progressively larger scoria. A thin layer of white fragmentary andesite precedes four feet of black ash and volcanic sand. Then at the 16 to 21 foot levels, yellow ash grades into glacial till. The Pleistocene till beneath this to the recorded depth of 60 feet is composed of reworked grey tuff with interspersed rounded boulders of andesite.

That this vulcanism is recent is attested by the lack of erosion of the soft cones, layers of ejecta over glacial till, and a lack of acquired characters in the substratal profiles. Of this particular area Williams (26, p.51) writes:

> "Other eruptions took place recently in the country to the north, close to the Santiam Highway. Several small cones were built there and a flow of basalt obstructed local drainage to produce Clear Lake (5 miles south of Fish Lake). That these eruptions occurred within the present millennium seems quite likely, for standing on the floor of the lake are the upright trees of a drowned forest."

In addition, Campbell (9, p.21), working on the southern portion of the chain believed that obsidian extruded from Bellnap Crater was around 300 years old because primary succession had not proceeded beyond the lichen stage.

Perhaps more conclusive dating lies in a tree ring chronology of several Douglas fir -- the largest and oldest on the flows -- found at the western edge of the lavas just south of U. S. Highway 20. From superficial inspection, it appeared that the coarse lavas had flowed or been pushed around them. One tree, symmetrical and intact for its age, 85 feet in height, with a DBH of 68 inches, was cut down and a radial wedge taken for ring analysis. An extensive excavation bore out the original presumption, for its roots lay at 6 feet below the level of the black block basalt. Beneath its roots was a layer of water-worked grey scoria innerbedded in grey soil. Unquestionably, then, this tree existed before and continued to exist after the lava inundation. Perhaps it grew on a slight rise in the trough since the lip of the flow, a hundred feet or so away, is as high as 10 feet in places.

The sequence of rings of this tree may be found in Figure 30, part D. The stump at three feet above the lava displays no included burn scars or misconformities which might exactly set the date it was surrounded. Its skeletal plot shows it to be 638 years old. For the first nine years it grew rapidly, then gradually tapered off, possibly because of forest consolidation. However, on its 43rd year (595 years ago), it entered a period of restricted growth which lasted for 12 years. It gradually recovered, as is portrayed in its progressively increasing size of rings up to its 178th year (460 years ago). Growth was again restricted severely for 8 years. The remaining 452 rings are complacent.

It is doubtful if these two divergences of growth can be ascribed to climatic influence. In the first place, climatic fluctuations do not show in the ring record in areas where optimal temperature and moisture conditions prevail. In the second place, there are 452 years of ring complacency -- a time when there was climatic fluctuation as will be shown later in tree ring chronologies of lodgepole pine (Pinus contorta var. murrayana) growing on the upland sterile ash flats. Moreover, this particular tree was rooted in soil, and oxygen and water was available through the large interstices of the block lava.

If these assumptions are true, then the two disconformities of growth must be ascribed to some other environmental agency or agencies. It is possible that the first restriction of growth was caused by the basalt flow since it was the first of the chain of volcanic events. The second restriction which occurred 135 years later might represent the most intense period of explosive eruption that built the cones. Hot magmatic gases and showers of acid rain could have caused this series of microscopic rings.

Other trees fared less well in the deeper lava sites. One cast was found at the lip near the site of the above-mentioned Douglas fir where the lava was piled to a depth of 12 feet.

This rough chronology, then, places the origin of the Nash Crater flows around 1354 to 1497. Undoubtedly activity commenced earlier, since the first date represents the terminal or westernmost extention of the basalts. During the intervening years, cone-building was sporadic, as is evidenced by the series of very different ejecta layers of Little Nash Crater. The latter date may not represent the terminus of this activity, but merely its most intense period.

IV. MACROCLIMATE OF THE SANTIAM REGION

The particular relation of a number of physical features provides Oregon and the Pacific Northwest with a characteristic and diversity of broad climatic types. From its very latitudinal position, it lies at the southern border of the wet mesothermal, boreal province. However, its land mass to ocean mass relation, together with the prevailing movements of the Polar Pacific Air Mass from the northwest, furnish it with a distinct maritime climate. This air mass is cold, humid and unstable but warmer than the land over which it passes in the wintertime. As a result, the cooling effect of the land and shore continental upwelling, together with the relatively unstability of the air mass, produces heavy winter precipitation. To the south, the Tropical Pacific Air Mass acquires warm, humid, and unstable characters from the oceans over which it lies. It is pulled north by the movement of the westerlies, overriding the colder Polar Pacific air and forming warm fronts.

In the summer these movements are reversed. Air moves from the warmer land to the ocean. Precipitation cycles are inverted and loss of heat becomes great at night. The climate becomes semi-arid.

The climatic pattern is further intensified by the orographic effects of Oregon's land mass topography. The north-south axis of the Coast and Cascade ranges forms effective and almost continuous barriers to the prevailing winter movements of the

Pacific air masses. An intensification of precipitation-loss occurs with uplift and cooling as the winds move up and over the ranges. On the eastern slopes, derived of their moisture, they descend, compressing, warming up, and taking up moisture. Thus the rest of Oregon east of the Cascades is arid because of this rain-shadow effect.

In addition, the Cascades act as a barrier to the winter movements of the dry, cold and stable Polar Continental Air Mass. This insures moderate temperature control by the maritime air masses. Occasionally stagnation, when of sufficiently long duration in the Great Basin, produces enough pressure for cold air to spill over the mountains. The climate becomes continental with low temperatures and snow until major movements within the center of the continent relieves the pressure.

Weather staions on the western slopes of the Cascades are few. Hansen (15, p.50) found that the average mean annual rainfall of seven stations, located from 700 to 3,900 feet, is approximately 91 inches. The precipitations range from 62 to 124 inches. Though he mentions that the temperature data are scanty and not reliable for wide ranges of altitude, he found that roughly there is a divergence of about 25° F. between maximum and minimum averages.

In the Santiam region, the orographic pattern of the mid-Cascades is somewhat altered by the slight rain-shadow effect of the Western Cascades' crest. The climate in the Western-High

Cascades or McKenzie trough was recorded for ten years at the Santiam Junction Highway Maintenance Station which is located in the study area. Unfortunately there are no weather stations on the west slope of the Low Cascades and the High Cascades for comparison of data.

Absolute monthly precipitations and their seasonal and yearly variations are depicted in Table I. These data are also diagrammatically compared in Figure 8. The heaviest precipitation occurs in the winter months, from the last of September to the last of June, and particularly in November and December. Figures for this period vary from 16 to 3 inches, probably depending upon the disposition of the Polar Continental Air Mass during those years. The dry summer months are shown by the low figures of July and August when the rainfall may be but a fraction of an inch, and not over 2 inches. There are noteworthy seasonal and yearly variations -- yet plotted trends of Figure 8 show a conformity to the earlier described maritime influence. The average annual precipitation is approximately 50 inches.

Temperatures and relative humidities for this area are summarized in Tables II and III respectively. A glance at Figures 9 and 10 unfolds the proclivities of variation in maximum and minimum monthly values for each. The former indicates a surprising stability of minimum temperatures around 20° F. for the months of May through October, or a degree of freezing conditions

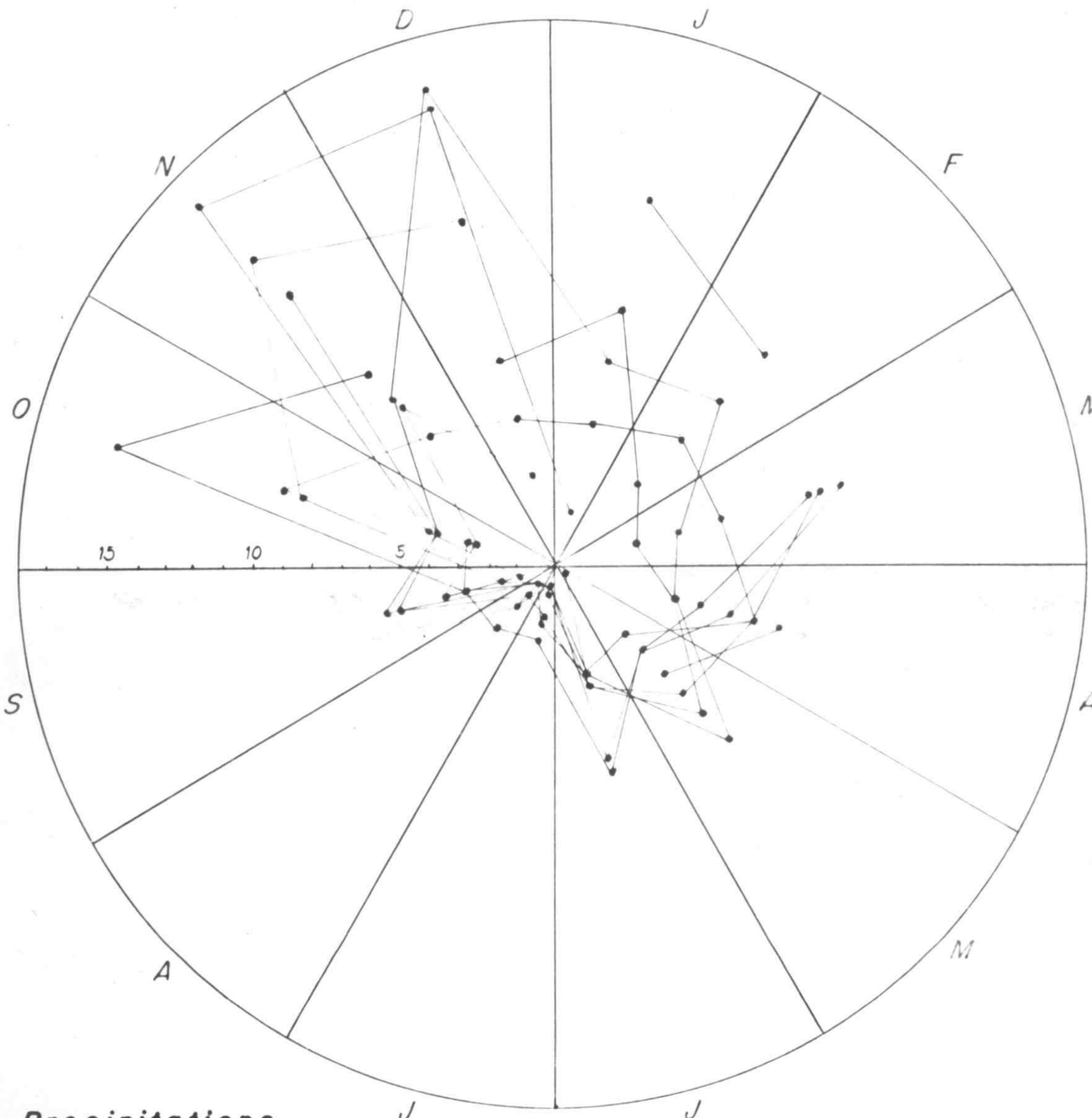
Table I

Erratic monthly total precipitations in inches for Santiam Highway Junction Weather Station*

Year	J	F	M	A	M	J	J	A	S	O	N	D
1940	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	6.94
1941	8.49	3.62	2.24	3.95	7.97	3.29	1.71	.53	5.71	3.96	7.44	16.12
1942	6.86	7.46	4.04	3.99	6.50	3.81	.74	.02	.98	4.14	16.80	15.77
1943	1.26	-----	9.82	5.87	3.67	6.12	.33	1.62	-----	9.21	5.87	4.91
1944	4.85	5.80	5.53	6.85	2.93	3.44	.22	.11	3.65	2.48	7.11	2.89
1945	-----	-----	-----	7.55	4.93	-----	.23	.53	2.80	2.73	-----	-----
1946	12.29	9.86	-----	-----	.09	3.77	-----	.78	1.79	8.60	14.30	11.75
1947	-----	-----	8.48	4.93	.69	6.92	2.08	2.50	1.75	15.01	8.87	-----
1948	-----	-----	9.00	6.58	5.87	3.84	1.60	1.06	5.16	3.99	12.53	-----

* discontinued in January, 1949.

Figure 8. Graphic representation of the monthly average precipitations noted in Table I. The months are shown around the periphery of the graph and the scale is in inches.



Precipitations

Table II

Monthly maximum and minimum temperatures in degrees Fahrenheit for Santiam Highway Junction Weather Station.

Month	Year																	
	1940		1941		1942		1943		1944		1945		1946		1947		1948	
	Ma	Mi	Ma	Mi	Ma	Mi	Ma	Mi	Ma	Mi	Ma	Mi	Ma	Mi	Ma	Mi	Ma	Mi
J	---	---	58	13	55	15	43	-30	50	-6	54	2	---	---	51	-3	56	3
F	---	---	53	10	45	8	49	12	44	-4	---	---	---	---	59	27	50	-9
M	---	---	65	18	56	3	62	3	62	-2	---	---	---	---	69	12	49	10
A	---	---	70	20	76	21	72	19	69	10	---	---	---	---	85	20	65	7
M	---	---	82	27	79	22	72	19	78	25	---	---	78	21	88	23	77	12
J	---	---	87	27	91	26	82	27	82	31	---	---	85	25	79	25	86	30
J	---	---	94	29	96	32	92	26	96	26	---	---	105	26	89	27	85	27
A	---	---	90	29	98	24	90	26	90	23	---	---	96	25	85	23	85	26
S	---	---	69	23	90	21	97	27	93	26	---	---	84	25	87	24	92	22
O	---	---	64	10	80	20	68	23	72	27	---	---	78	20	85	27	72	17
N	---	---	64	9	52	9	60	16	61	15	---	---	78	1	64	26	56	6
D	59	2	52	2	50	1	50	12	72	9	---	---	48	21	50	12	---	---

Ma - maximum; Mi - minimum

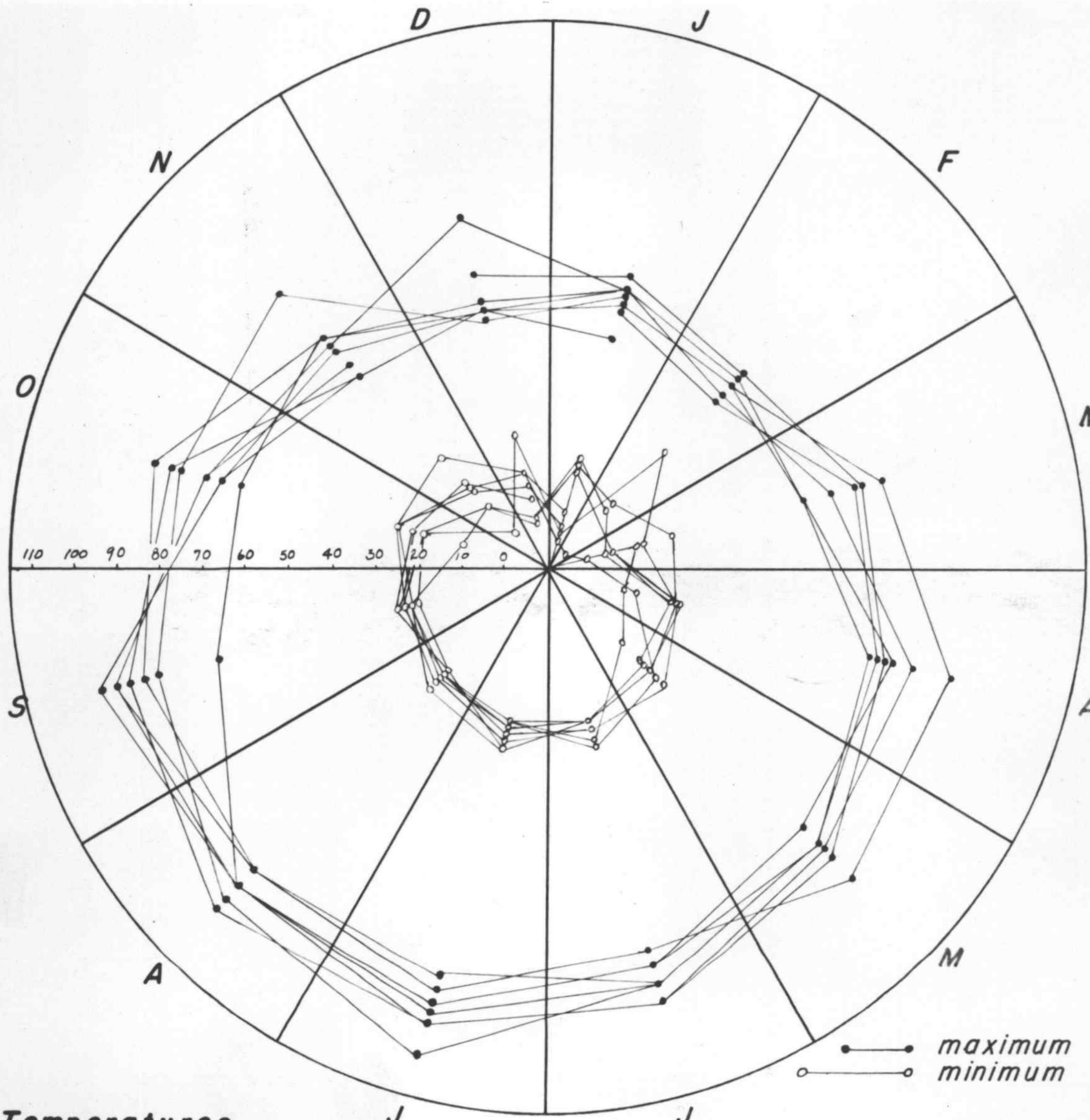
Table III

Monthly maximum and minimum humidities as percent relative humidity for Santiam Highway Junction Weather Station

Month	Year																	
	1940		1941		1942		1943		1944		1945		1946		1947		1948	
	Ma	Mi	Ma	Mi	Ma	Mi	Ma	Mi	Ma	Mi	Ma	Mi	Ma	Mi	Ma	Mi	Ma	Mi
J	---	---	100	40	100	30	100	55	100	28	94	30	---	---	92	30	72	20
F	---	---	100	40	99	28	100	50	95	30	---	---	---	---	90	30	73	10
M	---	---	86	16	100	40	100	45	94	24	---	---	---	---	90	26	73	35
A	---	---	94	16	100	28	100	28	100	32	---	---	---	---	86	18	76	18
M	---	---	99	35	100	35	100	24	96	18	---	---	96	16	81	15	72	20
J	---	---	99	28	100	29	100	26	96	26	---	---	100	14	80	17	75	20
J	---	---	100	20	100	22	100	24	96	18	---	---	90	20	79	14	80	14
A	---	---	99	25	100	26	100	22	98	20	---	---	90	16	76	14	76	12
S	---	---	99	28	100	15	100	22	98	16	---	---	94	24	78	10	79	11
O	---	---	100	22	98	20	100	32	98	24	---	---	95	28	76	14	78	16
N	---	---	100	22	100	34	99	30	98	32	---	---	90	30	78	24	72	21
D	98	28	100	36	100	45	100	45	98	24	---	---	90	40	72	20	---	---

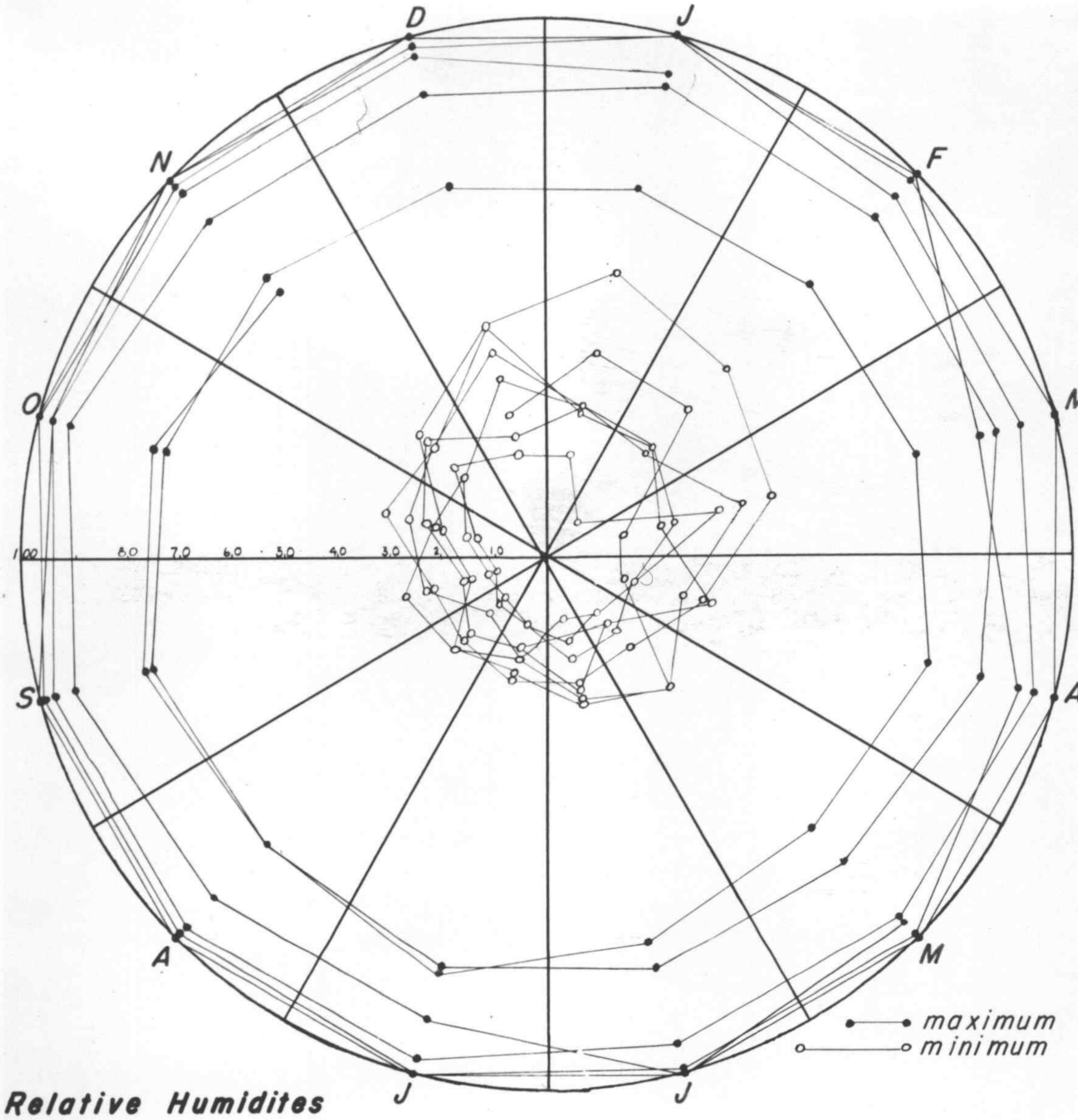
Ma - maximum; Mi - minimum

Figure 9. Graphic representation of the maximum and minimum temperature data of Table II. The months are shown around the periphery of the graph and the scale is in degrees Fahrenheit.



Temperatures

Figure 10. Graphic representation of the maximum and minimum relative humidity data of Table III. The months are shown around the periphery of the graph and the scale is in percent.



Relative Humidites

during the growing season. The most extreme of the winter lows are relatively high and average well above 0° F. Correspondingly, the monthly maximum temperatures are quite evenly high during the summer at between 80 and 100 degrees and become progressively lower to around 50° F. in February. Through all months there is a greater range between maxima and minima -- approximately 50 degrees -- than is to be expected for a maritime climatic province. Such a gap in extremes approaches those found in continental montane types.

The maximum humidities recorded in Figure 10 are high throughout the year, dropping little from 100 percent. They clearly show that precipitation effectivity is high for some part of each month. The low minimum percents for the summer months are high as in typical maritime summers. However, the high minimum humidities of the winter months indicate, as is to be expected, a low evaporation potential.

Perhaps the key factor of this region's climate is the cumulative snowfall (24). As a regulatory body influencing humidity and temperature, and controlling the length of the growing season, it distinguishes the mountain maritime type. From October through April it constantly accumulates and reaches depths as high as 84 inches in February at Santiam Junction (Table IV). During the last part of April and the first of May, it gradually disappears. There is a great variation in depths, however, since there was no snow recorded for April 1, 1941.

Table IV

Accumulative snow cover data for the Santiam Junction snow course, Sec. 14 T. 13S, R. 7E, Elevation 3990 feet, from 1941 to 1945. Readings were taken of depths on the first of each month.

Year	January			February			March			April		
	In	WI	Den	In	WI	Den	In	WI	Den	In	WI	Den
1941	7.4	2.2	30	18.4	6.2	34	11.6	4.6	40	0.0	0.0	—
1942	——	——	--	22.4	8.8	39	40.8	14.6	36	35.1	14.7	42
1943	54.4	18.8	35	84.0	29.1	35	76.3	32.4	42	70.8	33.2	47
1944	11.6	2.8	24	12.8	3.8	30	25.0	6.8	27	22.1	8.3	38
1945	12.8	2.0	16	11.7	3.9	33	23.0	7.0	30	40.4	14.8	37
1946	Incomplete records											
Ave.	21.6	6.4	26	29.9	10.4	34	35.3	13.1	35	33.7	14.2	41

In - depth in inches; Wi - equivalent inches of water; Den - snow density

The heavy snow pack, which is around 30 inches in depth during the winter, not only stabilizes extremes of temperature and humidity, but also, it acts as an insulator, keeping soil temperatures constant and well above 0° F. During the early part of the growing season in the last week of May and into June, the snow mantle provides a constant supply of water for use and ground storage. Phenologic records show that the major portion of the vegetation completes its life cycles rapidly in correspondence with the duration of surface melt water and the limited ground storage through June.

V. COMMUNITY FLORISTICS

A. THE ASSOCIATIONS AND THEIR DISTRIBUTION.

A variability of intrinsic floristics, of species complements, and of social affinities seemed to wrrant a separation of the vegetation of Nash Crater lava flows into six associations. Their distributional pattern forms both a regulated and disconnected mosaic (Figure 11). Sharp ecotones focus the inherent individuality of each of its components.

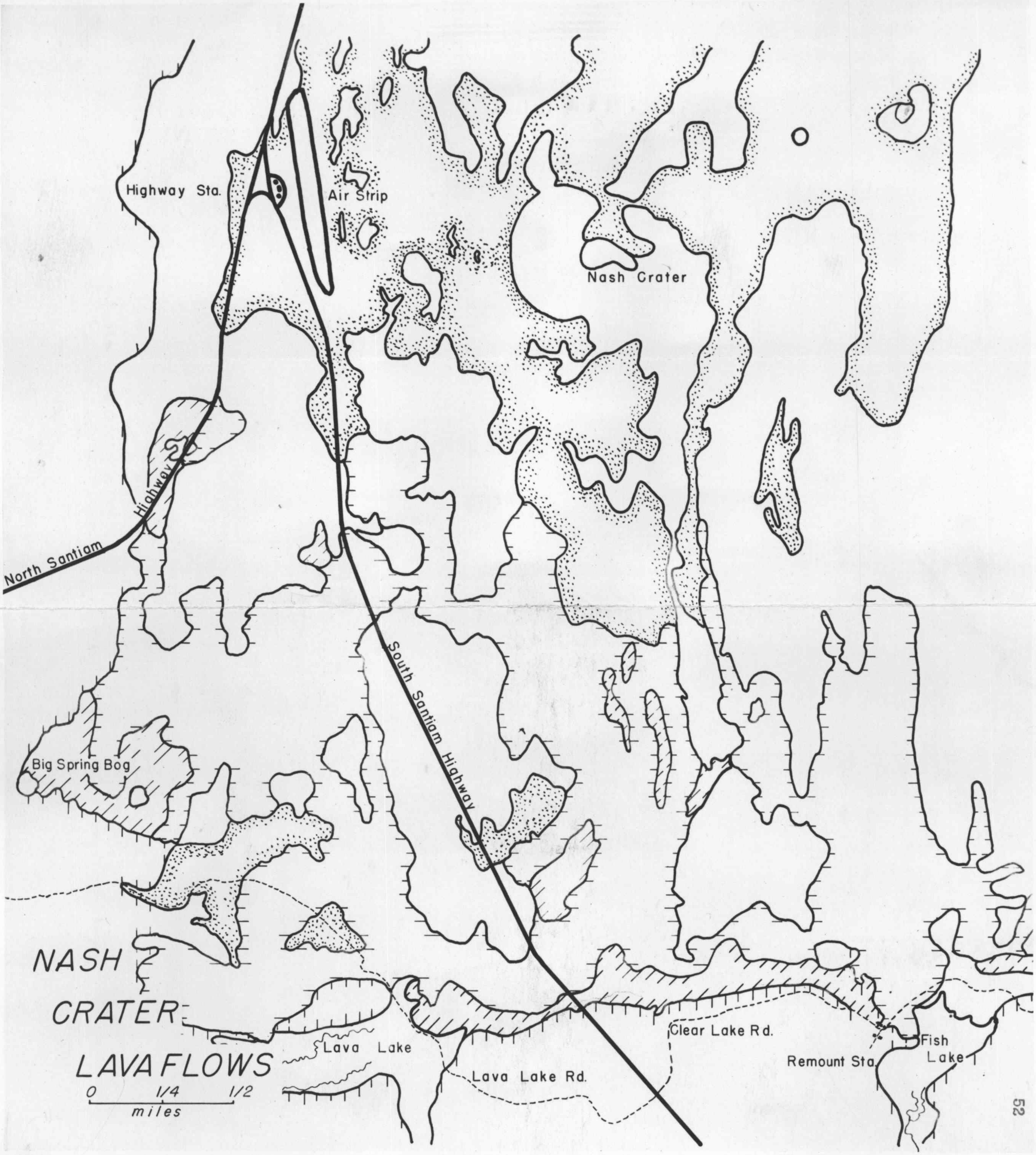
Around the periphery of the flows, the *Pseudotsugetum taxifoliae tsugosum* produces a dense forest on the glacial tills. It is the upper montane regional climax dominated by Douglas fir, western hemlock (*Tsuga heterophylla*), and lovely fir (*Abies amabilis*).

On the flows, the *Aceretum circinati lavosum* is confined to the bare expanses of block basalt. It is pervaded by vine maple (*Acer circinatum*), and is most extensively developed around Big Spring Bog and along the western edge of the lavas.

Surrounding the flows where lava adjoins glacial till, an ecotone community of separate character is fabricated in a narrow belt. This is the *Aceretum circinati xerophyllosum*, dominated in portions by vine maple, and in others by *Xerophyllum tenax*.

Three forest associations each cover approximately 1/3 of the area. Restricted to the lower elevations, the *Pseudotsugeto-abietum lasiocarpi*, actuated by scattered

Figure 11. A map of the distribution of the associations of the Nash Crater Lava Flows. The different borders represent the following associations: dotted - Pinetum contorti lapillosum; clear - Pseudotsugeto-abietum grandis; horizontal lines - Pseudotsugeto-abietum lasiocarpi; oblique lines - Aceretum circinati lavosum; vertical lines - Pseudotsugetum taxifoliae tsugosum.


Highway Sta.
Air Strip
Nash Crater
Highway
North Santiam
South Santiam Highway
Big Spring Bog
NASH
CRATER
LAVA FLOWS
0 1/4 1/2
miles
Lava Lake
Lava Lake Rd.
Clear Lake Rd.
Remount Sta.
Fish
Lake

Douglas fir and subalpine fir (Abies lasiocarpa), prevails on much the same substrate as the Aceretum circinati lavosum -- though there are smaller-sized scoria mixed in the broken crust. The second forest association, the Pseudotsugeto-abietum grandis, occurs throughout the flows on the most mesic substrates. These are the greyer, rounded block basalts in which there is mixed a high proportion of volcanic sand and ash, and the scoria cones -- mesic because of their orographic and slope drainage features. The association is ascended by Douglas fir and grand fir (Abies grandis).

The third forest association, the Pinetum contorti lapillosum, is confined to the deep ash and lapilli flats which lie to the lee of Nash and Little Nash Craters. Scattered stands subsist west of the craters, north of Lava Lake, and along the highway. Also, the association reaches to the lip of the crater of Nash Crater up the lee side where the substrate is one of lapilli rather than scoria. The arborescent synusia of this association contains but one species, lodgepole pine (Pinus contorta var. murrayana).

The sixth association is very small. At the northernmost edge of the area, Little Nash Crater's basalts dammed up an intermittent drainage line. As a result, a sedge-peat bog formed. Its characteristic vegetation, dominated equally by Vaccinium occidentale and Carex sitchensis, is designated as the Carexeto-vaccinetum occidentalis.

B. THE *Aceretum circinati lavosum* ASSOCIATION.

1. The Frutescent Synusia: Acer circinatum Union.

The structure of this union and the placement of its components is clearly portrayed in the phytosociologic data of Table V. Vine maple, by virtue of its high percent of frequence (84), abundance (198), density (4.0), and square meters of cover (25.8), is perceptibly the controlling dominant of this union. In addition, its percentage figures of total abundance and total cover are 67 and 77 respectively -- these data are not absolute and are indicative of interspecific relation. Its closest competitor, cascara (*Rhamnus purshiana*), has equivalent percentages of only 9 and 6. The other subdominants of importance, *Holodiscus glabrescens*, manzanita (*Arctostaphylos columbiana*), and thimbleberry (*Rubus parviflorus*), though they have low quantitative values, are constants of the community as attested by their presence in the three stations.

The fragmentary species, such as *Spiraea douglasii* var. *menziesii*, *Amelanchier florida*, and *Sambucus racemosa* var. *callicarpa*, co-exist in the lavas along the shore of Lava Lake.

The scattered aspect of the union denotes the harsh conditions under which these shrubs survive. The quantitative growth form of vine maple is low in comparison to specimens encountered in other associations. Figure 12 illustrates the sharp transition of the union with the climax forest, and the

Table V

Phytosociologic data of the *Acer circinatum* union of the *Aceretum circinati lavosum* association. This is the frutescent synusia.

Species	Quantitative: Abund. No.	Quantitative: Abund. % T.Ab.	Quantitative: Dens.	Quantitative: % F.	Quantitative: Cover Sq. M.	Quantitative: Cover % T.C.	Synthetic: Presence A	Synthetic: Presence B	Synthetic: Presence C
Acer circinatum Pursh	198	67	4.0	84	25.8	77	x	x	x
Rhamnus purshiana DC.	27	9	0.5	50	2.2	6	x	x	x
Holodiscus glabrescens (Greene) Hel.	16	5	0.3	34	4.3	13	x	x	x
Arctostaphylos columbiana Piper	12	4	0.1	22	1.0	3	x	x	x
Rubus parviflorus Nutt.	40	13	0.8	26	---	--	-	x	x
Arctostaphylos nevadensis Gray	2	--	---	4	---	--	-	x	-
Spiraea douglasii Hook. var. *menziesii* (Hook.) Presl.	1	--	---	2	---	--	-	-	x
Amelanchier florida Lindl.	1	--	---	2	---	--	-	-	x
Sambucus racemosa L. var. *callicarpa* (Greene) Jep.	--	--	---	--	---	--	-	-	x

Abund. - abundance; Dens. - density; % F. - percent frequency; No. - relative abundance; % T.Ab. - percent of total abundance; Sq. M. - square meters of area covered; % T.C. - percent of covered area; A - near Big Spring Bog; B - west end of the flows near the highway; C - at Fish Lake.

Figure 12. The sharp transition between the Aceretum circinati lavosum and the Pseudotsugetum taxifoliae tsugosum associations. Note the scattered development of the frutescent union over the block lavas.

inability of arborescent species to ecize on the block lava.

2. The Herbaceous Synusia: Cryptogrammo-penstemon Union.

The low number of constants of this union depicts its poor development (Table VI). The low abundance, density, and frequence of Cryptogramma acrostichoides -- a small fern -- though having the highest combination of quantitative values, can scarcely be called a dominant. It is evenly scattered throughout the lavas, but is of low occurance. Penstemon menzesii var. davidsonii and Juncus parryii construct clumped mats over pockets of wind-blown ash and organic debris accumulation. The grasses usually grow singly, barely able to exist, while Dicentra formosa and Trillium ovatum are confined to single stations growing in lava crevices near the ecotone. The majority of the species listed are encountered in debris deposited in the lava by high water at Lava Lake.

3. The Bryophytic Synusia: Rhacomitrium patens Union.

One is immediately impressed with the development of the moss mat out over the block lavas in this association. Here the bryophytes reach their maximum development in the area. However, Table VI shows that this florescence is accountable to one species, Rhacomitium patens. This lithophilous moss rapidly completes its life cycle as the last of the snow melts off in the spring, and soon curls up and becomes dry as the black basalts warm up.

Table VI

Phytosociologic data of the Cryptogrammo-penstemon and Rhacomitrium patens unions of the Aceretum circinati lavosum association. These are the herbaceous and bryophytic synusiae.

Species	Quantitative						Synthetic		
	Abund.		Dens.	% F.	Cover		Presence		
Herbs	No.	% T.Ab.			Sq. M.	% T.C.	A	B	C
Cryptogramma acrostichoides R. Br.	13	12	0.3	24	---	--	x	x	x
Penstemon menzesii Hook. var. davidsonii (Greene) Piper	8	7	0.2	18	---	--	x	x	x
Sedum oregonense (Wats.) Peck	11	10	0.2	16	---	--	x	x	x
Carex sp.	11	10	0.2	16	---	--	x	x	x
Juncus paryii Engelm.	4	4	0.1	6	---	--	x	x	x
Saxifraga integrifolia Hook.	3	3	0.0	4	---	--	x	x	x
Asarum caudatum Lindl.	6	6	0.1	12	---	--	x	-	x
Festuca occidentalis Hook.	2	2	0.0	2	---	--	-	x	x
Trillium ovatum Pursh	1	1	0.0	2	---	--	-	x	x
Sitanion hystrix (Nutt.) Smith	1	1	0.0	2	---	--	-	x	x
Stipa thurberiana Piper	--	--	---	--	---	--	-	x	x
Senecio triangularis Hook.	9	8	0.2	8	---	--	-	-	x
Mertensia paniculata (Ait.) G. Don var. borealis (Macbr.) Wms.	11	10	0.2	4	---	--	-	-	x
Dicentra formosa (Amdr.) DC.	5	5	0.1	8	---	--	x	-	-
Smilacina sessilifolia (Baker) Nutt.	7	6	0.1	8	---	--	-	-	x
Stachys ciliata Dougl.	6	6	0.1	4	---	--	-	-	x
Arenaria macrophylla Hook.	5	5	0.1	8	---	--	-	-	x
Polemonium carneum Gray	2	2	0.0	2	---	--	-	-	x
Thalictrum occidentale Gray	1	1	0.0	2	---	--	-	-	x
Hypericum scouleri Hook.	--	--	---	--	---	--	-	-	x
Arabis holboellii Hornemn. var. secunda (How.) Jepson	--	--	---	--	---	--	-	-	x
Smilacina racemosa (L.) Desf.	--	--	---	--	---	--	-	-	x
Radicula curvisiliqua (Hook.) Greene	--	--	---	--	---	--	-	-	x
Rudbeckia occidentalis Nutt.	--	--	---	--	---	--	-	-	x
Lilium columbianum Hans.	--	--	---	--	---	--	-	-	x
Apocynum androsaemifolium L. var. incanum A. DC.	--	--	---	--	---	--	-	-	x
Scrophularia lanceolata Pursh	1	1	0.0	2	---	--	-	-	x
Mosses									
Rhacomitrium patens (Dicks.) Heub.	--	--	---	68	3.3	66	x	x	x
Rhacomitrium lanuginosum (Hedw.) Brid.	--	--	---	12	1.5	30	x	x	x
Dicranum scoparium (L.) Hedw.	--	--	---	24	0.1	2	x	x	x
Hypnum fertile Sendt.	--	--	---	4	0.1	2	-	-	x

Abund. - abundance; Dens. - density; % F. - percent frequency; No. - relative abundance; % T. Ab. - percent of total abundance; Sq. M. - square meters of area covered; % T. C. - percent of covered area; A - near Big Spring Bog; B - west end of the flows near the highway; C - at Fish Lake.

The three other mosses are scarce, but Rhacomitrium patens has a frequency of 68 percent and out of the 50 1/4 meter quadrats attains a coverage of 3.3 square meters which represents 66 percent of the coverage of all species. Also present in this union are a number of lichens[1], all but two of which belong to the genus Cladonia. Their communal values are negligible and were not included in the sociologic analysis of the union.

4. Interrelations of the Community.

Aspection of the frutescent stratum is divided into two phases. The dominant, vine maple, and manzanita, are vernal species (Table VIA); whereas, Holodiscus glabrescens and thimbleberry are distinctly estival. Most of the forbes and grasses on the lavas proper are prevernal and vernal. Penstemon menzesii var. davidsonii and Juncus parryii are quite early and Saxifraga integrifolia completes its life cycle in less time than does any flowering plant. One other of the more important herbs, Sedum oregonense, predominates the summer aspects.

Perceivably this preponderance of vernal flowering and rapid completion of life cycles can be ascribed to the extreme water economies imposed by the lack of a soil. Surely the survival ability of the major herbs of this association is dependent upon a very plastic adaptation to xeric conditions.

[1] The lichen collection was kindly looked over by Professor F. Sipe of the Department of Biology of the University of Oregon. And since the nomenclature of this generic group is so difficult, he advised their identification only to genus.

Table VIA

Phenology of the shrubs and herbs of the *Aceretum circinati lavosum* association for the growing season of from the middle of May to the last of September, 1949.

Species	May	June	Months July	Aug.	Sept.
Shrubs					
Acer circinatum	- - - x	x ⊗ ⊗ ⊗	0 0 0 0	0 0 0 0	0 - -
Rhamnus purshiana	- - - -	- ⊥ x ⊗	⊗ ⊗ 0 0	0 0 0 0	? ? ?
Holodiscus glabrescens	- - - -	- - - -	- ⊥ x x	0 0 0 0	- - -
Arctostaphylos columbiana	- - - -	x ⊗ ⊗ ⊗	0 0 0 0	0 0 0 0	0 0 0
Rubus parviflorus	- - - -	- - - x	x ⊗ ⊗ 0	0 0 0 -	- - -
Arctostaphylos nevadensis	- - - x	x x ⊗ ⊗	⊗ 0 0 0	0 0 0 0	0 0 0
Spiraea douglasii var. *menziesii*	- - - -	- - - -	⊥ ⊥ ⊥ x	x x ⊗ ⊗	0 0 0
Amelanchier florida	- - - x	x x x x	x ⊗ ⊗ 0	0 0 0 0	0 0 -
Sambucus racemosa var. *callicarpa*	- - - x	x x ⊗ ⊗	0 0 0 0	0 0 0 0	0 0 0
Herbs					
Penstemon menzesii var. *davidsonii*	- - - x	x x ⊗ ⊗	⊗ 0 0 0	0 0 0 0	0 0 0
Sedum oregonense	- - - -	- - ⊥ x	x x x x	⊗ ⊗ 0 0	- - -
Carex sp.	- - - x	x x 0 0	0 - - -	- - - -	- - -
Juncus parvii	- - - x	x x 0 0	0 - - -	- - - -	- - -
Saxifraga integrifolia	- - - x	x ⊗ 0 0	0 - - -	- - - -	- - -
Asarum caudatum	- - - x	x x x 0	0 0 0 0	0 - - -	- - -
Festuca occidentalis	- - - -	- x x 0	0 0 0 0	- - - -	- - -
Trillium ovatum	- - - -	x x ⊗ ⊗	⊗ 0 0 0	0 - - -	- - -

Table VIA continued

Sitanion hystrix	-	-	-	-	-	x	x	0	0	0	-	-	-	-	-	-	-	-	-
Stipa thurberiana	-	-	-	-	-	x	x	0	0	0	0	0	0	0	-	-	-	-	-
Senecio triangularis	-	-	-	-	-	-	-	-	-	-	-	x	x	x	⊗	⊗	⊗	0	0
Mertensia paniculata var. *borealis*	-	-	-	-	-	-	-	-	-	-	x	x	⊗	⊗	⊗	0	0	0	0
Dicentra formosa	-	-	-	-	-	-	-	x	x	⊗	⊗	0	0	-	-	-	-	-	-
Smilacina sessilifolia	-	-	-	-	-	-	x	x	⊗	⊗	⊗	0	0	0	-	-	-	-	-
Stachys ciliata	-	-	-	-	-	-	-	-	-	-	x	x	⊗	⊗	⊗	0	0	0	-
Arenaria macrophylla	-	-	-	-	-	x	x	⊗	⊗	⊗	0	0	0	0	-	-	-	-	-
Polemonium carneum	-	-	-	-	-	-	-	-	-	-	⊥	x	x	x	⊗	⊗	⊗	⊗	0
Thalictrum occidentalis	-	-	-	-	-	-	-	x	x	⊗	0	0	0	0	-	-	-	-	-
Hypericum scouleri	-	-	-	-	-	-	-	-	-	-	-	-	x	x	x	⊗	⊗	⊗	0
Arabis holboellii var. *secunda*	-	-	-	-	x	⊗	⊗	⊗	⊗	⊗	⊗	0	0	0	-	-	-	-	-
Smilacina racemosa	-	-	-	-	x	x	x	⊗	⊗	0	0	0	0	-	-	-	-	-	-
Radicula curvisiliqua	-	-	-	-	-	-	-	-	-	x	⊗	⊗	⊗	⊗	⊗	⊗	⊗	0	0
Rudbeckia occidentalis	-	-	-	-	-	-	-	-	-	-	x	x	x	⊗	⊗	⊗	⊗	⊗	0
Lilium columbianum	-	-	-	-	-	-	-	-	-	-	-	x	⊗	0	0	0	-	-	-
Apocynum androsaemifolium var. *incanum*	-	-	-	-	-	-	-	-	-	-	⊥	x	⊗	⊗	0	0	0	?	?
Scrophularia lanceolata	-	-	-	-	-	-	-	-	x	⊗	⊗	⊗	⊗	⊗	0	0	0	-	-

- - floral inactivity; ⊥ - in bud; x - flowering; ⊗ - flowering and fruiting; 0 - fruiting; ? - unknown.

The dynamics of this association are but slightly pronounced, as one would expect in such a severe prilithosere. Reactions and successions are by necessity processes involving long periods of time.

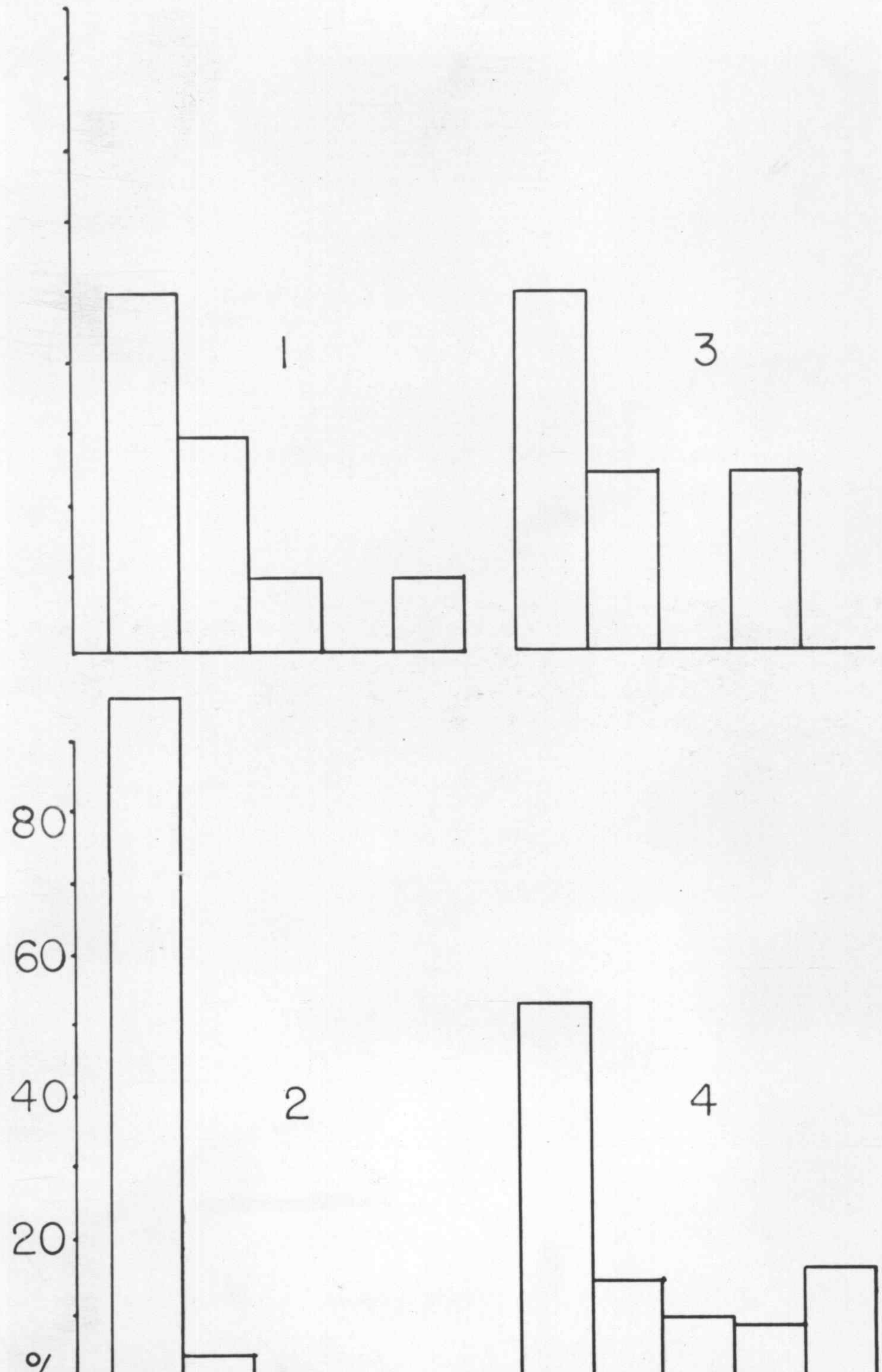
There seems to be little evidence that a classical series of xerarch stages have and are occurring. The organic erosion of the basalt by crustose lichens followed by foliose lichens and mosses is not apparent, nor do the herbs seem to depend upon these initial reactions for their establishment.

The herbs are usually found in depressions on the blocks which have become filled in with wind-blown organic and inorganic material. Likewise, the shrubs are confined to crevices which have accumulated a small measure of soil in the same way. The greater fabrication of both the shrub and herbaceous layers nearer the arborescent ecotones is probably accountable to a greater filling in by organic matter from the forests.

Several occurrences of tree seedlings were found in the herbaceous mats, but since these dry out early in the growing season, the seedlings are unable to survive.

The frequency plots of the separate unions, when compared to Raunkiaer's normal, attests the youthfulness of the association and its lack of consolidation (Figure 13). In particular, the paucity of the herbaceous layer is shown by the high percent of species in class A with none in the higher classes. This is indicative of the primary stages of secondary subseral succession and fluctuation. However, in this case, the severity of

Figure 13. Frequency graphs of the unions of the Aceretum circinati lavosum. 1 - frutescent synusia; 2 - herbaceous synusia; 3 - bryophytic synusia; 4 - Raunkaier's normal. The capital letters represent the percentage of species (y-axis) that had the following frequencies: A - 0 to 20%; B - 21 to 40%; C - 41 to 60%; D - 61 to 80%; E - 81 to 100%.


1
3
80
60
40
20
%
2
4
A B C D E
A B C D E

environment has produced a stability, and it is within the amplitude of only a few plants to inhabit the basalts.

A lack of stratification and consolidation is shown in Figure 12. There is, then, little or no interaction or specific dependence. The social or household economics are loosely knit, and the species as pioneers are dependent upon their own survival amplitudes as individuals to occupy the area. Such organization is an extreme of non-co-ordination when compared to that of a climax forest.

C. THE _Pseudotsugeto-abietum_ _lasiocarpi_ ASSOCIATION.

1. The Arborescent Synusia: Pseudotsugeo-abies Union.

The constants of this union, found at all three stations, are but two species, Douglas fir and subalpine fir (Table VII). The union is poor in species which is not surprising considering that the conditions for growth and establishment are not much different from those of the _Aceretum_ _circinati_ _lavosum_.

Both Douglas fir and subalpine fir control this stratum and the association. Their low densities and abundances, and high frequencies, depict an open forest in the first stages of consolidation (Figure 14). Douglas fir has a high absolute basal area which for 53 trees totals 32,006 square inches, and is 96 percent of the basal areas of all species. On the other hand, subalpine fir has a basal area of 1,234 square inches, which is but 4 percent of the total. And since the former

Table VII

Phytosociologic data of the Pseudotsugo-abies and Acer circinatum unions of the Pseudotsugeto-abietum lasiocarpi association. These are the arborescent and frutescent synusiae.

Species	Quantitative				Space*		Synthetic Presence		
	Abund. No.	Abund. % T.AB.	Dens.	% F.	Area	% T.C.	A	B	C
Trees									
Pseudotsuga taxifolia (Lambert.) Britt.	53	44	1.0	88	32,006	96	x	x	x
Abies lasiocarpa (Hook.) Nutt.	64	54	1.3	76	1,234	4	x	x	x
Tsuga heterophylla (Raf.) Sarg.	1	1	0.0	2	50	0	-	x	-
Pinus contorta Dougl. var. murrayana (Balf.) Engelm.	1	1	0.0	2	3	0	-	-	x
Tsuga mertensiana (Bong.) Sarg.	--	--	---	--	------	--	-	x	-
Abies grandis Lindl.	--	--	---	--	------	--	-	-	x
Shrubs									
Acer circinatum Pursh	83	17	1.7	78	17.7	56	x	x	x
Arctostaphylos nevadensis Gray	222	45	4.4	36	3.5	11	x	x	x
Castanopsis chrysophylla A. DC.	34	7	0.7	34	4.8	15	x	x	x
Pachistima myrsinites (Pursh) Raf.	61	12	1.3	12	1.5	5	x	x	x
Rhamnus purshiana DC.	25	5	0.5	32	1.1	3	x	x	x
Holodiscus glabrescens (Greene) Hel.	27	5	0.5	18	1.1	3	x	x	x
Arctostaphylos columbiana Piper	10	2	0.2	14	1.1	3	x	x	x
Rubus parviflorus Nutt.	20	4	0.4	10	0.2	1	-	x	-
Amelanchier florida Lindl.	12	2	0.2	8	0.4	1	-	-	x

Abund. - abundance; Dens. - density; % F. - percent frequency; No. - relative abundance; % T.Ab - percent of total abundance; % T.C. - percent of covered area or of total basal area; A - Lava Lake; B - highway at the west end of the flows; C - south of Nash Crater.

*Space is cover for the shrub stratum and basal area for the tree stratum; Area is in square meters for the shrub layer and in square inches for the tree layer.

Figure 14. The structural relationships of the species of the *Pseudotsugeto-abietum lasiocarpi*. Old, large Douglas fir and smaller subalpine fir make up the arborescent layer. Scattered vine maple and associated species compose the understory. Note the absence or poor development of the herbaceous union.

occupies so much more space than the latter, it would normally be considered the dominant. However, subalpine fir never attains large size, and in this open union, its other quantitative values are both equal to those of Douglas fir and sufficient to extenuate it as a co-dominant. The distribution of abundance in the different size-classes bears out the structural size differences (Table VIIA). The combined quantitative data for all species is shown in the phytographs of Figure 15.

Lodgepole pine appears in the union at the eastern ecotone of the lodgepole forest with this association. Grand fir and mountain hemlock (_Tsuga mertensiana_) were found outside of the quadrats as small seedlings on duff accumulations in patches of subalpine fir.

2. The Frutescent Synusia: Acer circinatum Union.

The ascendancy of vine maple of this stratum is continued over from the adjacent barer basalts (Table VII). It has an even distribution (78 percent frequency) coupled with sufficient consolidation (83 abundance and 1.7 density) and degree of cover (17.7 square meters). These qualifications of dominance are much higher than those of any other species in the union.

A comparison with the frutescent layer of the _Aceretum circinati lavosum_ evinces a high degree of affinity. The species list is almost identical, except that _Castanopsis chrysophylla_ and _Pachistima myrsinites_ from their centers of development in the adjacent Douglas fir-grand fir association, are able to

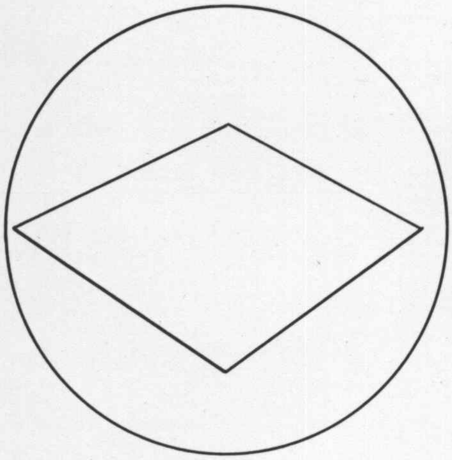
Table VIIA

Size class distribution of the abundance of the aboreal species of the *Pseudotsugeto-abietum lasiocarpi* association.

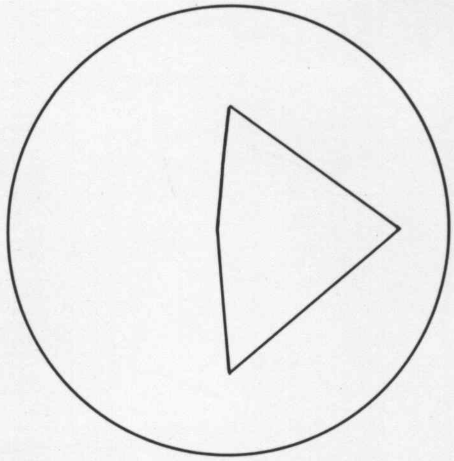
Species	Size classes R	1	2	3	4	5	T
Pseudotsuga taxifolia	8	0	0	5	19	21	53
Abies lasiocarpa	21	8	23	12	0	0	64
Tsuga heterophylla	0	0	0	1	0	0	1
Pinus contorta var. *murrayana*	0	1	0	0	0	0	1
Tsuga mertensiana	---	---	---	---	---	---	---
Abies grandis	---	---	---	---	---	---	---

R - reproduction; 1 - 1 1/2" to 2 1/2"; 2 - 3" to 6"; 3 - 6 1/2" to 12"; 4 - 12 1/2" to 24"; 5 - 24 1/2" and over; T - total.

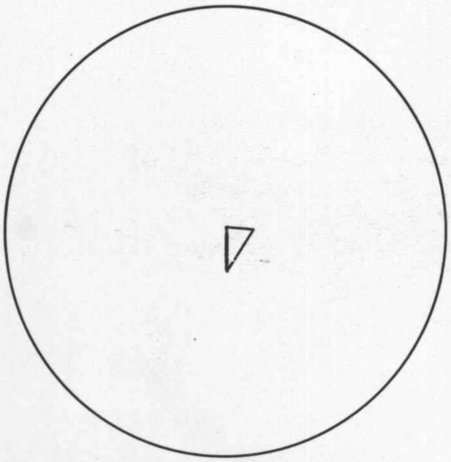
Figure 15. Phytographs of the arborescent species of the Pseudotsugeto-abietum lasiocarpi association. The top radius of the circle represents percent of total abundance; the righthand radius represents percent frequency; the lower radius represents number of size classes occupied; the lefthand radius represents the percent of the total basal area.



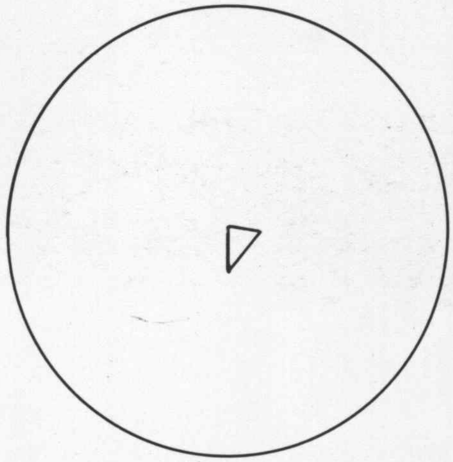
Pseudotsuga taxifolia



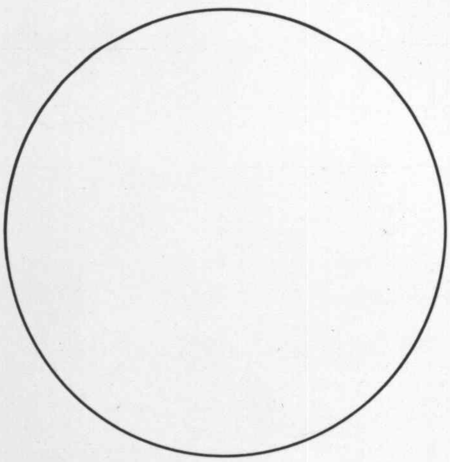
Abies lasiocarpa



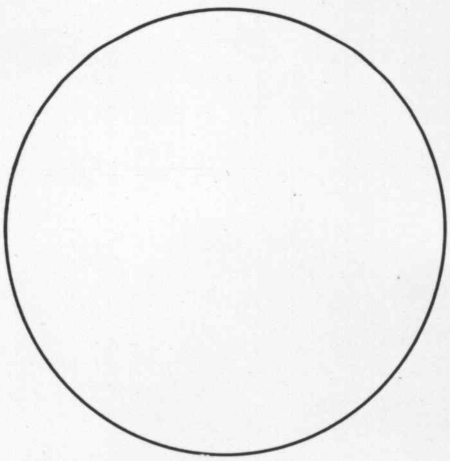
Pinus contorta v. murrayana



Tsuga heterophylla



Abies grandis



Tsuga mertensiana

come in slightly because of the forest influence. Also, the quantitative values of all species have dropped, perhaps because of the prevalence of the arborescent layer. In addition, an examination of the combined data of Table VII reveals this stratum to be scattered and unconsolidated. This is true for all of the frutescent unions of all of the associations under consideration. Structure and control is quite different from climax chaparral or subseral frutescent development.

3. The Herbaceous Synusia: The Sedum orgonense Union.

As in the preceding shrub layer, the forest influence has cut the quantitative values of the species — which are essentially the same as for the Aceretum circinati lavosum. Apparently then, the arborescent layer has not conditioned the environment sufficiently to permit a more mesic complement to come in. Yet it has accomplished enough consolidation to affect these species primarily adapted to the open lavas.

Sedum oregonense, though the highest sociologically of the species, hardly has values high enough to suffice as a dominant (Table VIII). Many species have dropped out, many of the remaining have high presence. Thus the layer is scattered, but constant, and poorly developed. One species, Chimaphila umbellata var. occidentalis, has moved in slightly and with high presence from the Pseudotsugeto-abietum grandis association.

Table VIII

Phytosociologic data of the Sedum oregonense and Rhacomitrium patens unions of the Pseudotsugeto-abietum lasiocarpi association. These are the herbaceous and bryophytic synusiae.

Species	Quantitative						Synthetic		
	Abund.		Dens.	% F.	Cover		Presence		
	No.	% T.Ab.			Sq. M.	% T.C.	A	B	C
Herbs									
Sedum oregonense (Wats.) Peck	42	30	0.8	44	---	--	x	x	x
Penstemon menzeisii Hook. var. davidsonii (Greene) Piper	34	23	0.7	34	---	--	x	x	x
Chimaphila umbellata (L.) Nutt. var. occidentalis (Rydb.) Blake	32	22	0.7	24	---	--	x	x	x
Carex sp.	8	6	0.2	4	---	--	x	x	x
Cryptogramma acrostichoides R. Br.	5	4	0.1	6	---	--	x	x	x
Stipa thurberiana Piper	4	3	0.1	6	---	--	-	x	x
Festuca occidentalis Hook.	10	7	0.2	10	---	--	-	x	-
Trillium ovatum Pursh	6	4	0.1	12	---	--	x	-	-
Sitanion hystrix (Nutt.) Smith	--	--	---	--	---	--	-	x	-
Mosses									
Rhacomitrium patens (Dicks.) Hueb.	--	--	---	86	3.1	76	x	x	x
Rhacomitrium lanuginosum (Hedw.) Brid.	--	--	---	22	0.8	21	x	x	x
Dicranum scoparium (L.) Hedw.	--	--	---	12	0.1	2	x	x	x

Abund. - abundance; Dens. - density; % F. - percent frequency; No. - relative abundance; % T. Ab. - percent of total abundance; Sq.M. - square meters of area covered; % T.C. - percent of covered area; A - Lava Lake; B - highway at the west end of the flows; C - south of Nash Crater.

4. The Bryophytic Synusia: Rhacomitrium patens Union.

Table VIII circumstantiates but little variation in this union from that of the open lavas. As a matter of fact, the species complement is identical and the interspecific relations are the same. Rhacomitrium patens has little or no quantitative variation, nor does the slight environmental change affect either its absolute or its relative dominance over the other species.

5. Interrelations of the Community.

The charted cycles of flowering and fruiting for the angiosperms of this association are identical to those of the same species in the Aceretum circinati lavosum (Table VIA). Likewise, their social affinities are not clear cut or very binding, for as the quantitative data have shown, little or no vertical zonation is present. Yet in clumps of subalpine fir around Lava Lake Arctostaphalos nevadensis, and Trillium ovatum, and occasionly thimbleberry are confined to the duff that has accumulated. Perceivably the restricted presence of more mesic shrubs and herbs and occasional seedlings of grand fir and mountain hemlock is due to slight but ameliorating arborescent reactions.

It has already been noted that this is a transition community. The degree of subalpine fir consolidation is its main individuality, for this species occurs but very rarely in other aggregations. Also, the lower strata are transcended from the Aceretum circinati lavosum. In this respect, the association is the Aceretum circinati lavosum with an arborescent stratum. Its only dynamics, for its scattered composition is very stable, is the slight infiltration of mesic herbs and shrubs. No syngenetic changes can be suggested in the irregular frequency plots (Figure 16). The class D and E percents of the arborescent graph denote a stable community; whereas, the B and C class gaps are indicative of a poor species complement. The graphs of the next two strata are superficially similar to floras undergoing rapid exchange, extinction, and establishment of stable, ultimate dominants.

D. THE Pseudotsugeto-abietum grandis ASSOCIATION.

1. The Arborescent Synusia: Pseudotsugo-abies Union.

This is the most varied and most socially advanced arborescent layer of the developmental communities. Its species complement is the richest, and its consolidation relatively high (Table IX). The pattern of species disposition is quite pronounced, and their grouping is comparable to a number of facies in an associes. Tying the union together, dominating it, is Douglas fir. It has 45 percent of the total abundance of the 12 species, a density of 7.2, a frequence of 100 percent, and a percent of total basal area of 78.

This forest is found on the grey basalts which have a high amount of finer ejecta mixed in. In stands where duff accumulation is high, together with this better substrate, semblances of profile development can be found. Along the South Santiam

Figure 16. Frequency diagrams of the synusiae of the Pseudo-tsugeto-abietum lasiocarpi association. 1 - arborescent synusia; 2 - frutescent synusia; 3 - herbaceous synusia; 4 - bryophytic synusia; 5 - Kenoyer's normal; 6 - Raunkaier's normal. The capital letters represent the percentage of species (y-axis) that had the following frequencies: A - 0 to 20%; B - 21 to 40%; C - 41 to 60%; D - 61 to 80%; E - 81 to 100%.

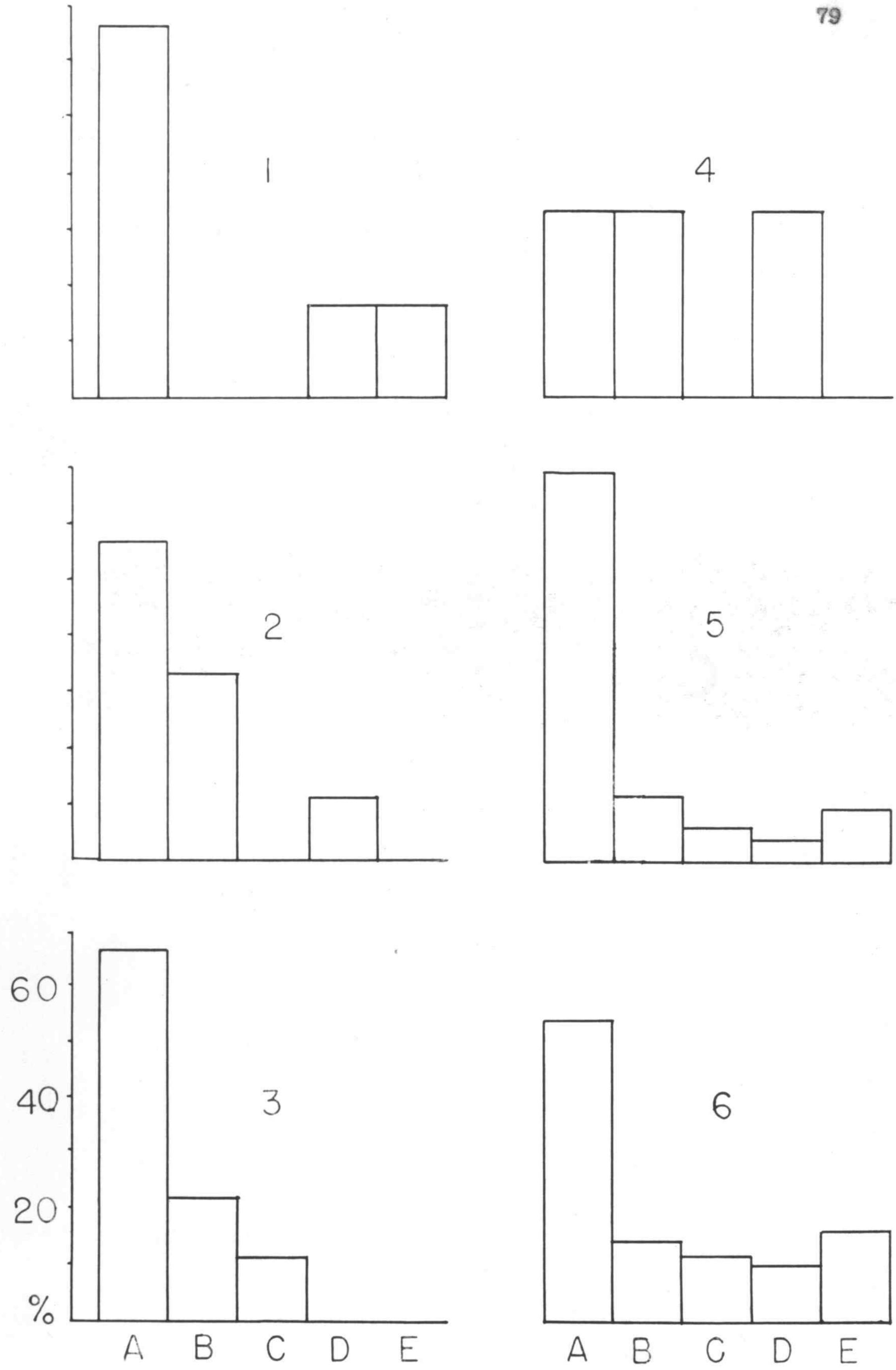

1
4
2
5
60
40
3
6
20
%
A B C D E
A B C D E

Table IX

Phytosociologic data of the Pseudotsugo-abies and Castanopsis chrysophylla unions of the Pseudotsugeto-abietum grandis association. These are the arborescent and frutescent synusiae.

Species	Quantitative						Synthetic		
	Abund.		Dens.	% F.	Space*		Presence		
	No.	% T.Ab.			Area	% T.C.	A	B	C
Trees									
Pseudotsuga taxifolia (Lambert.) Britt.	362	45	7.2	100	30,666	78	x	x	x
Abies grandis Lindl.	205	25	4.1	72	4,352	11	x	x	x
Pinus contorta Dougl. var. murrayana (Balf.) Engelm.	122	15	2.5	36	1,409	3	x	x	-
Pinus monticola Dougl.	66	8	1.3	32	1,893	5	-	x	-
Tsuga mertensiana (Bong.) Sarg.	12	1	0.2	4	317	1	-	x	-
Pinus ponderosa Dougl.	2	0	0.0	2	397	1	-	x	-
Abies amabilis (Dougl.) Forbes	8	1	0.2	8	198	0	-	x	-
Abies lasiocarpa (Hook.) Nutt.	17	2	0.3	22	39	0	-	x	-
Tsuga heterophylla (Raf.) Sarg.	5	0	0.1	8	3	0	-	x	-
Picea engelmanni (Parry) Engelm.	2	0	0.0	4	3	0	-	x	-
Abies concolor Lindl.	---	--	---	---	------	--	-	-	x
Populus trichocarpa T. & G.	---	--	---	---	------	--	-	-	x
Shrubs									
Castanopsis chrysophylla A. DC.	184	23	3.7	84	29.0	60	x	x	x
Pachistima myrsinites (Pursh) Raf.	240	31	4.8	42	5.7	12	x	x	x
Acer circinatum Pursh	68	9	1.4	10	4.3	8	-	x	x
Rubus parviflorus Nutt.	122	15	2.4	36	2.9	6	-	x	-
Ceanothus velutinus Dougl.	38	5	0.8	26	3.0	6	-	x	-
Salix sp.	17	2	0.3	26	1.1	2	-	x	-
Rhamnus purshiana DC.	21	3	0.4	24	0.8	2	x	-	-
Berberis nervosa Pursh	25	3	0.5	14	0.8	2	-	x	-
Vaccinium membranaceum Dougl.	20	2	0.4	8	0.3	0	-	x	-
Rubus vitifolius C. & S.	29	4	0.5	10	0.3	0	-	x	-
Arctostaphylos nevadensis Gray	14	2	0.3	8	0.1	0	x	-	x
Rosa gymnocarpa Nutt.	1	0	0.0	2	0.0	0	-	x	-
Holodiscus glabrescens (Greene) Hel.	1	0	0.0	2	0.0	0	x	-	-
Arctostaphylos columbiana Piper	---	--	---	--	---	--	x	-	-
Vaccinium myrtillus L. var. microphyllum Hook.	---	--	---	--	---	--	-	x	-

Abund. - abundance; Dens. - density; % F. - percent frequency; No. - relative abundance; % T. Ab. - percent of total abundance; % T.C. - percent of covered area or of total basal area; A - South Santiam Highway; B- Nash Crater; C - Fish Lake.

*Space is cover for the shrub stratum and basal area for the tree stratum; Area is in square inches for the tree layer and in square meters for the shrub layer.

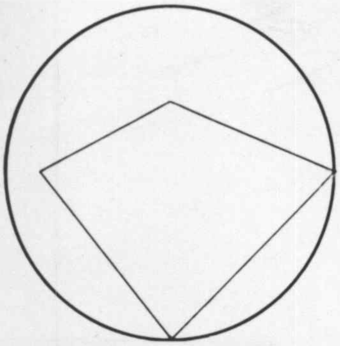
Highway and from Sawyer's Cave to the foot of Nash Crater, the union is almost pure Douglas fir (Figure 17). On the mesic higher benches north of Nash Crater and on its slopes, grand fir is vigorous and occupies as much or more of the canopy. In this portion of the association, there is a sharp transition into the lodgepole association on the ash flats which accounts for the placement of lodgepole pine in the union.

Orographic effect and drainage provide Nash's scoria slopes with the most favorable substrate conditions on the flows. Along with grand fir and Douglas fir, climax elements such as lovely fir, white pine (Pinus monticola), and western hemlock are present. At the top, the northwest-facing slope of the crater has a few individuals of subalpine distribution. These are mountain hemlock and Engelmann spruce (Picea engelmanni). On the mesic northwest-facing slope of Nash Crater the stratum is predominately grand fir; and on the xeric southeast-facing slope, it is composed of lodgepole pine, western yellow pine (Pinus ponderosa), and Douglas fir. In addition, and as is to be expected, the former slope is composed of scoria, and the latter of lapilli. These substrates, of course, augment the north-south slope effect.

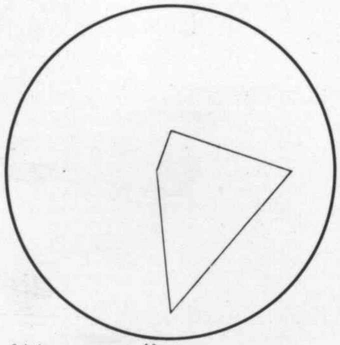
The combined stations' phytosociologic account gives grand fir sufficient values to rank it as a co-dominant with Douglas fir. The graphic presentation of these data substantiates grand fir as an aggressive species (Figure 18). Also, its distribution of abundance in the range of size classes indicates

Figure 17. Pure Douglas fir stand. Note the range of size classes of Douglas fir, the formation of duff over the lava basement. The shrubs in the foreground are chinquapin and pachistima.

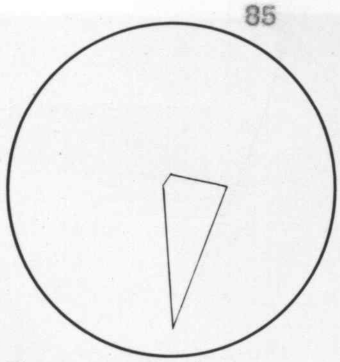
Figure 18. Phytographs of the arborescent species of the *Pseudotsugeto-abietum grandis* association. The top radius of the circle represents percent of total abundance; the righthand radius represents percent frequency; the lower radius represents number of size classes occupied; the lefthand radius represents the percent of the total basal area.



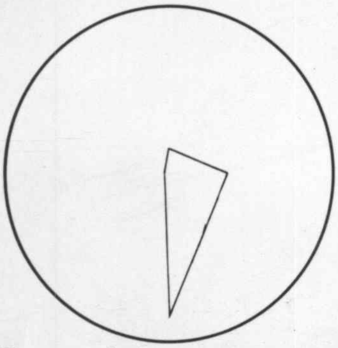
Pseudotsuga taxifolia



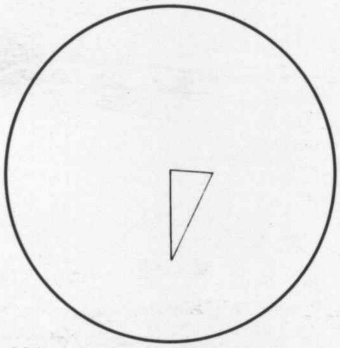
Abies grandis



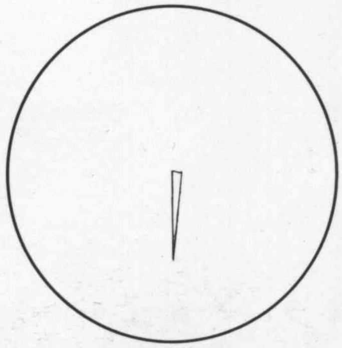
Pinus monticola



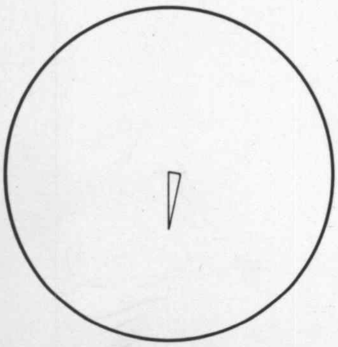
Pinus contorta v. murrayana



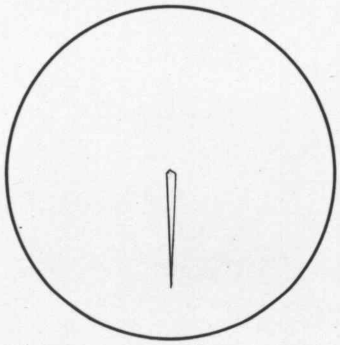
Abies lasiocarpa



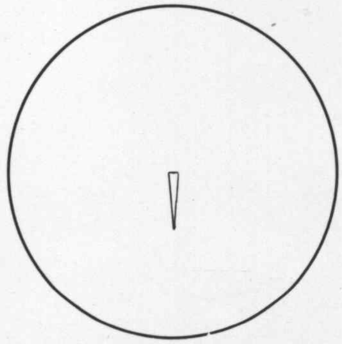
Abies amabilis



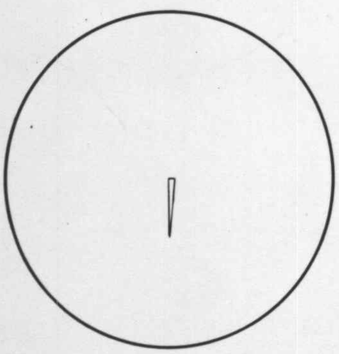
Tsuga heterophylla



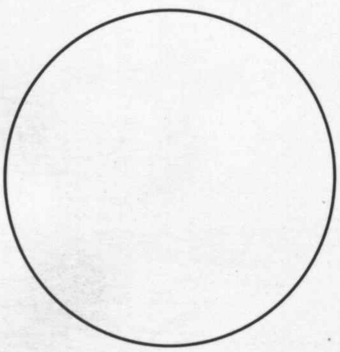
Tsuga mertensiana



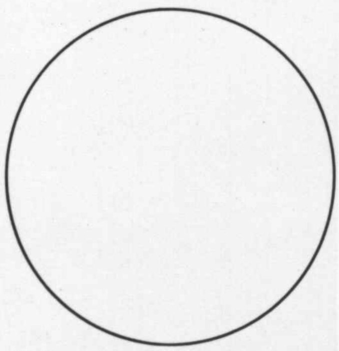
Pinus ponderosa



Picea engelmanni



Populus trichocarpa



Abies concolor

its active participation in the stratal economics (Table IXA). Of particular importance is the likewise uniform spread of Douglas fir in the size classes. This is the only association in which it achieves optimal, progressive increase.

2. The Frutescent Synusia: The Castanopsis chrysophylla Union.

A low number of constants (presence data, Table IX) denotes a diversity and heterogeneity of this stratum throughout the association as did the superior union. It is on the lowland, drier portions of the association's distribution, that the dominant, chinquapin (Castanopsis chrysophylla) has its greatest development. However, it is present throughout the extent of the union. Pachistima (Pachistima myrsinites) seems qualitatively to be a major feature of the union; but its low growth form (crown cover 5.7 meters) and its greater concentration (abundance 240) under the pure Douglas fir facies (frequence 42) relegate it to a sub-dominant role.

The sociologic values of the remaining species are negligible. However, certain affinities are apparent. Vine maple and thimbleberry are concentrated on the slopes of Nash Crater. Mesic species of the climax forest, such as Berberis nervosa, Vaccinium membranaceum, Rubus vitifolius, and Rosa gymnocarpa, also make their appearance at this station. Cinnamon bush (Ceanothus velutinus) is encountered in the ecotone where the ash flats and lavas overlap. Moreover, only a few specimens from the

Table IXA

Size class distribution of the abundance of the aboreal species of the *Pseudotsugeto-abietum grandis* association.

Species	Size classes R	1	2	3	4	5	T
Pseudotsuga taxifolia	81	54	95	54	55	13	362
Abies grandis	86	32	59	17	11	0	205
Pinus contorta var. *murrayana*	26	81	13	9	3	0	122
Pinus monticola	21	6	22	15	2	0	66
Tsuga mertensiana	8	0	1	2	1	0	12
Pinus ponderosa	0	0	0	1	1	0	2
Abies amabilis	4	0	1	3	0	0	8
Abies lasiocarpa	14	1	2	0	0	0	17
Tsuga heterophylla	4	1	0	0	0	0	5
Picea engelmanni	1	1	0	0	0	0	2
Abies concolor	---	---	---	---	---	---	---
Populus trichocarpa	---	---	---	---	---	---	---

R - reproduction; 1 - 1 1/2" to 2 - 1/2"; 2 - 3" to 6"; 3 - 6 1/2" to 12"; 4 - 12 1/2" to 24"; 5 - 24 1/2" and over; T - total.

preceding two *Acer circinatum* unions are present. Apparently *Holodiscus glabrescens*, *Rhamnus purshiana*, and *Arctostaphylos columbiana* are unable to meet the competition in a more closed community.

3. The Herbaceous Synusia: Chimaphila umbellata Union.

The four constants of this union depose the scattered production of the union by their low structural values (Table X). *Chimaphila umbellata* var. *occidentalis* has a relatively low frequency (44), but a high density (1.9). It is found principally on the lowland lavas with Douglas fir, chinquapin, and pachistima. Twinflower (*Linnaea borealis* var. *americana*) occupies the wetter and shaded sites. *Festuca occidentalis* grows in lava crevices in the shade.

The associated herbs of lesser value can be divided into much the same affinity groupings as were evident in the higher synusiae. Climax forest forbes, such as *Hieracium albiflorum*, *Anemone deltoidea*, *Achlys triphylla*, *Clintonia uniflora*, and others, are common to the moist slopes of Nash Crater. Likewise, on the open lavas and in the ecotone with the lodgepole association, components of both ash flat and block lava derivation are weakly represented.

4. The Bryophytic Synusia: Rhacomitrium patens Union.

From its high dominance in the bryophytic union of the

Table X

Phytosociologic data of the Chimaphila umbellata and Rhacomitrium patens unions of the Pseudotsugeto-abietum grandis association. These are the herbaceous and bryophytic synusiae.

Species	Quantitative: Abund. No.	Abund. % T.Ab.	Dens.	% F.	Cover Sq. M.	Cover % T.C.	Synthetic Presence A	B	C
Herbs									
Chimaphila umbellata (L.) Nutt. var. occidentalis (Rydb.) Blake	93	21	1.9	44	---	--	x	x	x
Linnaea borealis L. var. americana (Forbes) Rehder	57	13	1.1	22	---	--	x	x	x
Festuca occidentalis Hook.	6	1	0.1	8	---	--	x	x	x
Xerophyllum tenax (Pursh) Nutt.	7	2	0.1	4	---	--	x	x	x
Penstemon cardwellii How.	28	6	0.5	8	---	--	x	x	-
Carex sp.	15	4	0.3	8	---	--	x	-	x
Sedum oregonense (Wats.) Peck	3	0	0.0	2	---	--	x	x	-
Penstemon menzeisii Hook. var. davidsonii (Greene) Piper	7	1	0.1	6	---	--	x	-	x
Hieracium albiflorum Hook.	43	9	0.8	34	---	--	-	x	-
Fragaria bracteata Hel.	27	6	0.5	32	---	--	-	x	-
Anemone deltoidea Hook.	28	6	0.5	14	---	--	-	x	-
Achlys triphylla (Smith) DC.	14	3	0.3	10	---	--	-	x	-
Arenaria macrophylla Hook.	12	3	0.2	8	---	--	-	x	-
Penstemon confertus Dougl. var. procerus (Dougl.) Cov.	27	6	0.5	10	---	--	-	x	-
Clintonia uniflora (Schult.) Kunth.	26	6	0.5	14	---	--	-	x	-
Smilacina sessilifolia (Baker) Nutt.	16	4	0.3	32	---	--	-	x	-
Cornus canadensis L.	2	0	0.0	2	---	--	-	x	-
Lilium washingtonium Kell.	6	1	0.1	4	---	--	-	x	-
Carex inops Bailey	1	0	0.0	2	---	--	-	x	-
Gallium triflorum Michx.	1	0	0.0	2	---	--	-	x	-
Pteridium aquilinum (L.) Kuhn var. pubescens Underw.	5	1	0.1	6	---	--	x	-	-
Eriogonum nudum Dougl.	7	1	0.1	10	---	--	-	x	-
Trillium ovatum Pursh	5	1	0.1	6	---	--	-	x	-
Hieracium greenii Gray	2	0	0.0	2	---	--	x	-	-
Phacelia californica Cham.	2	0	0.0	2	---	--	-	x	-
Pyrola picata Smith	6	1	0.1	6	---	--	-	x	-
Listera convallarioides (SW.) Torrey	3	0	0.0	6	---	--	-	x	-
Pyrola secunda L.	3	0	0.0	2	---	--	-	x	-
Lathyrus bijugatus White var. sandbergii White	--	--	---	--	---	--	x	-	-
Pyrola bracteata Hook.	--	--	---	--	---	--	-	x	-
Antennaria racemosa Hook.	--	--	---	--	---	--	-	x	-
Chimaphila menziesii (R. Br.) Spreng.	--	--	---	--	---	--	-	x	-
Juncus paryii Engelm.	--	--	---	--	---	--	x	-	-
Goodyera decipiens (Hook.) St. John & Const.	--	--	---	--	---	--	-	x	-
Apocynum androsaemifolium L. var. incanum A. DC.	--	--	---	--	---	--	x	-	-
Bromus vulgaris (Hook.) Shear var. eximius Shear	--	--	---	--	---	--	-	x	-
Trisetum spicatum (L.) Richt.	--	--	---	--	---	--	x	-	-
Polystichum lonchitis (L.) Roth.	--	--	---	--	---	--	-	x	-
Polypodium hesperium Maxon	--	--	---	--	---	--	x	-	-
Woodsia scopulina D.C. Eaton	--	--	---	--	---	--	x	-	-
Mosses									
Rhacomitrium patens (Dicks.) Hueb.	--	--	---	42	4.1	45	x	x	x
Rhacomitrium lanuginosum (Hedw.) Brid.	--	--	---	4	0.8	8	x	x	x
Hypnum fertile Sendt.	--	--	---	8	0.2	2	x	-	x
Dicranium scoparium (L.) Hedw.	--	--	---	22	0.05	1	x	-	x
Aulacomnium androgynum (L.) Schwaegr.	--	--	---	4	0.05	1	x	-	x
Rhytidiadelphus triquestrus (L., Hedw.) Wars.	--	--	---	4	2.0	22	-	x	-
Polytrichum juniperinum (Willd.) Hedw.	--	--	---	7	0.9	10	-	x	-
Bryum miniatum Lesq.	--	--	---	3	0.7	7	x	-	-
Ditrichum sp.	--	--	---	3	0.3	3	x	-	-
Leptobryum pyriforme (L.) Schimp.	--	--	---	--	---	--	x	-	-
Homalothecium nuttallii (Wils.) Grout	--	--	---	--	---	--	x	-	-

Abund. - abundance; Dens. - density; % F. - percent frequency; No. - relative abundance; % T. Ab. - percent of total abundance; Sq. M. - square meters of area covered; % T. C. - percent of covered area; A - South Santiam Highway; B - Nash Crater; C - Fish lake.

Aceretum circinati lavosum. Rhacomitrium patens has succedingly lower values in the Pseudotsugeto-abietum lasiocarpi to a still lower degree in this association (Table X). Yet these values, modified by forest influence, are still high, and particularly so in relation to the other species. The center of outgrowth of this union is, as is to be expected, in the lower areas, since Rhacomitrium patens grows only on rock substrate.

There is a greater number of mosses in this union than in the preceding unions or even those to follow. These are mesic but scattered on the forest floor. Apparently, also, the degree of light intensity explains in part their presence here for in the wetter but darker climax forest no bryophytic stratum exists. Polytrichum triquestris grows in the ash-lava ecotone.

5. Interrelations of the Community.

Certain groupings of structure in all layers define this association as a heterogenous unit embracing a variety of habitats and associated affinities. However, in each stratum, one or two constants as dominants are sufficient to tie the association together. Also, this association is the highest developmental aggregation, as is shown by the low infiltration of mesic species and the low quanitative and presence values of xeric species. Likewise, the frequency graphs of the herbaceous and bryophytic unions bear out this heterogeneity by their lengths of the class A columns and an absence of stable species in classes D and E (Figure 19). The spectrums of the frutescent and arborescent layers denote an approximity to climax conditions by reason of the frequencies of their dominants. Yet class B is high in both and either C or D is missing -- an index of incomplete stability.

The phenologic record of the flowering plants is not as well defined into aspectional stages as in the preceding communities. Again this is perhaps a result of the habitat variety. As a general rule the mesic species are estival on their higher and cooler site (Table XA). Prevernal species from the preceding communities are slightly later, presumably because of the greater duration of the snow pack under the forest cover. Both dominants, chinquapin and _Chimaphila umbellata_ var. _occidentalis_ of the shrub and herb layers, respectively, are estival. Also of note is the incomplete cycle of a species of Salix. It is able to become established in the forest but the existing conditions are not sufficient for it to have a high degree of vitality.

E. THE _Pinetum contorti lapillosum_ ASSOCIATION.

1. The Arborescent Synusia: Pinus contorta Union.

Striking differences of species complement and structure set this union apart from those of the receding forest associations which have shown social intergradations. Here, co-extensive with the ash-lapilli mantle to the lee of the craters, lodgepole pine,

Figure 19. Frequencies of the synusiae of the Pseudotsugeto-abietum grandis. 1 - arborescent synusia; 2 - frutescent synusia; 3 - herbaceous synusia; 4 - bryophytic synusia; 5 - Kenoyer's normal; 6 - Raunkaier's normal. The capital letters represent the percentage of species (y-axis) that had the following frequencies: A - 0 to 20%; B - 21 to 40%; C - 41 to 60%; D - 61 to 80%; E - 81 to 100%.

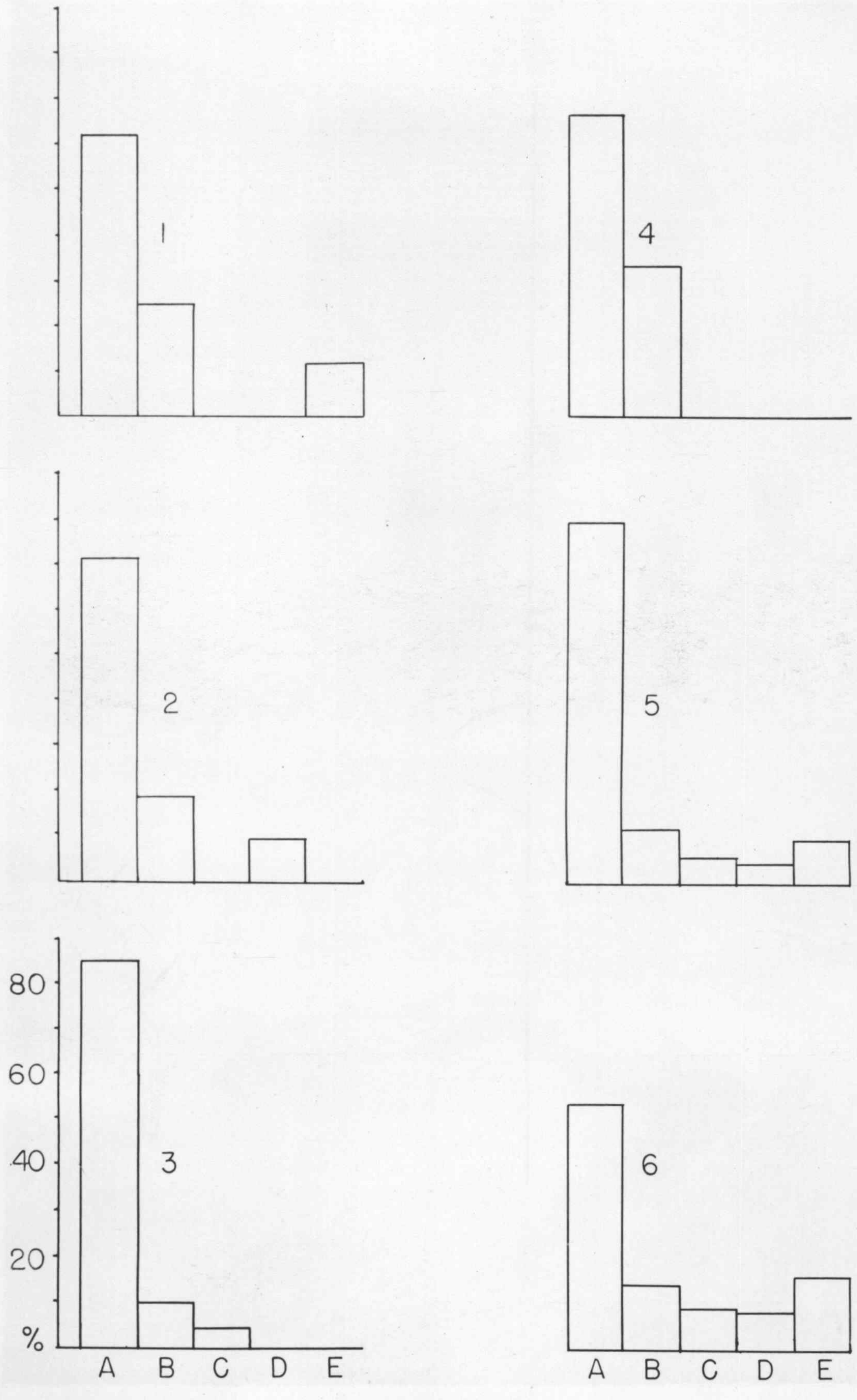

1
4
2
5
80
60
40
3
6
20
%
A B C D E
A B C D E

Table XA

Phenology of the shrubs and herbs of the <u>Pseudotsugeto-abietum grandis</u> association for the growing season of from the middle of May to the last of September, 1949.

Species	May	June	July	Aug.	Sept.
			Months		
Shrubs					
<u>Castanopsis chrysophylla</u>	- - - -	- - - -	- - - ⊥	x x ⊗ ⊗	0 0 0
<u>Pachistima myrsinites</u>	- - - x	x ⊗ ⊗ ⊗	⊗ ⊗ ⊗ ⊗	⊗ ⊗ ⊗ ⊗	⊗ ⊗ ⊗
<u>Acer circinatum</u>	- - - -	- x ⊗ ⊗	⊗ 0 0 0	0 0 0 0	0 0 0
<u>Rubus parviflorus</u>	- - - -	- - - x	x x x ⊗	⊗ ⊗ 0 0	0 - -
<u>Ceanothus velutinus</u>	- - - -	- ⊥ x x	x x ⊗ 0	0 0 0 0	0 0 0
<u>Salix sp.</u>	- - - -	- - - -	- - - -	- - - -	- - -
<u>Rhamnus purshiana</u>	- - - -	- - - -	⊥ x ⊗ ⊗	0 0 0 0	0 ? ?
<u>Berberis nervosa</u>	- - - -	⊥ x x ⊗	0 0 0 0	0 0 0 0	0 0 0
<u>Vaccinium membranaceum</u>	- - - x	x x ⊗ ⊗	0 0 0 0	0 0 0 -	- - -
<u>Rubus vitifolius</u>	- - - -	- - - -	- x x x	⊗ ⊗ 0 0	0 0 0
<u>Arctostaphylos nevadensis</u>	- - - x	x x x ⊗	⊗ ⊗ ⊗ 0	0 0 0 0	0 0 0
<u>Rosa gymnocarpa</u>	- - - -	- - - -	- x x ⊗	⊗ 0 0 0	0 0 0
<u>Holodiscus glabrescens</u>	- - - -	- - - -	- - - ⊥	⊥ x x 0	0 0 0
<u>Arctostaphylos columbiana</u>	- - - x	x x ⊗ ⊗	0 0 0 0	0 0 0 0	0 0 0
<u>Vaccinium myrtillus</u> var. <u>microphyllum</u>	- - - -	- - x x	x 0 0 0	0 0 0 0	- - -
Herbs					
<u>Chimaphila umbellata</u> var. <u>occidentalis</u>	- - - -	- ⊥ ⊥ ⊥	⊥ ⊥ x x	x ⊗ ⊗ ⊗	0 0 0
<u>Linnaea borealis</u> var. <u>americana</u>	- - - -	- - - -	⊥ x x ⊗	⊗ ⊗ 0 0	0 0 0
<u>Festuca occidentalis</u>	- - - -	- - - -	- - x x	0 0 0 0	0 0 0

Table XA continued

Xerophyllum tenax	- - - -	- - - x	⊗ ⊗ ⊗ 0	0 0 0 0	0 0 0
Penstemon cardwellii	- - - -	- - - -	- ⊥ x x	⊗ ⊗ ⊗ ⊗	0 0 0
Carex sp.	- - - x	x x 0 0	0 - - -	- - - -	- - -
Sedum oregonense	- - - -	- - - -	- ⊥ x x	⊗ ⊗ 0 0	0 - -
Penstemon menziesii var. *davidsonii*	- - - x	x x x ⊗	⊗ ⊗ ⊗ ⊗	0 0 0 0	- - -
Hieracium albiflorum	- - - -	- - ⊥ x	x x x x	⊗ ⊗ ⊗ ⊗	⊗ 0 0
Fragaria bracteata	- - - -	- - x x	x x ⊗ ⊗	0 0 - -	- - -
Anemone deltoidea	- - - -	- - ⊥ x	x x x ⊗	⊗ 0 0 0	0 0 -
Achlys triphylla	- - - -	⊥ x x ⊗	⊗ 0 0 0	0 0 0 0	0 - -
Arenaria macrophylla	- - - -	- x x x	⊗ ⊗ ⊗ 0	0 0 0 ?	? ? ?
Penstemon confertus var. *procerus*	- - - -	- ⊥ ⊥ x	x ⊗ ⊗ ⊗	⊗ 0 0 0	0 0 0
Clintonia uniflora	- - - -	- - ⊥ x	x ⊗ ⊗ ⊗	⊗ 0 0 0	0 0 0
Smilacina sessilifolia	- - - -	- - - x	x x ⊗ ⊗	⊗ 0 0 0	- - -
Cornus canadensis	- - - -	⊥ ⊥ x x	x x ⊗ ⊗	⊗ 0 0 0	0 0 0
Lilium washingtonium	- - - -	- - - -	- x x x	⊗ ⊗ 0 0	0 0 -
Carex inops	- - - -	- x x 0	0 0 0 0	- - - -	- - -
Gallium triflorum	- - - -	- - - -	- x x ⊗	⊗ ⊗ 0 0	0 ? ?
Eriogonum nudum	- - - -	- - x x	x x x x	⊗ ⊗ ⊗ 0	0 - -
Trillium ovatum	- - - x	x x ⊗ ⊗	0 0 0 0	0 0 0 0	0 0 0
Hieracium greenii	- - - -	- - - -	- - x x	x ⊗ 0 0	0 0 -
Phacelia californica	- - - -	- - x x	x x x ⊗	⊗ ⊗ ⊗ 0	0 0 0
Pyrola picata	- - - -	- - - -	- ⊥ ⊥ x	x ⊗ 0 0	0 0 -
Listeria convallarioides	- - - -	- - ⊥ x	x x ⊗ ⊗	⊗ 0 0 0	? ? ?
Pyrola bracteata	- - - -	- - - -	- - - ⊥	⊥ x x ⊗	0 0 0

Table XA continued

Pyrola secunda	- - - - - - - - - ⊥ x x x ⊗ 0 0 0 0 0
Lathyrus bijugatus var. *sandbergii*	- - - - - - - - - x x x ⊗ ⊗ ⊗ 0 0 - -
Antennaria racemosa	- no record -
Chimaphila menziesii	- - - - - - - - ⊥ ⊥ x x x ⊗ ⊗ ⊗ 0 0 0
Juncus parryii	- - - x x ⊗ 0 0 0 - - - - - - - - - -
Goodyera decipiens	- - - - - - - - - ⊥ ⊥ ⊥ ⊥ x x ⊗ ⊗ ⊗ 0
Apocynum androsaemifolium var. *incanum*	- - - - - - - - - - - - ⊥ x x ? ? ? ?
Bromus vulgaris var. *eximus*	- - - - - x x 0 0 0 0 0 0 0 0 0 0 - -
Trisetum spicatum	- - - - - x x 0 0 0 0 0 0 - - - - - -

- - floral inactivity; ⊥ in bud; x - flowering; ⊗ - flowering and fruiting; 0 - fruiting; ? - unknown.

a species adapted to sterile, xeric environments, dominates the forest. Table XI reveals that for 50 quadrats, 1,560 trees were counted for a density of 31.2 individuals per quadrat. Moreover, its frequence of 100 percent evenly distributes this abundance over the entire area of sampling. This, then, is a dense or closed forest.

Rising through the mantle, scattered monadnocks of lava support the remaining species. Also up the lee slope of Nash Crater, the forest is predominatly lodgepole pine; however, the orographic effect overcomes the substratal conditions enough to allow yellow pine, Douglas fir, and grand fir to come in.

There is some difference in the quantitative growth form of lodgepole pine throughout the union. Optimum growth is reached in specimens on the high benches around Nash Crater (Figure 20); whereas, stunted, broken trees predominate on the lower flats to the lee of Little Nash Crater (Figure 21).

The relation of lodgepole pine to the other species is strikingly shown in the summed quantitative data of the synusia's phytographs (Figure 22). Neither Douglas fir, western yellow pine, or grand fir can be considered as union sub-dominants for they are not active in the community, but only on lava outcrops included in the area of control. Table XIA shows the high reproductive capacity of lodgepole pine and a preponderance of trees in the lower size class. This is indicative of both early consolidation

Table XI

Phytosociologic data of the Pinus contorta and Ceanothus velutinus unions of the Pinetum contorti lapillosum association. These are the arborescent and frutescent synusiae.

Species	Quantitative							Synthetic		
	Abund.		Dens.	% F.	Space [*]			Presence		
	No.	% T.Ab.			Area	% T.C.		A	B	C
Trees										
Pinus contorta Dougl. var. murrayana (Balf.) Engelm.	1560	95	31.2	100	17,625	86		x	x	x
Pseudotsuga taxifolia (Lambert.) Britt.	32	2	0.6	32	9,969	10		x	x	x
Pinus ponderosa Dougl.	9	0	0.2	14	654	3		x	x	-
Abies grandis Lindl.	30	2	0.6	34	153	1		-	x	-
Tsuga mertensiana (Bong.) Sarg.	3	0	0.0	4	50	0		-	x	-
Abies amabilis (Dougl.) Forbes	1	0	0.0	2	0	0		-	x	-
Tsuga heterophylla (Raf.) Sarg.	1	0	0.0	2	0	0		-	x	-
Pinus monticola Dougl.	--	--	---	--	---	--		-	x	-
Shrubs										
Ceanothus velutinus Dougl.	298	60	6.0	66	51.0	75		x	x	x
Ribes viscosissimum Pursh	41	8	0.8	40	10.0	15		x	x	x
Pachistima myrsinites (Pursh) Raf.	101	20	2.0	18	3.9	6		-	x	x
Arctostaphylos nevadensis Gray	34	7	0.6	26	2.1	3		-	x	-
Rubus parviflorus Nutt.	8	2	0.2	12	0.0	0		-	x	-
Juniperus communis L. var. sibirica (Burgsd.) Rydb.	8	2	0.2	6	0.5	1		-	x	-
Prunus emarginata (Dougl.) Walp.	3	1	0.0	2	0.2	0		-	-	x
Rhamnus purshiana DC.	1	0	0.0	2	0.0	0		-	x	-
Salix sp.	1	0	0.0	2	0.0	0		-	x	-
Holodiscus glabrescens (Greene) Hel.	--	--	---	--	---	--		-	x	-
Castanopsis chrysophylla A. DC.	--	--	---	--	---	--		-	x	-

Abund. - abundance; Dens. - density; % F. - percent frequency; No. - relative abundance; % T. Ab. - percent of total abundance; % T. C. - percent of covered area or of total basal area; A- Santiam Jct.; B - around and on Nash Crater; C - towards west end of flows near the highway.

* Space is cover for the shrub stratum and basal area for the tree stratum; Area is in square meters for the shrub layer and in square inches for the tree layer.

Figure 20. Forest composition of the Pinetum contorti lapillosum association as it is found on the more mesic benches at the foot of Nash Crater. The arborescent stratum is composed of lodgepole pine. Ceanothus velutinus makes up the lower stratum. Note the high degree of consolidation in both.

Figure 21. Composition of the lodgepole forest on the lapilli flats near the highway junction. Note the much poorer growth form of the pine than in the preceding photograph. In the background, the Douglas fir-grand fir forest is confined to a lava ridge. Note the sharp ecotone between the two.

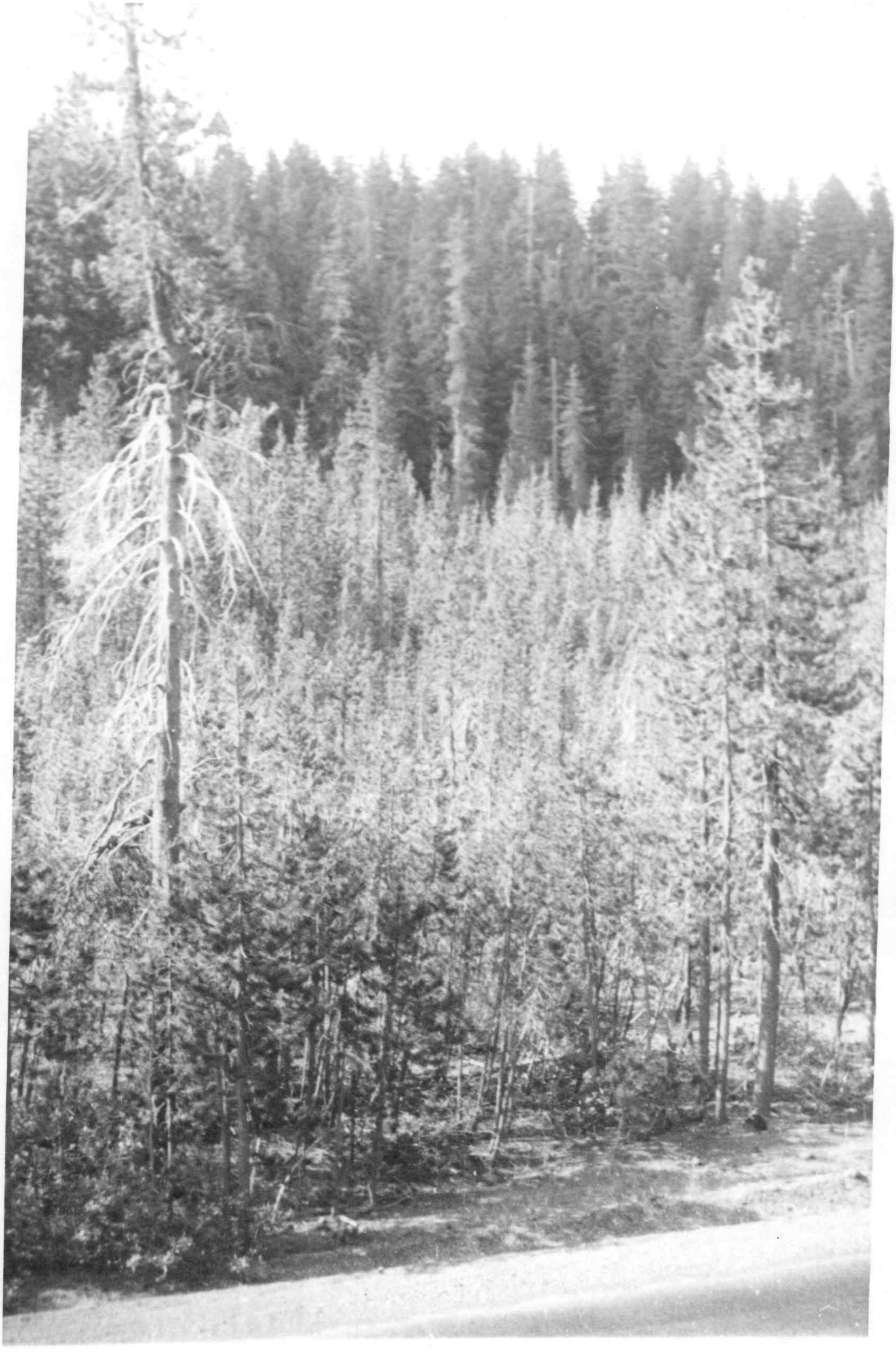
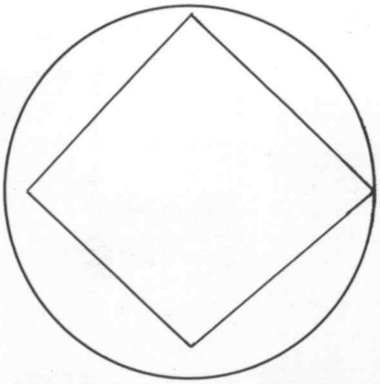
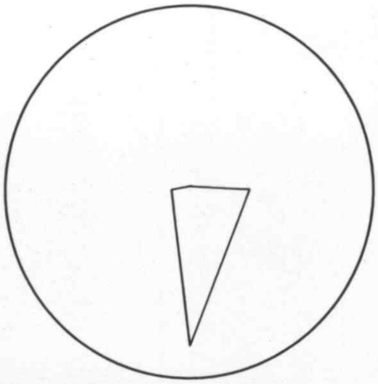


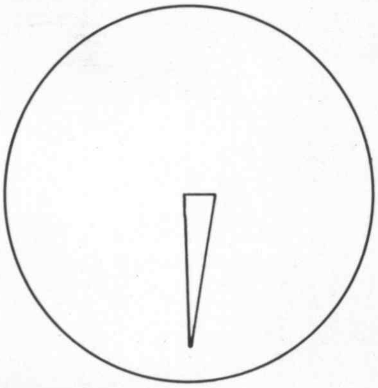
Figure 22. Phytographs or combined sociologic data of the arborescent species of the Pinetum contorti lapillosum association. The top radius of the circle represents percent of total abundance; the righthand radius represents percent frequency; the lower radius represents number of size classes occupied; the lefthand radius represents the percent of the total basal area.



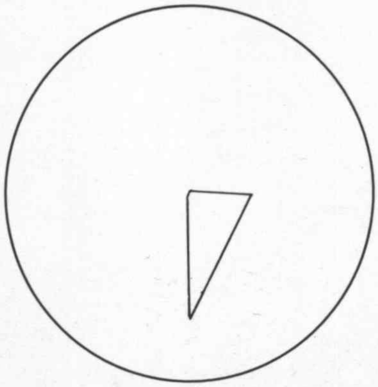
Pinus contorta v. murrayana



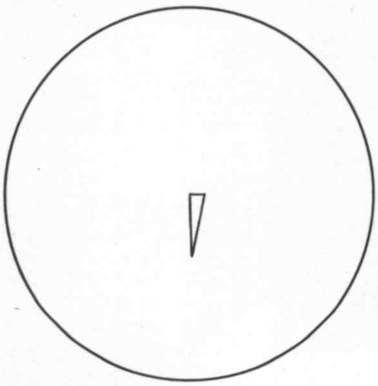
Pseudotsuga taxifolia



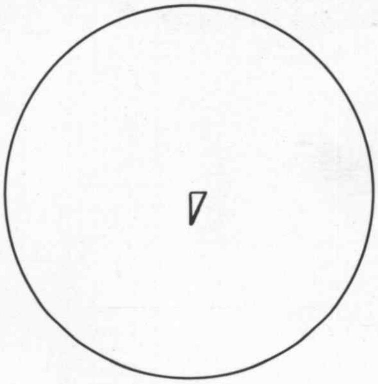
Pinus ponderosa



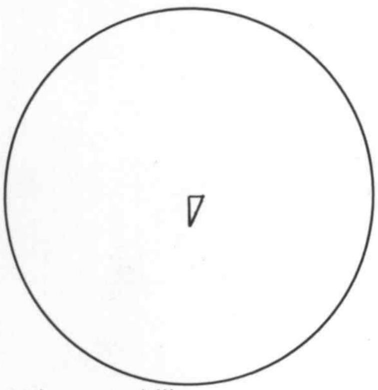
Abies grandis



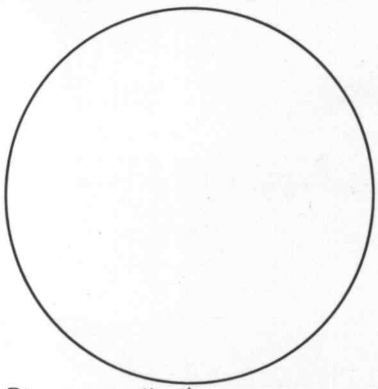
Tsuga mertensiana



Tsuga heterophylla



Abies amabilis



Pinus monticola

Table XIA

Size class distribution of the abundance of the aboreal species of the *Pinetum contorti lapillosum* association.

Species	R	1	2	3	4	5	T
	Size Classes						
Pinus contorta var. *murrayana*	426	757	200	173	4	0	1560
Pseudotsuga taxifolia	16	7	5	3	0	1	32
Pinus ponderosa	4	1	1	2	1	0	9
Abies grandis	27	1	1	0	1	0	30
Tsuga mertensiana	2	0	0	1	0	0	3
Abies amabilis	1	0	0	0	0	0	1
Tsuga herterophylla	1	0	0	0	0	0	1
Pinus monticola	---	---	---	---	---	---	---

R - reproduction; 1 - 1 1/2" to 2 1/2"; 2 - 3" to 6"; 3 - 6 1/2" to 12"; 4 - 12 1/2" to 24"; 5 - 24 1/2" and over; T - total.

and of the fact that most of the area is restrictive to growth. Most lodgepole pines complete their short life cycle never reaching more than 2 to 4 inches in diameter.

2. The Frutescent Synusia: Ceanothus velutimus Union.

Two constants are distinctive in this union. Presumably they have almost the same ecologic requirements as lodgepole pine. The dominant is Ceanothus velutimus which reaches greatest cover in the higher flats where it forms almost impenetrable thickets.(Table XI) Near Little Nash, however, the union is absent under the broken scrub lodgepole pine stand. Besides Ribes viscosissium and Salix sp. which are true sub-dominants associated with Ceanothus velutimus, the remaining species occur with the arborescent elements on the lava outcrops. One exception, Juniperus communis var. sibirica, subsists as a small mat at the top of the southeast rim of Nash Crater.

3. The Herbaceous Synusia: The Carexo-penstemon Union.

Quite a different herbaceous flora is associated with this xeric, sterile habitat. Many are apparent influents from eastern Oregon deserts. Table XII reveals two species with sufficient combined sociologic control to be considered as dominants. These are Carex inops and Penstemon confertus var. procerus. Their values of abundance and frequence are relatively low; however, this is because of their poor development on the flats around Santiam Highway Junction. At the lowest stand along the highway

Table XII

Phytosociologic data of the Carexo-penstemon and Polytrichum juniperinum unions of the Pinetum contorti lapillosum association. These are the herbaceous and bryophytic synusiae.

	Quantitative						Synthetic		
	Abund.		Dens.	% F.	Cover		Presence		
	No.	% T.Ab.			Sq. M.	% T.C.	A	B	C
Herbs									
Carex inops Bailey	164	26	3.3	52	---	--	x	x	x
Penstemon confertus Dougl. var. procerus (Dougl.) Cov.	255	41	5.1	40	---	--	x	x	x
Epilobium angustifolium L.	23	4	0.4	32	---	--	x	x	x
Fragaria bracteata Hel.	111	18	2.2	34	---	--	x	x	-
Stipa thurberiana Piper	10	1	0.2	14	---	--	x	x	-
Sitanion hystrix (Nutt.) Smith	9	1	0.2	10	---	--	x	x	-
Pedicularis racemosa Dougl.	13	2	0.3	8	---	--	-	x	x
Lomatium angustatum (C. & R.) St. John	4	1	0.1	6	---	--	x	x	-
Eriogonum nudum Dougl.	3	0	0.0	4	---	--	x	x	-
Hieracium greenii Gray	3	0	0.0	4	---	--	x	x	-
Eriogonum marifolium Torr.	---	--	---	--	---	--	x	x	-
Penstemon menzesii Hook var. davidsonii (Greene) Piper	5	1	0.1	4	---	--	-	x	-
Arenaria macrophylla Hook.	13	2	0.2	8	---	--	x	-	-
Clintonia uniflora (Schult.) Kunth.	1	0	0.0	2	---	--	-	x	-
Achlys triphylla (Smith) DC.	2	0	0.0	2	---	--	-	x	-
Haplopappus greenii Gray	2	0	0.0	2	---	--	x	-	-
Pyrola secunda L.	1	0	0.0	2	---	--	-	x	-
Spraguea umbellata Torr.	1	0	0.0	2	---	--	x	-	-
Lupinus lyallii Gray	2	0	0.0	2	---	--	x	-	-
Pyrola dentata Smith	3	0	0.0	4	---	--	-	x	-
Chimaphila umbellata (L.) Nutt. var. occidentalis (Rydb.) Blk.	---	--	---	--	---	--	-	x	-
Sedum oregonense (Wats.) Peck	---	--	---	--	---	--	-	x	-
Eriogonum pyrolaefolium Hook var coryphaeum T. & G.	---	--	---	--	---	--	-	x	-
Anaphalis margaritacea (L.) B. & H.	---	--	---	--	---	--	-	x	-
Arabis holboellii Horn. var. secunda (How.) Jep.	---	--	---	--	---	--	-	x	-
Aster radulinus Gray	---	--	---	--	---	--	x	-	-
Arabis lyallii Wats.	---	--	---	--	---	--	-	x	-
Mosses									
Polytrichum juniperinum (Willd.) Hedw.	---	--	---	22	2.5	86	x	x	x
Rhacomitrium lanuginosum (Hedw.) Brid.	---	--	---	4	0.2	8	-	-	x
Rhacomitrium patens (Dicks.) Hueb.	---	--	---	4	0.2	6	-	x	x

Abund. - abundance; Dens. - density; % F. - percent frequency; No. - relative abundance; % T. Ab. - percent of total abundance; Sq. M. - square meters of area covered; % T.C. - percent of covered area; A - Santiam Junction; B - around and on Nash Crater; C - towards west end of flows near the highway.

and west of Little Nash Crater, they form dense cover. On the high benches at the base of Nash Crater, Fragaria bracteata is ascendant. The latter's incomplete presence excludes it as a union constant, or association type species.

Lomatium angustatum, the several Eriogonum species, Haplopappus greenii, Spraguea umbellata, Aster radulinus, and Lupinus lyallii occupy the most xeric sites. These occur in no other sere on the flows.

4. The Bryophytic Synusia: Polytrichum juniperinum Union.

One moss, Polytrichum juniperinum, is the only moss that prevails on ash and lapilli. Its low frequence (22) describes its inconsistent establishment. The other species, Rhacomitrium patens and R. lanuginosum, are, as before, associated with the lavas of the scattered projecting knolls.

5. Interrelations of the Community.

Phenologic peaks are evident in the data of Table XIIA. Two herbaceous species, Spraguea umbellata and Lomatium angustatum, form a sparse prevernal, vernal aspect. The bulk of the species commence flowering in the late vernal and estival periods. Several species, mostly composites, are autumnal as Aster radulinus, Hieracium greenii, and Pedicularis racemosa.

The affinities of this association are distinct and separate from those which border it. The very nature of the environmental

Table XIIA

Phenology of the shrubs and herbs of the *Pinetum contorti lapillosum* association for the growing season of from the middle of May to the last of September, 1949.

Species	May	June	Months July	Aug.	Sept.
Shrubs					
Ceanothus velutinus	- - - -	- ⊥ x x	x x ⊗ 0	0 0 0 0	0 0 0
Ribes viscosissimum	- - - -	- - - -	x x ⊗ ⊗	0 0 0 -	- - -
Pachistima myrsinites	- - - x	x ⊗ ⊗ ⊗	⊗ ⊗ ⊗ ⊗	⊗ ⊗ ⊗ ⊗	⊗ ⊗ ⊗
Arctostaphylos nevadensis	- - - x	x x x ⊗	⊗ ⊗ ⊗ 0	0 0 0 0	0 0 0
Rubus parviflorus	- - - -	- - - x	x x x ⊗	⊗ ⊗ 0 0	0 - -
Prunus emarginata	- - - -	- x x ⊗	⊗ 0 0 0	0 0 - -	- - -
Rhamnus purshiana	- - - -	- - - -	x ⊗ ⊗ 0	0 0 0 0	? ? ?
Salix sp.	- - - -	- - - -	- - - -	- - - -	- - -
Holodiscus glabrescens	- - - -	- - - -	- - - ⊥	x ⊗ ⊗ 0	0 0 0
Castanopsis chrysophylla	- - - -	- - - -	- - ⊥ x	x ⊗ ⊗ 0	0 0 0
Herbs					
Carex inops	- - - -	- x x 0	0 0 0 0	- - - -	- - -
Penstemon confertus var. *procerus*	- - - -	- ⊥ ⊥ x	x ⊗ ⊗ ⊗	⊗ 0 0 0	0 0 0
Epilobium angustifolium	- - - -	- - - -	⊥ x x ⊗	⊗ ⊗ ⊗ ⊗	0 0 0
Fragaria bracteata	- - - -	- - x x	x x ⊗ ⊗	0 0 - -	- - -
Stipa thurberiana	- - - -	- x x 0	0 0 0 0	0 - - -	- - -
Sitanion hystrix	- - - -	- x x 0	0 0 - -	- - - -	- - -
Pedicularis racemosa	- - - -	- - - -	- - ⊥ x	x x ⊗ ⊗	⊗ 0 0
Lomatium angustatum	- - - x	x ⊗ ⊗ ⊗	⊗ ⊗ ⊗ ⊗	⊗ 0 0 0	0 0 0

Table XIIA continued

Eriogonum nudum	-	-	-	-	-	-	x	x	x	x	x	x	⊗	⊗	⊗	0	0	-	-
Hieracium greenii	-	-	-	-	-	-	-	-	-	-	x	x	x	⊗	0	0	0	0	-
Eriogonum marifolium	-	-	-	-	-	-	x	⊗	⊗	⊗	⊗	⊗	⊗	0	0	0	0	-	-
Penstemon menzesii var. *davidsonii*	-	-	-	-	x	x	x	⊗	⊗	⊗	0	0	0	0	0	0	0	0	0
Arenaria macrophylla	-	-	-	-	-	x	x	⊗	⊗	⊗	0	0	0	0	-	-	-	-	-
Clintonia uniflora	-	-	-	-	-	-	⊥	x	x	⊗	⊗	⊗	⊗	0	0	0	0	0	0
Achlys triphylla	-	-	-	-	⊥	x	x	⊗	⊗	0	0	0	0	0	0	0	0	-	-
Haplopappus greenii	-	-	-	-	-	-	-	-	-	-	⊥	x	x	⊗	⊗	⊗	⊗	0	0
Pyrola secunda	-	-	-	-	-	-	-	-	-	-	⊥	x	⊗	⊗	⊗	⊗	⊗	⊗	⊗
Spraguea umbellata	-	-	x	x	x	x	⊗	0	0	0	-	-	-	-	-	-	-	-	-
Lupinus lyallii	-	-	-	-	-	-	x	⊗	⊗	⊗	⊗	⊗	⊗	0	0	0	0	0	-
Pyrola dentata	-	-	-	-	-	-	-	-	-	⊥	x	x	x	⊗	⊗	⊗	0	0	0
Chimaphila umbellata var. *occidentalis*	-	-	-	-	-	⊥	⊥	⊥	⊥	⊥	x	x	x	⊗	⊗	⊗	0	0	0
Sedum oregonense	-	-	-	-	-	⊥	⊥	x	x	x	x	⊗	⊗	⊗	0	0	0	-	-
Eriogonum pyrolaefolium var. *coryphaeum*	-	-	-	-	-	x	x	x	x	x	x	⊗	⊗	⊗	⊗	0	0	0	0
Anaphalis margaritacea	-	-	-	-	-	-	-	x	x	x	x	⊗	⊗	⊗	⊗	⊗	⊗	0	0
Arabis holboellii var. *secunda*	-	-	-	-	x	⊗	⊗	⊗	⊗	⊗	⊗	0	0	0	-	-	-	-	-
Aster radulinus	-	-	-	-	-	-	-	-	-	-	-	x	x	x	⊗	⊗	⊗	⊗	0
Arabis lyallii								- no record -											

- - floral inactivity; ⊥ - in bud; x - flowering; ⊗ - flowering and fruiting; ? - unknown.

complex to which its flora is adapted, an absence of infiltration, except upon lava knolls within its area, distinguishes it as a primary sere. Clearly lodgepole pine and its associated species are primary invaders. They have, so far, altered the environment but little to allow their replacement. Dead Douglas fir seedlings are diffused throughout the forest, but no active establishment, not associated with the presence of lava, is apparent.

Over much of the area of the association, there is a loose social organization. In the more mesic portions of the flats, C. velutinus constructs a thick layer under the open lodgepole pine canopy; and beneath it, a verdant mat of P. confertus var. procerus, C. inops, and E. angustifolium covers the ground. Yet it is doubtful if the lower layers owe their existence to, or are altered by, the lodgepole pine canopy. The slight degree of soil and light aeration do not preclude active competition. Actually growing conditions are at their best, as is reflected in the plants themselves.

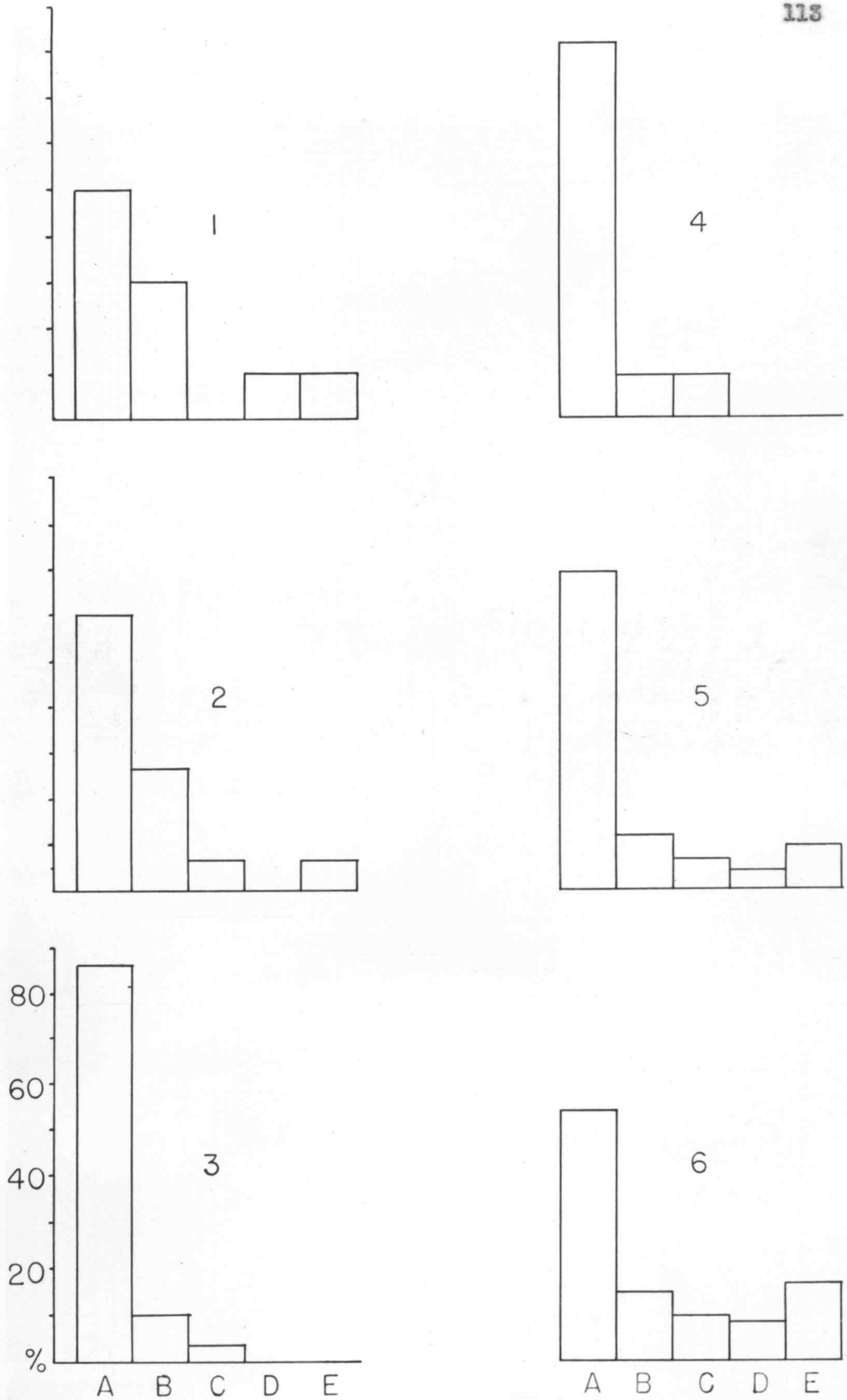
Primary succession and the youth of the sere are both confirmed in these inconsistencies and the proportion of species in the A and B columns of the frequence plots (Figure 23).

F. THE Pseudotsugetum taxifoliae tsugosum ASSOCIATION.

1. The Arborescent Synusia: Pseudotsugo-tsuga Union.

Many thousands of years separate this forest union from

Figure 23. Frequency graphs for the synusiae of the Pinetum contorti lapillosum association. 1 - arborescent synusia; 2 - frutescent synusia; 3 - herbaceous synusia; 4 - bryophytic synusia; 5 - Kenoyer's normal; 6 - Raunkaier's normal. The capital letters represent the percentage of species (y-axis) that had the following frequencies: A - 0 to 20%; B - 21 to 40%; C - 41 to 60%; D - 61 to 80%; E - 81 to 100%.


1
4
2
5
80
60
40
20
%
3
6
A B C D E
A B C D E

those of the preceding associations. The substrate is deep and rich. The canopy is closed and the forest floor dark and bare. Species are present whose seedlings will develop in a very low intensity of light, and thus perpetuate themselves indefinitely. This closed stratum ameliorates environmental extremes. Mesism, competition, sciophytic dependance, are all measures of its composition. This is the middle montane climax forest of the Cascades (Figure 24).

The sampling and quantitative data are not indicative of this entire union or of the entire association. It extends over many square miles on both sides of the Western Cascades. Three stations were selected around its peripheral convergence with the lava associations. These serve, however, for comparison with the Nash Crater lava communities, and are indicative of at least a part of the association.

In 12 quadrats, a basal area of 26,219 square inches, which is 83 percent of the total basal area of all species, was recorded for Douglas fir (Table XIII). In addition, these figures are from but 25 individuals. Its high frequence of 92 and density of 2.1, together, show its dominance.

Western hemlock and lovely fir have both a density of 17.5 and a high frequency of 75 and 83 respectively. However, their basal areas are low in relation to that of Douglas fir and are but 4 and 7 percent of the total respectively. Table XIIIA depicts the distribution of abundances in the various size classes.

Figure 24. Closed forest consolidation of the *Pseudotsugetum taxifoliae tsugosum* association. The arborescent stratum is composed of large Douglas fir and western hemlock. A sequence of size classes is found only in the latter. Little or no development of the lower synusiae is apparent.

Table XIII

Phytosociologic data of the *Pseudotsugo-tsuga* and *Roseto-vaccinium* unions of the *Pseudotsugetum taxifoliae tsugosum* association. These are the arborescent and frutescent synusiae.

Species	Quantitative						Synthetic		
	Abund.		Dens.	% F.	Space*		Presence		
	No.	% T.Ab.			Area	% T.C.	A	B	C
Trees									
Pseudotsuga taxifolia (Lambert.) Britt.	25	5	2.1	92	26,219	83	x	x	x
Tsuga heterophylla (Raf.) Sarg.	198	41	17.5	75	1,164	4	x	x	x
Abies amabilis (Dougl.) Forbes	200	41	17.5	83	2,262	7	x	x	x
Abies grandis Lindl.	28	6	2.3	50	1,005	3	x	x	x
Pinus monticola Dougl.	5	1	0.4	16	901	2	x	x	x
Taxus brevifolia Nutt.	28	6	2.3	25	28	0	-	x	-
Picea engelmanni (Parry) Engelm.	---	--	---	--	---	--	-	-	x
Shrubs									
Vaccinium membranaceum Dougl.	101	40	8.4	58	1.5	40	x	x	x
Rosa gymnocarpa Nutt.	43	17	3.4	83	0.2	4	x	x	x
Rubus vitifolius C. & S.	17	7	1.4	42	0.1	2	x	x	x
Pachistima myrsinites (Pursh) Raf.	42	17	3.3	50	0.7	19	x	-	x
Acer circinatum Pursh	9	3	0.7	15	0.6	15	x	-	x
Berberis nervosa Pursh	32	13	2.6	25	0.3	8	-	x	x
Amelanchier florida Lindl.	4	2	0.3	8	0.4	10	-	x	-
Castanopsis chrysophylla A. DC.	1	0	0.1	8	0.0	0	-	x	-

Abund. - abundance; Dens. - density; % F. - percent frequency; No. - relative abundance; % T. Ab. - percent of total abundance; % T.C. - percent of covered area or of total basal area; A - between North Santiam Highway and Big Spring Bog; B - Clear Lake Junction; C - Lava Lake.

*Space is cover for the shrub stratum and basal area for the tree stratum; Area is in square meters for the shrub layer and in square inches for the tree layer.

Table XIIIA

Size class distribution of the abundance of the aboreal species of the *Pseudotsugetum taxifoliae tsugosum* association.

Species	R	1	2	3	4	5	T
	Size classes						
Pseudotsuga taxifolia	16	7	5	3	0	1	25
Tsuga heterophylla	181	1	4	4	5	3	198
Abies amabilis	163	13	11	7	6	0	200
Abies grandis	14	1	6	3	4	0	28
Pinus monticola	3	0	0	0	1	1	5
Taxus brevifolia	23	3	2	0	0	0	28
Picea engelmanni	---	---	---	---	---	---	---

R - reproduction; 1 - 1 1/2" to 2 1/2"; 2 - 3" to 6"; 3 - 6 1/2" to 12"; 4 - 12 1/2" to 24"; 5 - 24 1/2" and over; T. - total.

Since western hemlock has more trees in the larger size classes and high abundance and frequence, it is also considered as a dominant of this stratum. These size class data also reveal that the Douglas fir are large, that this species has relatively no reproduction, and that the other two species are the converse.

Grand fir and white pine are the other two association type species of this union. Their sociologic data depose them as sub-dominants. Yew (Taxus brevifolia) is found only in the most consolidated portions of the forest as a scattered low tree. One Englemann spruce was encountered in reconnaissance.

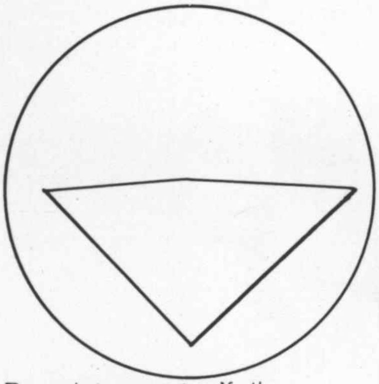
The above relationships are graphically illustrated in the combined quantitative data of the species' phytographs (Figure 25).

2. The Frutescent Synusia: Roseto-vaccinium Union.

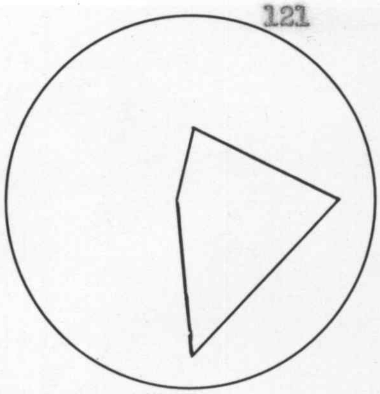
Three constants typify this union and do not seem to be dependants of the closed forest conditions, but rather tolerants. Vaccinium membranaceum, Rosa gymnocarpa, Rubus vitifolius, and Berberis nervosa form a discontinuous stratum, except in openings of the forest or at its edges. Also in the deep forest, their form is weak, their vitality low.

The most widely distributed shrub is R. gymnocarpa (frequency 83); whereas V. membranaceum, though occurring in patches (frequence 58), has higher density (8.4) and cover (40 percent of the total values (Table XIII). These together

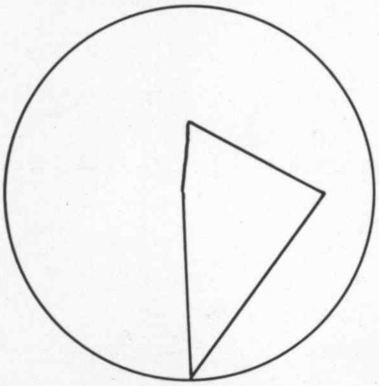
Figure 25. Phytographs of the arborescent stratum of the Pseudotsugetum taxifoliae tsugosum association. The top radius of the circle represents percent of total abundance; the righthand radius represents percent frequency; the lower radius represents number of size classes occupied; the lefthand radius represents the percent of the total basal area.



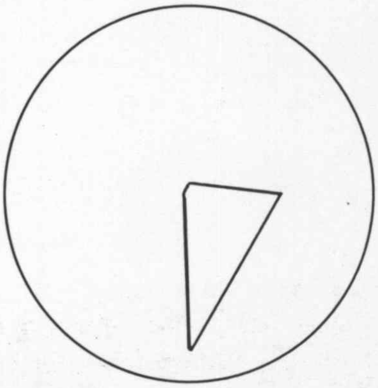
Pseudotsuga taxifolia



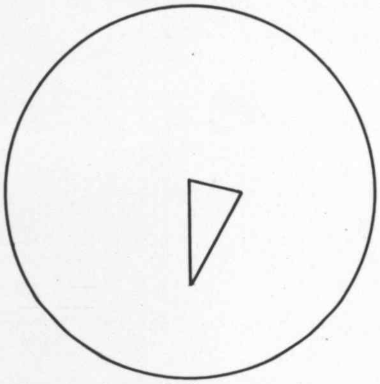
Abies amabilis



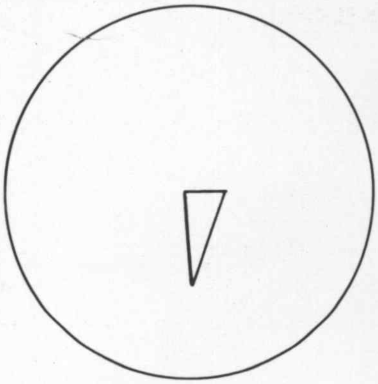
Tsuga heterophylla



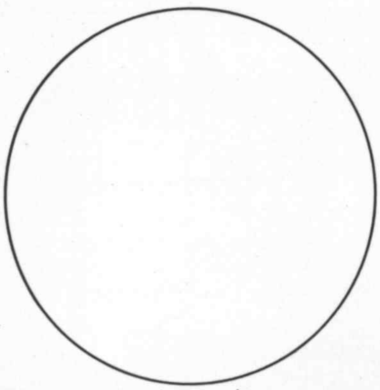
Abies grandis



Taxus brevifolia



Pinus monticola



Picea engelmanni

may be more-or-less considered as co-dominants of this poorly defined union. The other species occur only at the edge of the forest adjacent to the lavas, where the light is sufficient for their survival.

3. The Herbaceous Synusia: Linnaeto-cornus Union.

The richness of the species present mark the development of this union (Table XIV). At all stations, many are constants of high vitality dependant upon climax forest coaction and reaction.

Twinflower (Linnaea borealis var. americana) forms a scattered mat over much of the forest floor (density 7.6 and frequency 83). Associated with it, to a lesser extent, Cornus canadensis has a high consolidation except in the older portion of the forest at Clear Lake Junction. Also, many species as Achlys triphylla and Clintonia uniflora have this same distributional pattern.

Such saprophytes as Allotropa virgata, Corallorhiza mertensiana, and Pyrola aphylla are dependent upon the duff accumulation, high soil moisture efficiency, and shade afforded by the old, closed arborescent stratum. Other species as Chimaphila menziesii, Listeria convallarioides, Adenocaulon bicolor, and Disporum oreganum grow in more open sites.

4. Interrelations of the Community.

With the exception of Berberis nervosa, the shrubs were unable

Table XIV

Phytosociologic data of the Linnaeto-cornus union and the bryophytes of the Pseudotsugetum taxifoliae tsugosum association. This is the herbaceous synusia.

Species	Quantitative						Synthetic		
	Abund.		Dens.	% F.	Cover		Presence		
	No.	% T.Ab.			Sq. M.	% T.C.	A	B	C
Herbs									
Linnaea borealis L. var. americana (Forbes) Rehder	92	25	7.6	83	---	--	x	x	x
Cornus canadensis L.	80	22	6.6	58	---	--	x	x	x
Achlys triphylla (Smith) DC.	48	13	4.0	66	---	--	x	x	x
Chimaphila umbellata (L.) Nutt. var. occidentalis (Rydb.) Blake	43	12	3.4	58	---	--	x	x	x
Clintonia uniflora (Schult.) Kunth	29	6	2.4	58	---	--	x	x	x
Trillium ovatum Pursh	5	2	0.4	25	---	--	x	x	x
Anemone deltoidea Hook.	5	2	0.4	25	---	--	x	x	x
Viola glabella Nutt.	7	2	0.6	16	---	--	x	x	x
Goodyera decipiens (Hook.) St. John & Const.	2	0	0.2	8	---	--	x	x	x
Anemone oregana Gray	2	0	0.2	8	---	--	x	x	x
Allotropa virgata T. & G.	--	--	---	--	---	--	x	x	x
Corallorhiza mertensiana Bong.	--	--	---	--	---	--	x	x	x
Smilacina sessilifolia (Baker) Nutt.	15	4	1.2	25	---	--	x	-	x
Xerophyllum tenax (Pursh) Nutt.	4	1	0.3	8	---	--	x	-	x
Pyrola aphylla Smith	--	--	---	--	---	--	x	x	-
Pyrola secunda L.	11	3	0.9	25	---	--	x	-	-
Tiarella unifoliata Hook.	12	3	1.0	16	---	--	x	-	-
Pyrola bracteata Hook.	6	2	0,5	8	---	--	x	-	-
Fragaria bracteata Hel.	4	1	0.3	8	---	--	x	-	-
Chimaphila menziesii (R. Br.) Spreng.	--	--	---	--	---	--	x	-	-
Listeria convallarioides (Sw.) Torrey	--	--	---	--	---	--	x	-	-
Adenocaulon bicolor Hook.	--	--	---	--	---	--	x	-	-
Disporum oreganum (Wats.) B. & H.	--	--	---	--	---	--	x	-	-
Mosses									
Rhytidiadelphus triguestrus (L., Hedw.) Warnst.	--	--	---	8	0.1	87	x	x	x
Bryum miniatum Lesq.	--	--	---	8	0.02	13	-	x	x

Abund. - abundance; Dens. - density; % F. - percent frequency; No. - relative abundance; % T. Ab. - percent of total abundance; Sq.M. - square meters of area covered; % T.C. - percent of covered area; A - between North Santiam Highway and Big Spring Bog; B - Clear Lake Junction; C - Lava Lake.

to complete their life cycles in the dense forest at Clear Lake Junction. Along the highway and around clearings or a thinning of the stand, as at Lava Lake and Big Spring stations, the remaining constants were quite vigorous. Phenologic data of the plants of this association show no conspicuous lag behind their cycles where they have occurred in other forest associations (Table XIVA). The vernal aspect is quite barren, however, and is represented possibly only by Viola glabella. Twinflower and C. canadensis reach their peaks during the summer. The dark forest sciophytes as Goodyera decipiens, Allotropa virgata, Corallorhiza mertensiana, and Pyrola aphylla make up the late summer aspect after the forest becomes warmer and drier.

The dynamics and state of syngenetical development are graphically illustrated in the phytographs and size classes table. The large sized Douglas fir, without reproduction, will evidently be replaced by the aggressive species, as western hemlock and lovely fir. The structural relationships also suggest that the glacial tills were first occupied by Douglas fir. The few large western hemlock further suggest a limited infiltration. But as reaction proceeded, the degree of consolidation increased to a point of present dominance by the mesic species. In proportion, fewer Douglas fir were able to become established and only a high abundance of rather early individuals remains.

Definite social structure is visible in the number of species which could only exist in this deep forest environment. In places

Table XIVA

Phenology of the shrubs and herbs of the *Pseudotsugetum taxifoliae tsugosum* association for the May - September growing season of 1949.

Species	May	June	Months July	Aug.	Sept.
Shrubs					
Vaccinium membranaceum	- - - -	- x x x	⊗ ⊗ 0 0	0 0 0 -	- - -
Rosa gymnocarpa	- - - -	- - - -	- - x ⊗	⊗ 0 0 0	0 0 0
Rubus vitifolius	- - - -	- - - -	- - ⊥ x	x ⊗ ⊗ 0	0 0 0
Pachistima myrsinites	- - - x	x x x ⊗	⊗ ⊗ ⊗ ⊗	⊗ ⊗ ⊗ ⊗	⊗ ⊗ ⊗
Acer circinatum	- - - -	- x ⊗ ⊗	⊗ ⊗ ⊗ 0	0 0 0 0	0 0 0
Berberis nervosa	- - - -	⊥ ⊥ x x	⊗ 0 0 0	0 0 0 0	0 0 0
Amelanchier florida	- - - -	x x x 0	0 0 0 0	0 0 0 0	0 0 0
Castanopsis chrysophylla	- - - -	- - - -	- - - -	- - ⊥ x	x ⊗ ⊗
Herbs					
Linnaea borealis var. *americana*	- - - -	- ⊥ ⊥ x	x ⊗ ⊗ ⊗	⊗ ⊗ 0 0	0 0 0
Cornus canadensis	- - - -	⊥ ⊥ x x	x x ⊗ ⊗	⊗ 0 0 0	0 0 0
Achlys triphylla	- - - -	- - - x	x ⊗ ⊗ 0	0 0 0 0	0 - -
Chimaphila umbellata var. *occidentalis*	- - - -	- ⊥ ⊥ ⊥	⊥ ⊥ x x	x ⊗ ⊗ ⊗	0 0 0
Clintonia uniflora	- - - -	- - ⊥ x	x ⊗ ⊗ ⊗	⊗ 0 0 0	0 0 0
Trillium ovatum	- - - -	⊥ x ⊗ ⊗	⊗ ⊗ 0 0	0 0 - -	- - -
Anemone deltoidea	- - - -	- - ⊥ x	x x x ⊗	⊗ 0 0 0	0 0 0
Viola glabella	- - - -	x ⊗ ⊗ ⊗	0 - - -	- - - -	- - -
Goodyera decipiens	- - - -	- - - -	- ⊥ ⊥ ⊥	⊥ x x ⊗	⊗ ⊗ 0
Anemone oregana	- - - -	- x x ⊗	⊗ ⊗ 0 0	0 0 0 0	- - -

Table XIVA continued

Allotropa virgata	-	-	-	-	-	-	-	-	⊥	x	⊗	⊗	0	0	-	-	-	-	-
Corallorhiza mertensiana	-	-	-	-	-	-	-	⊥	x	⊗	⊗	0	0	0	0	0	0	0	-
Smilacina sessilifolia	-	-	-	-	-	-	-	-	x	x	x	⊗	⊗	⊗	0	0	0	-	-
Xerophyllum tenax	-	-	-	-	-	-	-	x	x	⊗	⊗	⊗	⊗	0	0	0	0	0	0
Pyrola aphylla	-	-	-	-	-	-	-	-	-	-	-	-	⊥	x	x	⊗	?	?	?
Tiarella unifoliata	-	-	-	-	-	-	-	-	-	-	⊥	x	⊗	⊗	⊗	⊗	0	0	0
Pyrola bracteata	-	-	-	-	-	-	-	-	-	-	-	⊥	⊥	x	x	⊗	⊗	0	0
Fragaria bracteata	-	-	-	-	-	-	-	x	x	x	x	⊗	⊗	0	0	-	-	-	-
Chimaphila menziesii	-	-	-	-	-	⊥	⊥	⊥	⊥	⊥	x	x	x	⊗	⊗	⊗	0	0	0
Listeria convallarioides	-	-	-	-	-	-	⊥	x	x	x	⊗	⊗	⊗	⊗	0	0	0	0	-
Adenocaulon bicolor	-	-	-	-	-	-	-	-	-	⊥	x	x	⊗	⊗	⊗	⊗	0	0	-
Disporum oreganum	-	-	-	-	-	-	-	x	x	⊗	⊗	⊗	0	0	-	-	-	-	-

- - floral inactivity; ⊥ - in bud; x - flowering; ⊗ - flowering and fruiting; 0 - fruiting; ? - unknown.

where cover is very dense, stratification breaks down, competition and certain physical minima are too severe, and only saprophytes are present. Yet these species are the complement of a stable terminus, irreplaceable outside of disturbance, and thus make up a closely knit aggregation.

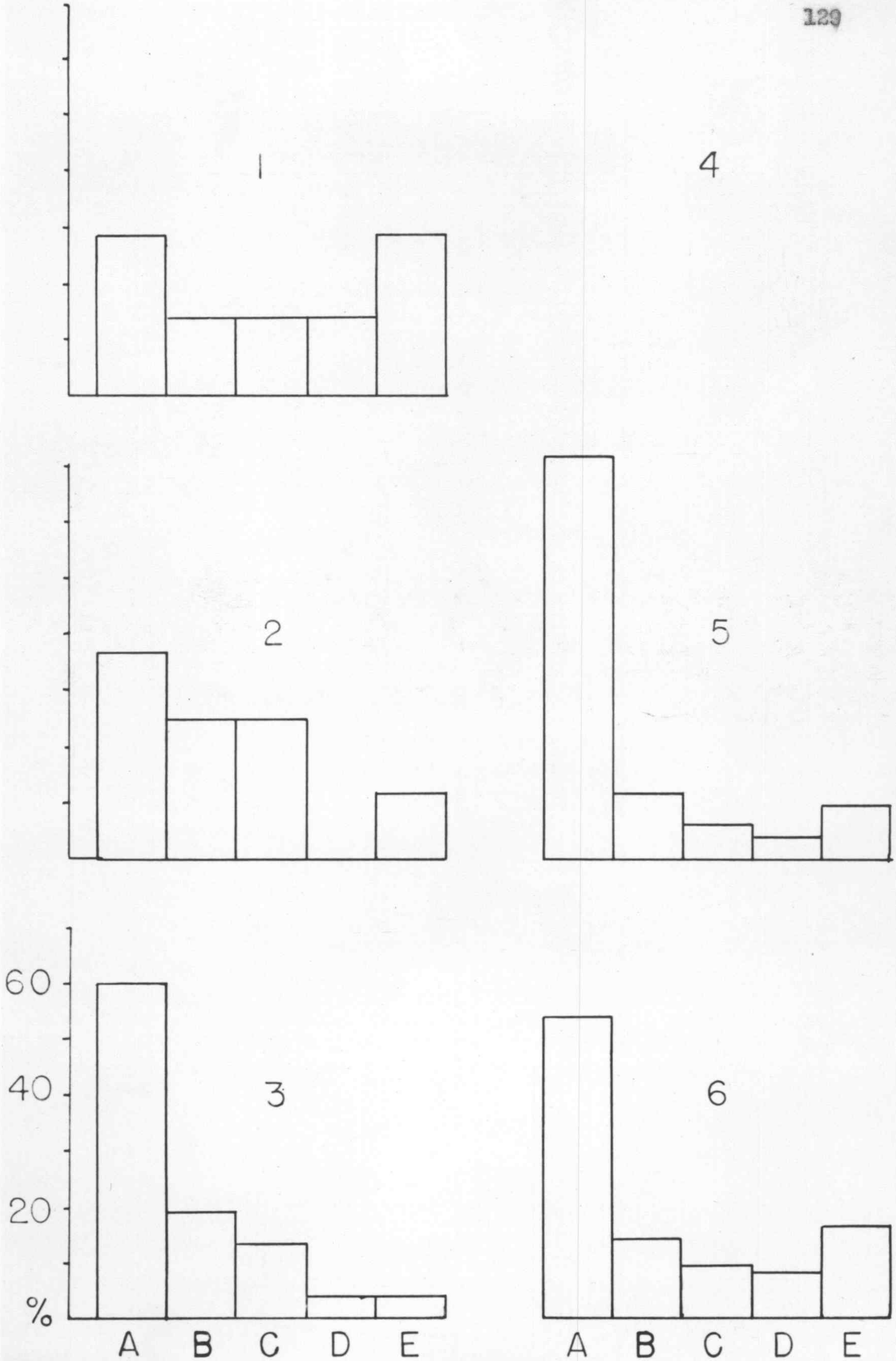
Furthermore the extreme to which consolidation has taken place is shown in the frequency plots (Figure 26). When compared to Raunkiaer's normal, class E, indicative of climax dominants, is very high; class A, indicative of invaders or the unstable portion of a flora, is very low. The poor development of the Roseto-vaccinium union is reflected in its plot, though class E is represented and class A is low. Normality is approached in the herbaceous stratum.

G. The Carexeto-vaccinetum occidentalis ASSOCIATION.

1. The Frutescent Synusiae: Salix Union and Vaccinium occidentalis Union.

The high lava dam at Big Spring Bog marks the end of a flow which cuts off a small intermittent drainage line. Its fan defines the crescent shape of the bog which drains for a short distance along the edge of the lava to the west to disappear into its lip. The Aceretum circinati lavosum, then, marks the southern boundary of this small association, and on the north the Pseudotsugetum taxifoliae tsugosum crowds down to its marginal ditch.

Figure 26. Frequency graphs of the synusiae of the Pseudotsugetum taxifoliae tsugosum association. 1 - arborescent synusia; 2 - frutescent synusia; 3 - herbaceous synusia; 4 - bryophytic synusia; 5 - Kenoyer's normal; 6 - Raunkaier's normal. The capital letters represent the percentage of species (y-axis) that had the following frequencies: A - 0 to 20%; B - 21 to 40%; C - 41 to 60%; D - 61 to 80%; E - 81 to 100%.


1
4
2
5
3
6
60
40
20
%
A
B
C
D
E
A
B
C
D
E

Two well defined shrub unions are quite separate over the bog. Around the shallower edges, a dense thicket or rim of Salix scouleriana and S. piperi extends 30 feet towards the bog center. At the very edge of the slightly formed marginal ditch and on soil, a thin scattering of Alnus sinuata ring the outer circumference of this union. Mixed in with the willow are Sambucus racemosa var. callicarpa, Amelanchier florida, and Spiraea douglasii var. menziesii with individuals of Lonicera involucrata var. ledebourii along its inner periphery. The second union, the Vaccinium occidentalis union, occupies the center and greater part of the bog on the deep sedge-peat, intrazonal substrate (Figure 27).

A single sampling transect of 16 quadrats was used to define area control rather than separate union control. The results in Table XV unfold the great consolidation of V. occidentalis portrayed in Figure 27. A density or unit area abundance of 15, a frequence of 81 percent are low for its union. Here it is the only shrub. For the bog as a whole it is the dominant. Of the remaining shrubs which compose the Salix union, S. scouleriana and S. piperi have the superior quantitative values.

2. The Herbaceous Synusia: Carex sitchensis Union.

In this lower stratum, there is a grouping as in the shrub layers. Smilacina sessilifolia, Glyceria pauciflora, Mimulus dentata, Calamagrostis canadensis, and Cicuta douglasii are present

Figure 27. Big Spring Bog occupied by the *Carexeto-vaccinetum occidentalis* association. The salix union forms a peripheral band around the inner edge of the bog. The inner portion is made up of a dense cover of *Vaccinium occidentalis* and *Carex sitchensis*. In the background, the climax forest descends to the edge of the bog.

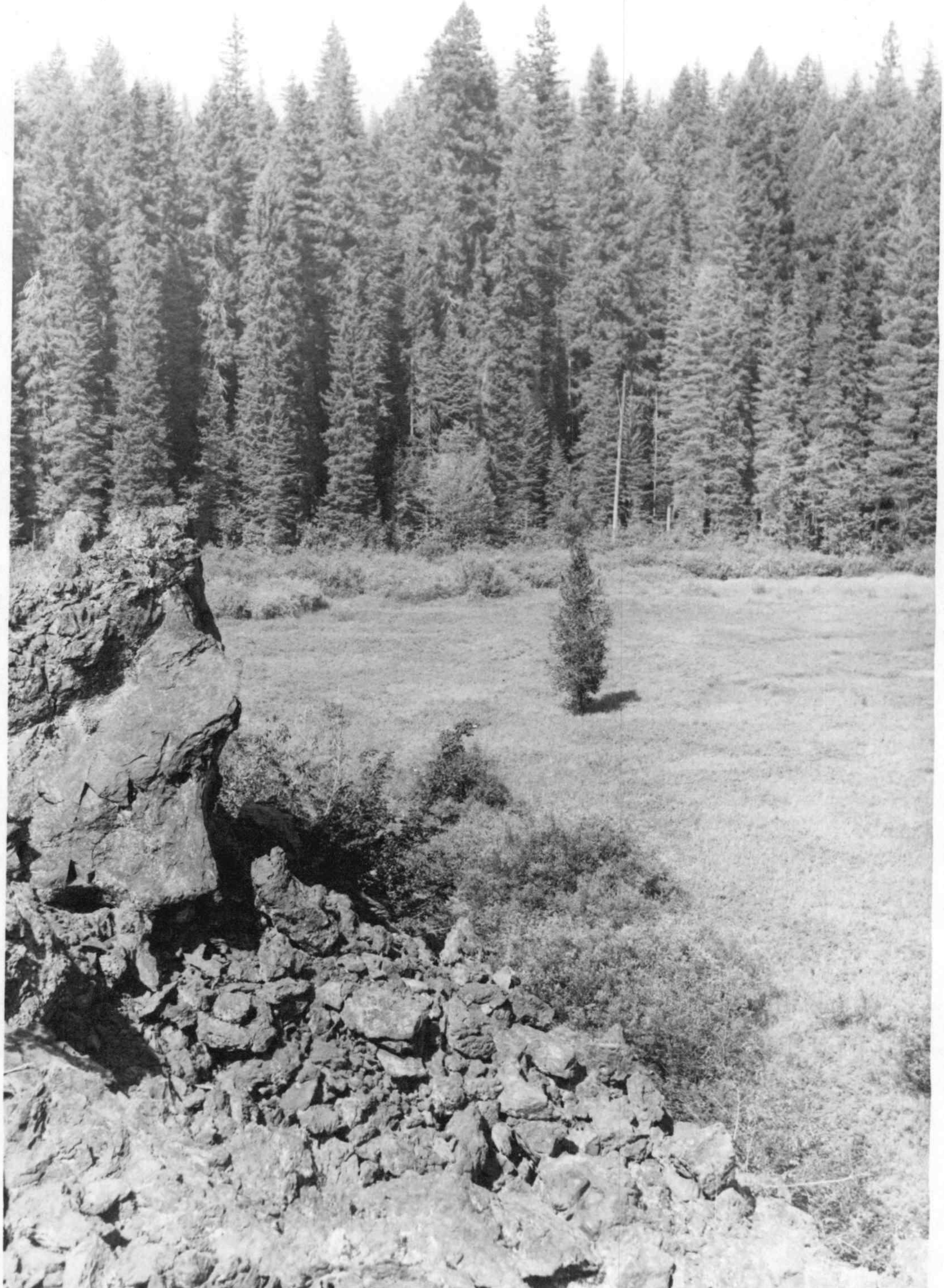


Table XV

Phytosociologic data of the Salix and Vaccinium occidentalis unions and the Carex sitchensis union of the Carexeto-vaccinetum occidentalis association. The former are of the frutescent synusia and the latter of the herbaceous.

Species	Abundance No.	Abundance % T.Ab.	Density	% F.	Space* Area	Space* % T. C.
Shrubs						
Vaccinium occidentalis Gray	240	82	15.0	81	36.0	79
Salix scouleriana Barr.	14	5	0.9	6	3.2	7
Salix piperi Bebb.	21	7	1.3	12	2.1	5
Alnus sinuata (Regel) Rydb.	3	1	0.2	6	2.0	4
Sambucus racemosa L. var callicarpa (Greene) Jep.	4	1	0.2	6	1.2	3
Lonicera involucrata Banks var. ledebourii Jep.	7	2	0.4	12	0.3	1
Amelanchier florida Lindl.	4	1	0.2	6	0.4	1
Spiraea douglasii Hook var. menziesii (Hook.) Presl.	1	0	0.0	6	0.0	0
Herbs						
Carex sitchensis Presc.	324	64	20.2	87	---	--
Smilacina sessilifolia (Baker) Nutt.	26	5	1.6	21	---	--
Agrostis thurberiana Hitchcock	14	3	0.9	37	---	--
Potentilla palustris (L.) Scop.	28	5	1.7	6	---	--
Carex rostrata Stokes	42	8	2.6	12	---	--
Juncus filiformis L.	20	4	1.3	6	---	--
Carex disperma Dewey Carex leptopoda Mack.	22	4	1.4	6	---	--
Habenaria leucostachys (Lindl.) Wats.	5	1	0.2	25	---	--
Glyceria pauciflora Presl.	5	1	0.2	6	---	--
Mimulus dentata Nutt.	5	1	0.2	12	---	--
Carex sp.	5	1	0.2	6	---	--
Calamagrostis canadensis (Michx.) Beauv.	8	1	0.4	6	---	--
Cicuta douglasii (DC.) C. & R.	2	0	0.1	12	---	--
Mimulus primuloides Benth.	--	--	---	--	---	--
Hypericum anagalloides C. & S.	--	--	---	--	---	--

Abund. - abundance; Dens. - density; % F. - percent frequency; No. - relative abundance; % T. Ab. - percent of total abundance; % T.C. - percent of total covered area.
*Space is cover and area is in square meters of intercepted area.
Two lodgepole pine were growing in the bog but were not sampled; the bryophytic layer was composed of a solid mat of Rhacomitrium sp. without sporophytes.

only beneath the willow cover. However, this synusia comprises only one union since elements of the open bog extend into this zone. Most of the above species are expressly palustrophytes confined to the shallow water and swampy conditions of the marginal ditch.

Over the bog, one plant, Carex sitchensis dominates this union; its high frequence (87) and density (20.2) also brings into relief its sociologic position since it grows as high as V. occidentalis (Table XV). It is easily the superior plant irregardless of life form, and thus, was considered a co-dominant with V. occidentalis in designating the association.

In open patches of water, Carex rostrata, Juncus filiformis, and Potentila palustris predominate. Only C. rostrata is present on the slightly higher peat with C. sitchensis. Scattered individuals of Agrostis thurberiana (frequence 37; density 0.9), and Habenaria leucostachys (F. 25; D. 0.2) are associated with the closed cover of C. sitchensis and C. rostrata. One moss forms a dense lower stratum[1].

3. Interrelations of the Community.

The chemico-physical factors which typify a bog environment

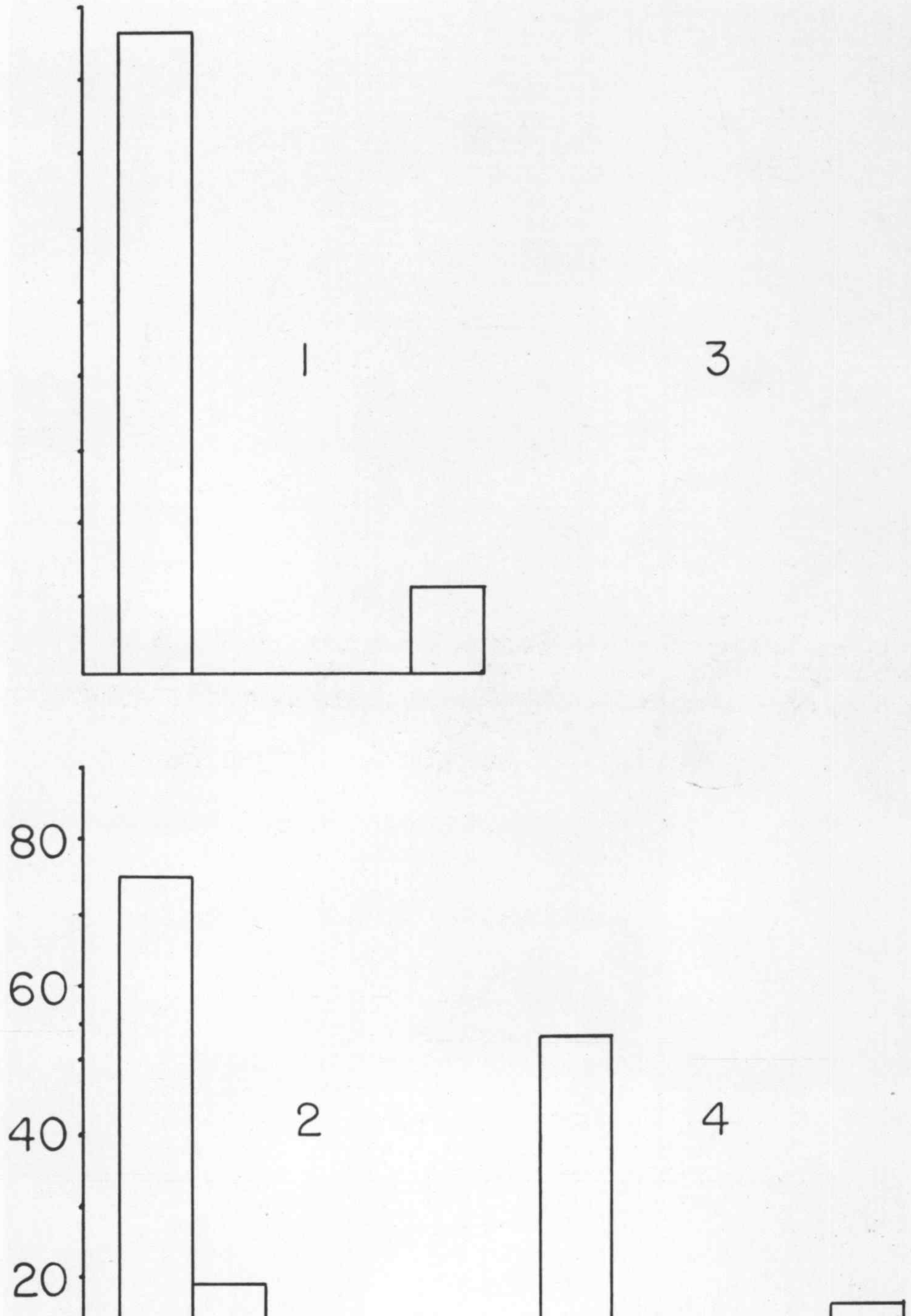
[1] Unidentifiable as it apparently produces no sporophytes. It is believed by Mr. Frank Nichol to be close to the genus Rhacomitrium.

define a rather select and quite different flora in any region. It is not surprising here that few or no affinities with the surrounding associations are visible in the species list. *Smilacina sessilifolia* from the climax forest does infiltrate a short ways into the bog. And three individuals of one other species, *Pinus contorta* var. *murrayana* -- left off of the species list so as not to introduce an additional layer into the already crowded table -- are established in the open bog. However, these are but slight changes. The lack of active hydrarch succession to the higher forest units illustrates the youth of the bog. Yet, the physiography of the basin and the drainage pattern both discount a raising of the water and peat levels to a height much above the present levels. Undoubtably then, incoming sediments will soon fill in the bog, lower the water table, and forest enroachment take place.

Within the association, one change is taking place. The few remaining, small spaces of open water are gradually being filled in by sedge peat, closely followed by *V. occidentalis* and *C. sitchensis*. The extent of the willow band seems fixed by the depth of the substrate around the shore line. Conceivably, as the bog fills in, it will cover over the peat and be followed by the climax forest stage.

The frequency charts reveal, in both synusiae, wide gaps in the middle of the spectrum (Figure 28). This, then, is a

Figure 28. Frequency graphs of the unions of the Carexeto-vaccinetum occidentalis association. 1 - frutescent synusia; 2 - herbaceous synusia; 3 - bryophytic synusia; 4 - Raunkaier's normal. The capital letters represent the percentage of species (y-axis) that had the following frequencies: A - 0 to 20%; B - 21 to 40%; C - 41 to 60%; D - 61 to 80%; E - 81 to 100%.


1
3
80
60
40
20
%
2
4
A B C D E
A B C D E

primary sere in its first stages of development prior to fluctuation and replacement.

Throughout the short spring and into summer, the bog is covered with water from the melting snows. Drainage is slow and only in late summer and early autumn does the outflow lower the water table down into the peat. This is particularly reflected in the phenology of the lower life forms(Table XVA). Their life cycles are often quite short but must vary from year to year depending upon the depth of the snow pack and the melting factors.

Vernal species as S. piperi and S. scouleriana flowered behind those of other associations. Many herbs were pushed into the autumnal phase by the high water, including Mimulus primuloides, Hypericum anagalloides and Cicuta douglasii.

H. THE Aceretum circinati xerophyllosum ASSOCIATION.

Lying between the lavas and the climax forest, this association presents an interrupted belt never more than 10 to 15 feet in width. As an ecotone community of such small area, it may not have adequate unity to attain association status. Its species are derived from the adjoining associations, and only two species may be considered constants.

These type species are vine maple and Xerophyllum tenax (Tables XVI and XVII). Both have low frequence and do not

Table XVA

Phenology of the shrubs and herbs of the <u>Carexeto-vaccinetum occidentalis</u> association for the May - September growing season of 1949.

Species	May	June	Months July	Aug.	Sept.
Shrubs					
Vaccinium occidentalis	- - - -	- - - x	⊗ 0 0 0	0 0 0 0	0 0 -
Salix scouleriana	- - - -	- - - x	x 0 - -	- - - -	- - -
Salix piperi	- - - -	- - - x	x 0 - -	- - - -	- - -
Alnus sinuata			- no record -		
Sambucus racemosa var. *callicarpa*	- - - -	- - x x	x ⊗ ⊗ 0	0 0 0 0	0 0 0
Lonicera involucrata var. *ledebourii*	- - - -	- - - x	x ⊗ ⊗ ⊗	0 0 0 0	0 0 0
Amelanchier florida	- - - -	- - x x	⊗ ⊗ ⊗ 0	0 0 0 0	0 0 0
Spiraea douglasii var. *menziesii*	- - - -	- - - -	- ⊥ ⊥ x	x x ⊗ ⊗	0 0 0
Herbs					
Carex sitchensis	- - - -	- - x x	⊗ 0 0 0	0 0 - -	- - -
Smilacina sessilifolia	- - - -	- - ⊥ x	x ⊗ ⊗ 0	0 0 0 -	- - -
Agrostis thurberiana	- - - -	- - x x	0 0 0 -	- - - -	- - -
Potentilla palustris	- - - -	- - - -	- ⊥ x x	⊗ ⊗ 0 0	0 0 0
Carex rostrata	- - - -	- - - -	x x ⊗ ⊗	0 0 0 0	- - -
Juncus filiformis	- - - -	- - - x	x ⊗ 0 0	0 - - -	- - -
Carex disperma			- no record -		
Carex leptopoda			- no record -		
Habenaria leucostachys	- - - -	- - - -	- - ⊥ x	x ⊗ ⊗ 0	0 - -

Table XVA continued

Glyceria pauciflora	- - - -	- - - -	- - ⊥ x	x 0 0 0	0 - -
Mimulus dentata	- - - -	- - - -	- - x x	⊗ ? ? 0	0 - -
Carex sp.	- no record -				
Calamagrostis canadensis	- - - -	- - - -	- - - ⊥	x 0 0 0	0 0 -
Cicuta douglasii	- - - -	- - - -	- - - -	⊥ x x ⊗	⊗ ⊗ 0
Mimulus primuloides	- - - -	- - - -	- - - -	- - - -	x x ⊗
Hypericum anagalloides	- - - -	- - - -	- - - -	- - - x	⊗ ⊗ ⊗

- - floral inactivity; ⊥ - in bud; x - flowering; ⊗ flowering and fruiting; 0 - fruiting; ? - unknown.

Table XVI

Phytosociologic data of the *Acer circinatum* union and the bryophytic layer of the *Aceretum circinati xerophyllosum* association.

	Quantitative						Synthetic		
	Abund.		Dens.	% F.	Cover		Presence		
	No.	% T.Ab.			Sq. M.	% T.C.	A	B	C
Shrubs									
Acer circinatum Pursh	40	26	3.3	66	7.5	79	x	x	x
Rubus parviflorus Nutt.	45	30	3.7	33	0.2	2	-	x	x
Pachistima myrsinites (Pursh) Raf.	15	10	1.2	33	0.2	2	-	x	x
Arctostaphylos nevadensis Gray	9	6	0.7	16	0.6	6	-	-	x
Rhamnus purshiana DC.	10	7	0.8	42	0.2	1	x	-	-
Vaccinium membranaceum Dougl.	21	15	1.7	8	0.2	2	-	-	x
Castanopsis chrysophylla A. DC.	5	3	0.4	8	0.5	6	-	-	x
Berberis nervosa Pursh	3	2	0.2	8	0.2	1	-	-	x
Rosa gymnocarpa Nutt.	2	1	0.2	8	0.0	0	-	-	x
Mosses									
Hypnum fertile Sendt.	---	--	---	16	0.5	77	-	x	x
Rhacomitrium patens (Dicks.) Hueb.	---	--	---	16	0.2	33	-	x	x

Abund. - abundance; Dens. - density; % F. - percent frequency; No. - relative abundance; % T. Ab. - percent of total abundance; Sq. M. - square meters of area covered; % T.C. - percent of covered area; A - North Santiam Highway; B - near Fish Lake; C - South Santiam Highway.

Table XVII

Phytosociologic data of the Xerophyllum tenax union, the herbaceous synusia, of the Aceretum circinati xerophyllosum association.

Species	Quantitative				Synthetic		
	Abundance		Density	% F.	Presence		
	No.	% T.Ab.			A	B	C
Xerophyllum tenax (Pursh) Nutt.	41	30	3.4	53	x	x	x
Asarum caudatum Lindl.	25	18	2.1	25	-	x	x
Linnaea borealis L. var. americana (Forbes) Rehder	21	15	1.7	16	-	x	x
Trillium ovatum Pursh	6	4	0.5	42	x	-	x
Achlys triphylla (Smith) DC.	3	2	0.2	25	-	x	x
Chimaphila umbellata (L.) Nutt. var. occidentalis (Rydb.) Blk.	2	1	0.2	8	-	x	x
Anemone deltoidea Hook.	9	7	0.7	25	-	-	x
Trientalis latifolia Hook.	8	6	0.7	16	-	-	x
Mertensia paniculata (Ait.) G.Don. var. borealis (Macbr.) Wms.	4	3	0.3	16	-	-	x
Hieracium albiflorum Hook.	4	3	0.3	25	-	-	x
Lotus douglasii Greene	3	2	0.3	8	-	-	x
Fragaria bracteata Hel.	2	1	0.2	16	-	-	x
Viola glabella Nutt.	2	1	0.2	8	-	-	x
Lupinus albicaulis Dougl.	2	1	0.2	8	-	-	x
Anemone oregana Gray	1	1	0.1	8	-	-	x
Smilacina sessilifolia (Baker) Nutt.	1	1	0.1	8	-	-	x
Pteridium aquilinum (L.) Kuhn var. pubescens Underw.	1	1	0.1	8	x	-	-
Antennaria argentea Benth.	--	--	---	--	-	-	x
Apocynum androsaemifolium L. var. incanum A. DC.	--	--	---	--	-	-	x
Lilium washingtonium Kell.	--	--	---	--	-	-	x
Anaphalis margaritacea (L.) B. & H.	--	--	---	--	-	-	x
Vicia americana Muhl.	--	--	---	--	-	-	x
Iris chrysophylla How.	--	--	---	--	-	-	x
Pyrola bracteata Hook.	--	--	---	--	-	-	x
Arenaria macrophylla Hook.	--	--	---	--	-	-	x
Lathyrus bijugatus White var. sandbergii White	--	--	---	--	-	-	x

% F. - percent frequency; % T. Ab. - percent of total abundance; A - North Santiam Highway; B - near Fish Lake; C - South Santiam Highway.

prescribe any semblance of sociologic pattern or continuity. For convenience, the frutescent layer is called the Acer circinatum union and the herbaceous layer the Xerophyllum tenax union. All species do, however, on the fluvium, attain greater growth form than they do in their respective associations. Also, species from the climax forest commence their flowering much earlier in this ecotone (Table XVIIA).

The long association list is one of influents, most found at only one station. Moreover, this heterogeneity or admixture is manifest in the frequency diagrams (Figure 29). No species are present in class E of both strata. Both strata superfically appear to be approaching a terminus, and in the future, no doubt, this belt will be replaced by climax forest. Soil is present and deep and it is puzzling that there is an absence of small trees or seedlings in this apparently adequate niche.

I. SYNGENETICAL TRENDS.

A series of young priseres such as these present a study of arrested dynamics. Interchange, extinction, and invasion are negligible forces. The associations retain their primary integrity; and allegoric logic, not evidence, is the only index of the probable mechanistics of future transmutations.

Undoubtadly three of the associations are primary seres:

Table XVIIA

Phenology of the shrubs and herbs of the <u>Aceretum circinati xerophyllosum</u> association for the May - September growing season of 1949.

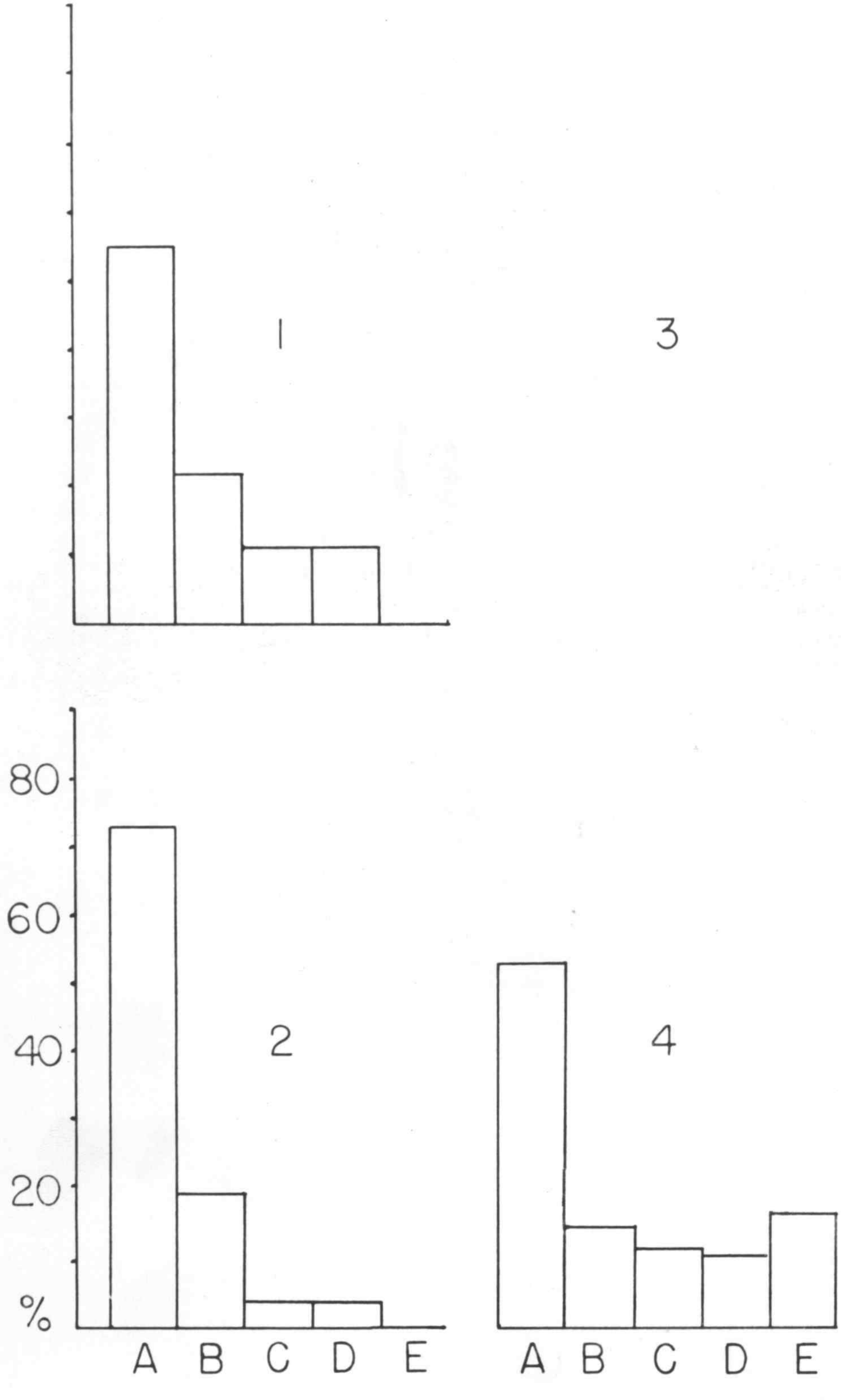
Species	May	June	July	Aug.	Sept.
Shrubs					
Acer circinatum	- - - x	x ⊗ ⊗ ⊗	0 0 0 0	0 0 0 0	0 - -
Rubus parviflorus	- - - -	- - - x	x ⊗ ⊗ ⊗	⊗ ⊗ 0 0	0 - -
Pachistima myrsinites	- - - x	x ⊗ ⊗ ⊗	⊗ ⊗ ⊗ ⊗	⊗ ⊗ ⊗ ⊗	⊗ ⊗ ⊗
Arctostaphylos nevadensis	- - - -	x x x ⊗	⊗ ⊗ ⊗ 0	0 0 0 0	0 0 0
Rhamnus purshiana	- - - -	- - - -	⊥ x ⊗ ⊗	0 0 0 0	0 0 0
Vaccinium membranaceum	- - - x	x x ⊗ ⊗	0 0 0 0	0 0 0 -	- - -
Castanopsis chrysophylla	- - - -	- - - -	- - - ⊥	x x ⊗ ⊗	0 0 0
Berberis nervosa	- - - -	⊥ x x ⊗	0 0 0 0	0 0 0 0	0 0 0
Rosa gymnocarpa	- - - -	- - - -	- x x ⊗	⊗ 0 0 0	0 0 0
Herbs					
Xerophyllum tenax	- - - x	x x x ⊗	⊗ ⊗ 0 0	0 0 0 -	- - -
Asarum caudatum	- - - -	- - - -	- - - ⊥	x x x x	0 0 0
Linnaea borealis var. americana	- - - -	- - - -	⊥ x x ⊗	⊗ ⊗ 0 0	0 0 -
Trillium ovatum	- - - x	x ⊗ ⊗ ⊗	⊗ 0 0 0	0 0 0 -	- - -
Achlys triphylla	- - - -	⊥ x x ⊗	⊗ 0 0 0	0 0 0 0	0 - -
Chimaphila umbellata var. occidentalis	- - - -	- ⊥ ⊥ ⊥	⊥ ⊥ x x	x ⊗ ⊗ ⊗	0 0 0
Anemone deltoidea	- - - -	- - ⊥ x	x x x ⊗	⊗ 0 0 0	0 - -
Trientalis latifolia	- - - -	- - x x	x ⊗ ⊗ 0	0 - - -	- - -
Mertensia paniculata var. borealis	- - - -	- - - -	x x ⊗ ⊗	⊗ 0 0 0	0 0 0
Hieracium albiflorum	- - - -	- - ⊥ x	x x x x	⊗ ⊗ ⊗ ⊗	⊗ 0 0

Table XVIIA continued

Lotus douglasii	- - - - - - - - - - ⊥ x ⊗ ⊗ ⊗ ⊗ ⊗ ⊗ 0
Fragaria bracteata	- - - - - - x x x x ⊗ ⊗ 0 0 - - - - -
Viola glabella	- no record -
Lupinus albicaulis	- - - - - - - x ⊗ ⊗ ⊗ ⊗ ⊗ ⊗ 0 0 0 - -
Anemone oregana	- - - - - x x ⊗ ⊗ ⊗ 0 0 0 0 0 0 - - -
Smilacina sessilifolia	- - - - - - ⊥ x x ⊗ ⊗ 0 0 0 0 - - - -
Antennaria argentea	- no record -
Apocynum androsaemifolium var. *incanum*	- - - - - - - - - - - - ⊥ x x ⊗ ⊗ 0 ?
Lilium washingtonium	- - - - - - - - - x x x ⊗ ⊗ 0 0 0 0 -
Anaphalis margaritacea	- - - - - - - x x x x ⊗ ⊗ ⊗ ⊗ ⊗ ⊗ 0 0
Vicia americana	- - - - - - x x ⊗ ⊗ ⊗ ⊗ 0 0 0 - - - -
Iris chrysophylla	- - - - - - - x x x ⊗ ⊗ ⊗ 0 0 - - - -
Pyrola bracteata	- - - - - - ⊥ ⊥ ⊥ ⊥ ⊥ x ⊗ ⊗ 0 0 0 0 -
Arenaria macrophylla	- - - - - - x x ⊗ ⊗ ⊗ 0 0 0 0 0 - - -
Lathyrus bijugatus var. *sandbergii*	- - - - - - - x x x x ⊗ ⊗ 0 0 0 0 - -

- - floral inactivity; ⊥ - in bud; x - flowering; ⊗ flowering and fruiting; 0 - fruiting; ? - unknown.

Figure 29. Frequencies of the discontinuous synusiae of the ecotone community, the Aceretum circinati xerophyllosum association. 1 - frutescent synusia; 2 - herbaceous synusia; 3 - bryophytic synusia; 4 - Raunkaier's normal. The capital letters represent the percentage of species (y-axis) that had the following frequencies: A - 0 to 20%; B - 21 to 40%; C - 41 to 60%; D - 61 to 80%; E - 81 to 100%.


1
3
80
60
40
20
%
2
4
A B C D E
A B C D E

the block basalts of the _Aceretum_ _circinati_ _lavosum_; the peats of the _Carexeto-vaccinetum_ _occidentalis_; and the ash-lapilli mantle of the _Pinetum_ _contorti_ _lapillosum_. Their species lists denote their individuality -- a lack of species that might replace the constants when the latter's reaction alters the present environments to make such invasion possible. Perceivably all three seres will be replaced in time by the regional climax, the _Pseudotsugetum_ _taxifoliae_ _tsugosum_.

A thread of species interchange links together four associations directly. The herbaceous and frutescent species of the _Aceretum_ _circinati_ _lavosum_ also make up the understory of the _Pseudotsugeto-abietum_ _lasiocarpi_; and in the _Pseudotsugeto-abietum_ _lasiocarpi_ a few seedlings and small trees are sparingly established of species which play dominant and sub-dominant roles in the _Pseudotsugeto-abietum_ _grandis_. A few shrubs and herbs, as we have seen, also are found here from the latter association with low quanitative values.

In the _Pseudotsugeto-abietum_ _grandis_, the major species of the preceding association occur weakly, and an invasion of climax species from the _Pseudotsugetum_ _taxifoliae_ _tsugosum_ are mixed in to a slight degree in the more mesic stands on the slopes of Nash Crater.

From these indications, then, the _Aceretum_ _circinatum_ _lavosum_ will be replaced by the _Pseudotsugeto-abietum_ _lasiocarpi_. The latter in turn will be supplanted by the _Pseudotsugeto-abietum_ *grandis* which will be superceded by the regional terminus, the *Pseudotsugetum taxifoliae tsugosum*.

It is improbable that the *Pseudotsugeto-abietum lasiocarpi* was preceded by the *Aceretum circinati lavosum* or the *Pseudotsugeto-abietum grandis* by the former. The lavas are young, the individual aggregations bound by distinct environmental differences, and only traces of reaction are visible -- such as a slight soil development in some portions of the *Pseudotsugeto-abietum grandis*.

Eventually the climax forest will cover the bog as it dries up, since it all but surrounds it. Likewise the dry ecotone vegetation between the lavas and the climax forest will directly be superceded by the *Pseudotsugetum taxifoliae tsugosum*. Herbs and shrubs are already tending towards local dominance.

Replacement of, or succession onto, the ash-lapilli flats is questionable for there are no present indications. A vast number of substratal alterations will be necessary by countless generations of lodgepole pine. Possibly, climax forest species will be able to come in with components of the *Pseudotsugeto-abietum grandis*. Undoubtedly, though, an arborescent cover of Douglas fir will first dominate, and in the absence of lava, the lower synusiae of the climax forest become established on the new soil. Past evidence makes such a supposition tenable. Many paleochronologic studies by Hansen of postglacial forest successions in the Pacific Northwest sustain a rather constant pattern of change. One such pollen record sequence (16, pp.845-847) in the Puget Sound Lowlands demonstrates the following replacement tendencies:

> "It is believed that lodgepole existed close to the ice front, and was able to invade deglaciated terrain almost immediately in the wake of the retreating ice, and thrive until physiographic and edaphic stability had been attained and sufficient time had elapsed for migration of Douglas fir and hemlock. The last two species, having a greater longevity, being of greater stature, and more tolerant of shade, gradually replaced the initial lodgepole pine forests........ The present successional relationships of Douglas fir and western hemlock in the Puget Lowland reveal that Douglas fir is a subclimax species that thrives and persists as a result of clearing or burning of the climax forest. If a forest is undisturbed by fire, disease, or cutting for five or six centuries, Douglas fir is almost entirely replaced by western hemlock and other climax dominants."

J. THE BIOLOGICAL SPECTRUM OF THE TOTAL VEGETATION.

Any collective flora may be divided into classes which are based upon life-form grouping and response. This is a selective environmental effect just as are other structural derivations -- namely: stratification, abundance, presence, dispersion, etc. Such life-form classes are founded upon the different positions of the perianating organs of plants during the unfavorable season of the year. A principle synthesized by the acute Danish botanist, C. Raunkiaer, familiar with world climates and floras, who expanded it into his widely accepted life-form system (21). In this large work, he formulated a normal world spectrum from a large number os species selected at random.

Obviously, the greater the height, the less protection is afforded to the buds. Floras predominately composed of species with high buds would be the expression of a mild unfavorable season such as in the tropical rain forest. Moreover, high percentages of lower life-forms would be indicative of severe environment during the unfavorable season, as in tundra. Oosting (18, p.113) states:

> "When a regional spectrum is determined, at least one of the life form percentages will invariably exceed the percentage of that group in the normal spectrum. This outstanding group is the real measure of the selective nature of the sum total of environmental factors involved and the climate can thus be termed Chamaephytic or Hemicryptophytic, etc., as the case may be."

The life-form spectrum was computed for the species of all associations studied. The class percentages were derived from life-form designations appended to each plant in the alphabetical species list of the appendix. Appearing on this list are many established ruderals not included in the association lists. Such are adventives restricted to the roadsides, Fish Lake picnic ground, and the Remount Station dump ground.

One must assume from the data of Table XVIII that the climate of the Nash Crater region is largely Cryptophytic. The Cryptophytic percentage of 29 strongly exceeds that of normal (6). There is also a significant increase in the Hemicryptophytes of this area — 42 as compared to 26 for the normal. Such a high percentage of Cryptophytes with a relatively, correspondingly low percentage of Chaemophytes has been broadly interpreted as characteristic of

Table XVIII

The life-form spectra of Nash Crater lava flows, other Northwest Pacific areas, and the world normal.

Region	No. of spp.	Percentage distribution of spp. Ph	Ch	H	Cr	Th
Nash Crater Lava Flows	174	20.0	5.0	42.0	29.0	3.0
Cascade Range	---	10.2	9.5	35.8	37.2	7.3
Oregon	---	9.6	6.3	37.3	25.3	21.3
Mary's Peak	---	19.0	2.0	54.0	25.0	0.0
Normal Spectrum	---	46.0	9.0	26.0	6.0	13.0

Ph - phanerophytes; Ch - chamaephytes; H - hemicryptophytes; Cr - cryptophytes; Th - therophytes.

temperate climates (18, p.113). Nevertheless, northern affinities are present, and edaphic and geologic factors in addition to climate produce a variety of habitats and associated species in this region. A Cryptophytic climate, not recognized by Raunkiaer, would seem more appropriately of a high latitude or orographic vegetation such as the boreal forests of North America. Mary's Peak, the highest peak in Oregon's coast range, represents strong boreal parities modified by maritime influence, and has much the same trends as are shown in the Nash Crater spectrum. The differences between these two in the Therophytic class probably reflects the xeric influence in the latter. The tremendous increase of Therophytes and the low percentage of Phanerophytes in the spectrum for Oregon as a whole, undoubtedly, is due to the semi-arid and arid eastern part of the state which makes up most of Oregon's area.

The spectrum for the Cascade range attests that it, too, represents a Cryptophytic climate. Also, the low percentage of Phanerophytes reflects northern affinities. However, its 10.2 percent value may be one caused by disturbance since it has a higher number of Therophytes than does the other spectra.

The differential habitat extremes would have been revealed in an analysis of spectra for the different communities of the Nash Crater flows. Yet these differences would have been slight, for still there are no disturbed or burned areas in these montane priseric aggregations. The absence of therophytes from all associations would discount variations of high Therophytic values which mark stages of subseral succession, as in abandoned field areas. The whole spectrum is perhaps distorted since the climax forest conditions are more favorable than in the area as a whole. The high percentage of Hemicryptophytes over the normal in conjunction with the Cryptophytic indications manifests the maritime modifications of a high latitade or boreal climate. This is also apparent in the spectra of the other three regions mentioned.

VI. ENVIRONMENTAL ANALYSIS

A. MICRO-CLIMATIC FACTORS.

The mean average precipitation of 50 inches has, as we have seen, a relatively high effectivity since there are high humidities even during the dry summer months. The regional temperatures are likewise moderate, tempered during the winter by marine influence, the snow pack, and exclusion of Continental Polar air by the High Cascades and Rockies. However, this regional orographic pattern is altered in the Santiam region somewhat by degrees of forest consolidation, substrate, and, to a lesser measure, topography.

Table XIX presents comparative temperature and humidity data of two stations maintained during the growing season in the two extremes of habitat diversity, the open lava and the climax forest. During the most effective portion of the growing season, which is the last of May, maximum temperatures are lower in the forest; the nightime difference is 19°, and that during the daytime, 9°. Ground moisture supply and melt water runoff is still high and the lava mass is still relatively cool. In the first half of July, however, the diurnal ranges become much greater. The night and day differentials are 16 and 23 degrees respectively. Also, the day maximum average is 103 degrees in the lavas for these 15 days. Minimum temperatures are always lower in the forest; and, as is to be expected, there is less of a range between maxima and minima in the forest

Table XIX

Maximum and minimum temperatures and relative humidities taken within the climax forest and in the open lava at ground level for most of the growing season of 1949.

Period	Temperatures								Humidities		
	Maximum				Minimum						
Station	N		D		N		D				
	H	Ave	H	Ave	L	Ave	L	Ave	Max	Min	Ave
June 25 to 30											
Lava	75	72	73	63	46	48	46	55	100	32	70
Forest	59	53	62	54	38	40	42	46	100	52	82
July 1 to 15											
Lava	99	88	107	103	48	51	50	65	74	15	41
Forest	80	72	90	80	48	48	48	59	84	40	62
July 15 to 31											
Lava	68	63	85	70	46	51	54	58	100	47	73
Forest	76	66	84	75	44	48	50	58	100	53	84
August 1 to 15											
Lava	74	72	96	81	48	51	55	62	70	40	54
Forest	60	59	62	59	40	45	50	60	79	62	70
August 15 to 31											
Lava	75	73	86	79	40	45	54	60	60	40	51
Forest	64	63	66	61	42	45	54	56	72	53	64

N - readings for the hours 8 PM to 8 AM; D - readings for the hours 8 AM to 8 PM; H - highest maximum temperature; L - lowest minimum temperature; Humidity readings are for the twenty four hours.

than in the lavas.

The humidity data reflect foggy and light rain interims during the summer, a condition already shown in the regional data, even though summer precipitation is very low. On an average, humidities are fairly high over the lavas, but always lower than those of the forest, in spite of their high air temperatures.

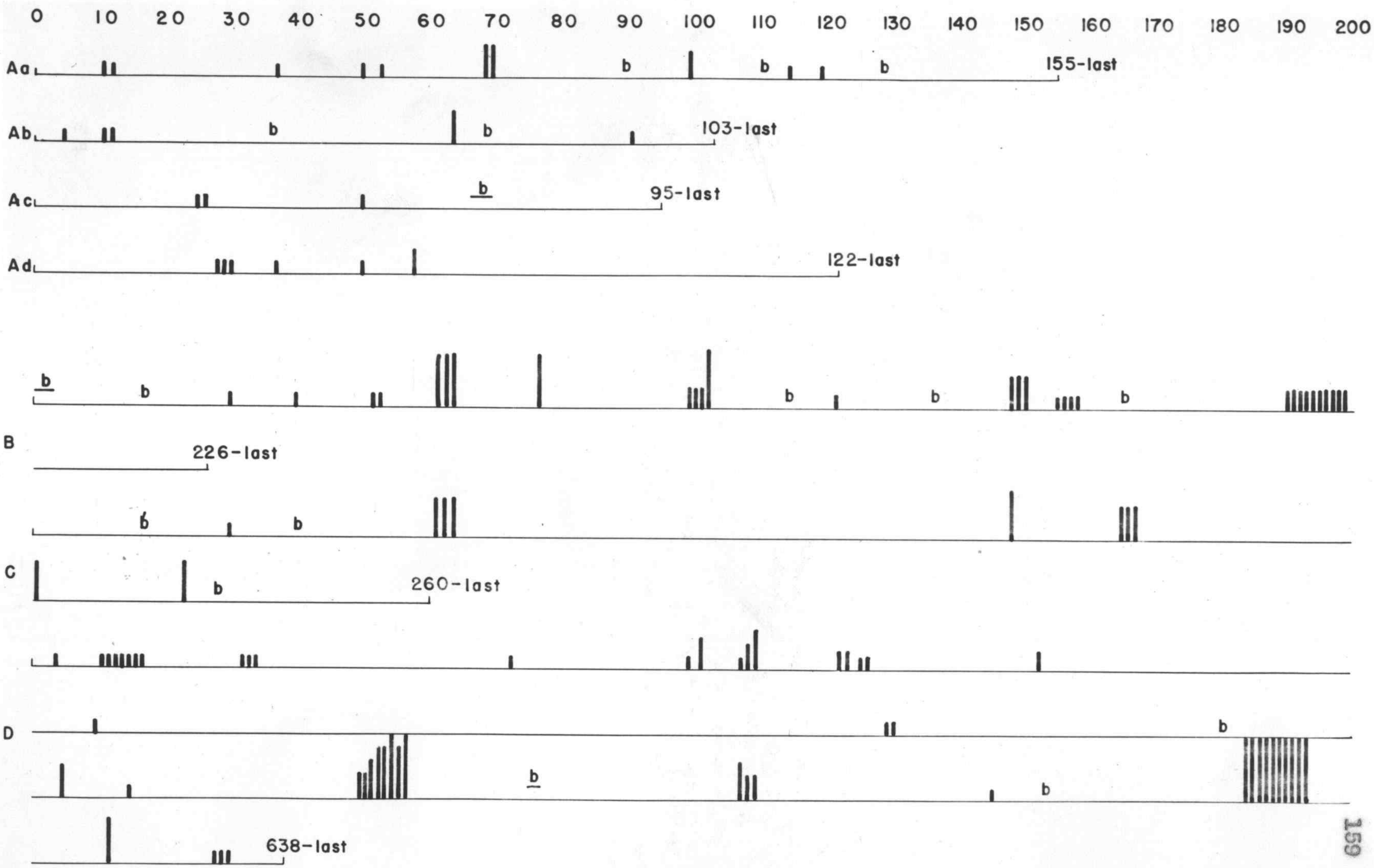
These trends are probably accountable both to, or to the lack of a heavy forest cover, and to the insolation absorptive capacity of the black lava. Beneath a shaded canopy evaporation is reduced, temperatures are more stable, and soil moisture is more effective. In both stations and for the region as a whole, air movement is notably absent so that evaporation, as reflected by humidities, is more a function of temperature.

Precipitation effectivity is further reflected in the dynamics of soil moisture in the various substrates, which will be discussed later.

Regional cycles are evident in the inconsistent ring patterns of lodgepole pine growing on the xeric lapilli flats and of Douglas fir in the lapilli-lava ecotone (Figure 30). Any fluctuations in growth or yearly ring increments might be considered as climatic in such seres where the chresard is near the critical minimum.

Part A comprises the plots of four lodgepole pine and parts B and C are of the peripheral Douglas fir. The apparent mismatching may be due to either fluctuating lodgepole pine consolidation or to a misinterpretation of the rings. Roughly,

Figure 30. Skeletal plots of the tree ring chronologies of Douglas fir and lodgepole pine growing near the airstrip. The height of the column indicates the relative narrowness of a ring in relation to the neighboring rings or the degree of an unfavorable year (14, pp.12-16). The letter "b" designates a big ring. Years are shown across the top of the diagram. A series - lodgepole pine; B and C - Douglas fir; D - Douglas fir used for chronology of the lavas.


0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
Aa
b
b
b
155-last
Ab
b
b
103-last
Ac
b
95-last
Ad
122-last
b
b
b
b
b
b
B
226-last
b
b
C
b
260-last
D
b
b
b
638-last

however, there appears to be a 50 year cycle, plus or minus 10 years, of no great intensity or divergence.

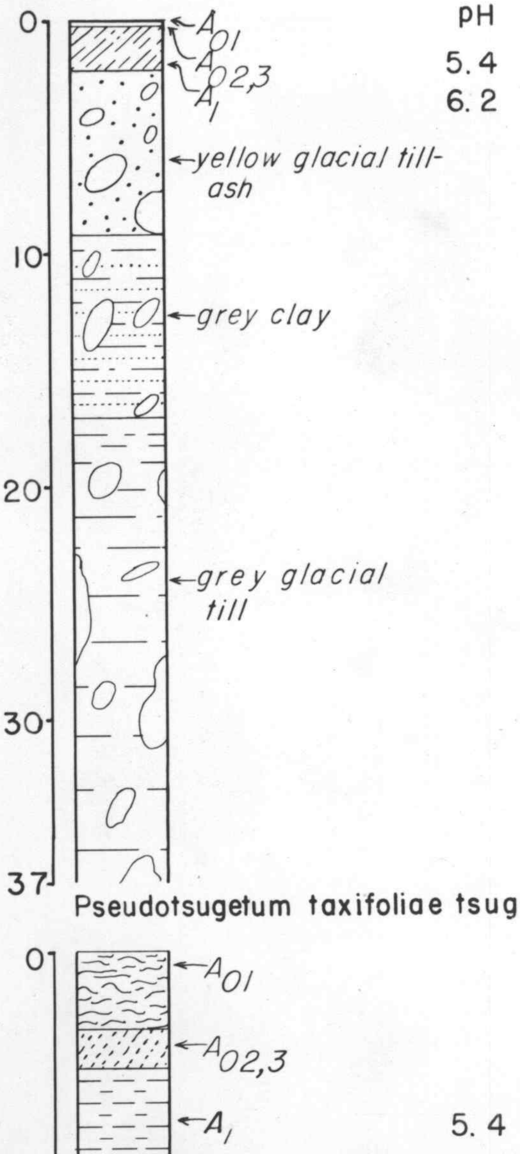
B. EDAPHIC FACTORS.

The entire substratal complex, from the ash covered glacio-fluvial soil to the block basalts and the deep ash-lapilli mantle, is one of extreme youth for in the profile ratio, despite the proposed volcanic chronology, inherited characters far outweigh acquired. Parent material is evident at all stations, and even under the climax forest the older vegetation and the regional climate have not produced a stabilized mature soil or montane podzol.

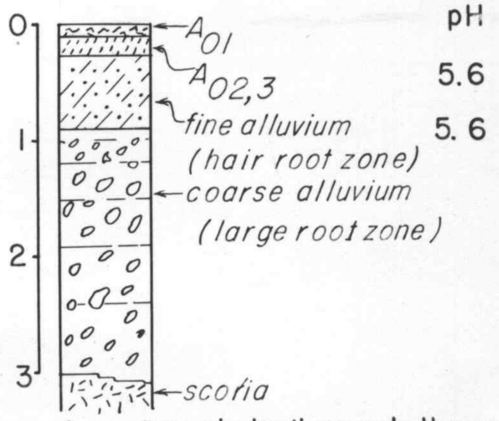
The typical profile of the Pseudotsugetum taxifoliae tsugosum is, to be sure, one but recently altered by ash deposition (Figure 31). A_{01}, 02, 03 layers are barely defined, but humus has become incorporated into 2 feet of the still-yellow ash to form an A_1. Profile layers below this depth are not discernable in the coarse yellow glacial till. However, this substrate is deep. At 10 feet it grades into hard grey clays, and thus provides an adequate substrate and root zone for the larger species.

The second profile, that of the Aceretum circinati lavosum, is not representative of the block lavas as a whole. Their composition is one of large black blocks, with large air crevices between -- there is no soil, no profile formed (Figure 32). Ash and wind-blown inorganic and organic material has been

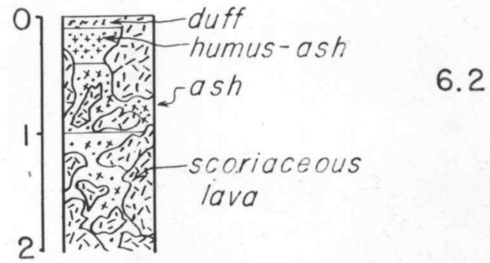
Figure 31. Representative profile diagrams of the general substrate under each of the different associations. pH determinations follow the layer sampled.



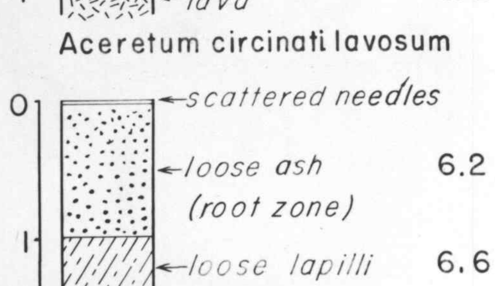
Pseudotsugetum taxifoliae tsugosum



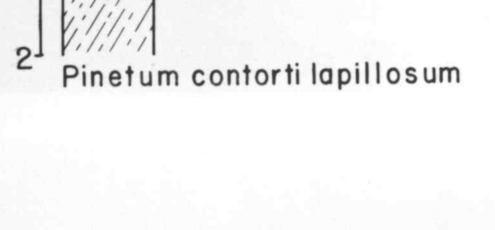
Aceretum circinati xerophyllosum



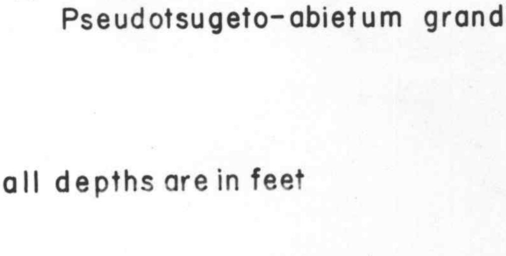
Pseudotsugeto-abietum lasiocarpi



Aceretum circinati lavosum



Pinetum contorti lapillosum



Pseudotsugeto-abietum grandis

all depths are in feet

Figure 32. The block basalts of the Aceretum circinati lavosum association. Note the lack of substrate, the large interstices, and the herbs growing in the soil pocket.

washed deep into this jumbled mass. The depicted profile does illustrate, however, pocket accumulations which are sufficient for vine maple and herbs to grow. The soil is wind borne, rich in humus and has top litter and humus layers.

The adjoining lavas which support the Pseudotsugeto-abietum lasiocarpi vary little from the preceding substrate. The blocks are perhaps smaller and the large interstices almost absent (Figure 33). Its profile, taken from a consolidated knoll, reveals both ash and scoria held in the relatively tight matrix. Here there has been no deep deposition of the finer ejectas, and the scoria is soft, crumbling easily and subject to rapid decomposition.

The more scoriaceous grey lavas of the Pseudotsugeto-abietum grandis are even softer and more decomposed. The profile diagram indicates the solid regolith and its finer textured inorganic framework. The A_0 layers are present and the humus zone of leaching is fairly well developed.

In the ash-lapilli flats of the Pinetum contorti lapillosum, mantle transmutation has been negligible underneath the existing vegetation. Substratal consolidation is evident (Figure 34), and it must not govern opportunity for establishment, as it does in the preceding lava substrate series. Its profile has no true A_{01} layer; its surface is bare, and only scattered needles and fallen lodgepole pine constitute this layer. Humus is absent in the upper soil layer, and the parent material seems as though it has just been deposited.

Figure 33. The basalts of the Pseudotsugeto-abietum lasiocarpi association. Note the smaller blocks and interstices in comparison to the receding substrate. Finer-textured materials are trapped nearer the surface and form a primitive soil.

Figure 34. The coarse ash-lapilli substrate of the *Pinetum contorti lapillosum* association. Note the poor growth form of the lodgepole pine.

The ecotone profile has the same characteristics as that of the Pseudotsugetum taxifoliae tsugosum. A_0 and A_1 layers are similar; however, the parent material is composed of sands and pebbles since the depression forms a channel for early spring runoff either to Fish or Lava Lakes or to Big Spring Bog along the face of the lavas.

No profile is recorded in Figure 31 for the sedge-peat intrazonal substrate of the Carexeto-vaccinetum occidentalis. A peat core[3] revealed both the customary gradations from brown-fibrous peat to marl typical of bogs and a depth of around 15 feet in the center. The grade of the surrounding slopes and the width of the marginal ditch, indicate that the edges must drop off rapidly to this depth.

Aside from the restrictions imposed by the degree of synthesized regolith available for vegetation, certain properties and their variance in the different young soils influence the character and structure of the flora that each will support. One of the most important, perhaps, is soil texture. Many associated edaphic factors affecting plants are governed by texture; and textural analysis, perhaps, defines their actions and potentialities as well as or better than long range measurements.

Texture affects root penetration, infiltration, rate of movement and amounts retained of water, fertility, soil structure, soil atmosphere, and soil temperature (12, pp.

[3] Sampled by H. P. Hansen for pollen analysis.

19-25). Coarse-textured soils have a high measure of infiltration. Conversely, fine soils have a high degree of runoff and a smaller amount of effective precipitation available to plants. Yet the amount infiltrated does move slower in fine-textured soils and thus more is usable. More important, however, is the amount of water ultimately held after gravitational water has drained off. The finer increments of a soil bind water through adsorption and the smaller the particle the greater the force of attraction. Thus the percent of silts, clays, or organic colloids present determines the amount of water retained for use. In close correlation, structure or pore space, depending on texture and colloid aggregation, defines aeration. Large interstitial spaces facilitate gas exchange so that maximum aeration is attained in coarse soils with low water-holding capacity, and the converse is true of clay-silt soils. In the latter, oxygen lack and high carbon dioxide content produced by respiration of soil organisms and roots may be limiting factors.

In coarse soils with free gas interchange, temperatures tend to approximate those of the atmosphere. Fine soils with less gas interchange and higher moisture contents tend to have seasonal lags and lower winter temperatures. In addition, many nutrient ions are held loosely by the colloid fraction of a soil so that in general the finer the texture of a soil the greater its fertility.

Figures 35, 36, and 37 are hydrometric curves of the

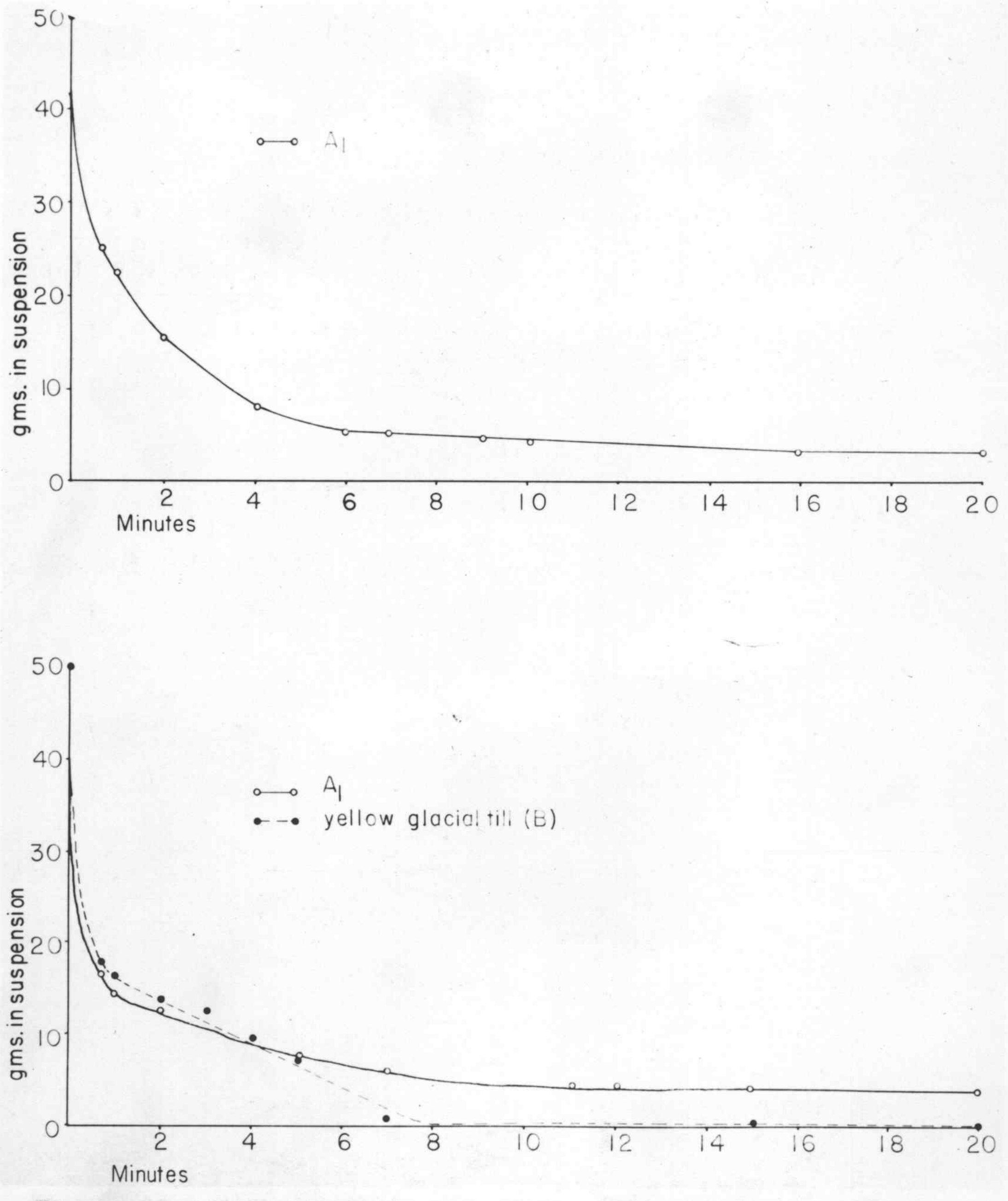


Figure 35. Hydrometric curves of the finer increments of the sampled layers of the representative profiles shown in Figure 31. The upper diagram is of the vine maple substrate and the lower is of the climax forest soil.

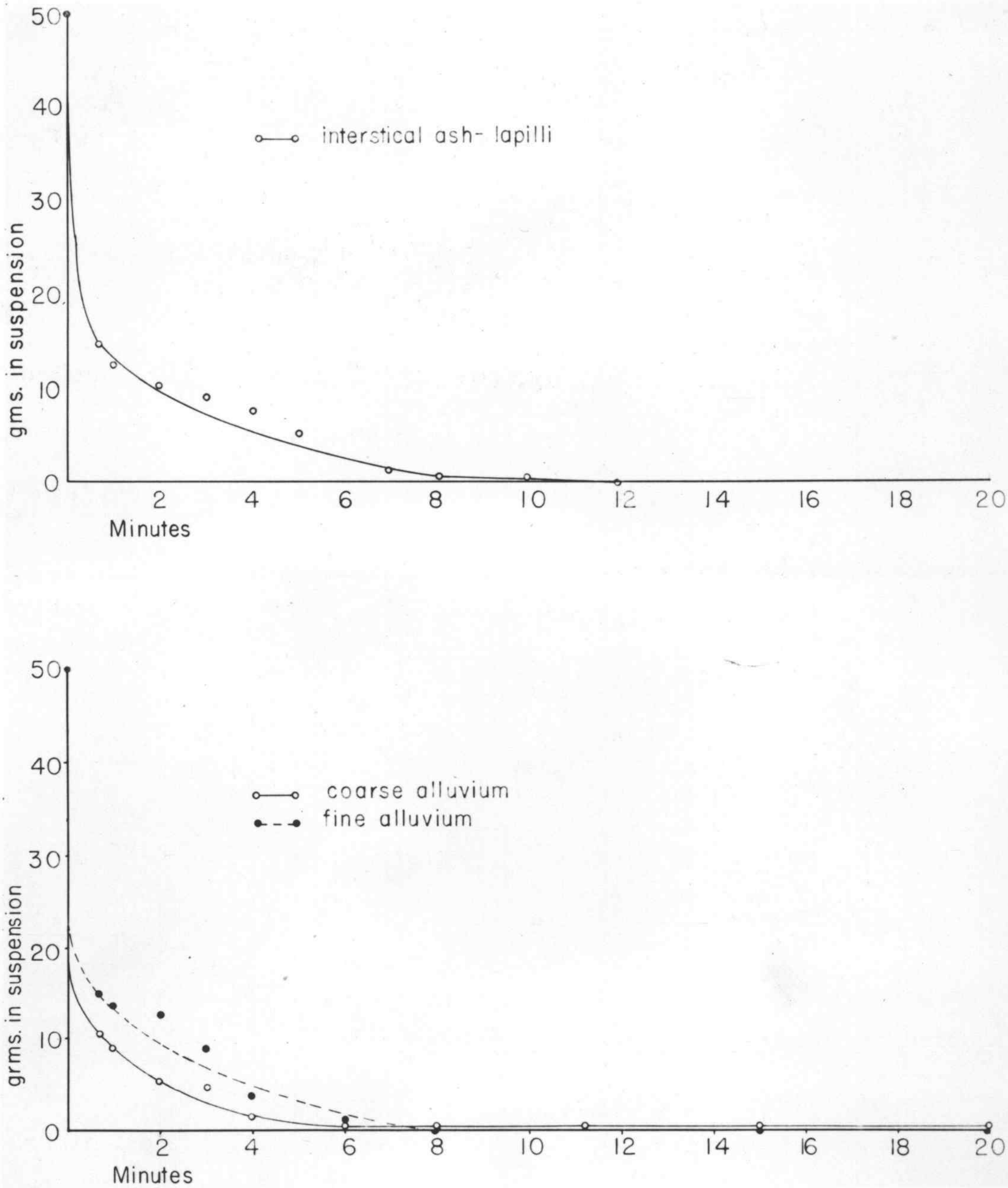
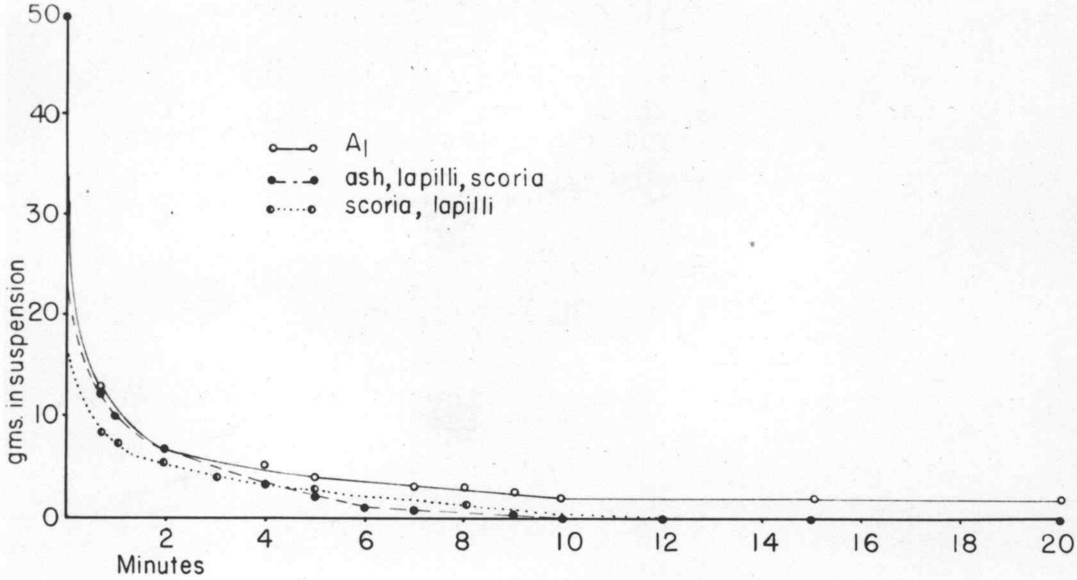


Figure 36. Hydrometric curves of the finer increments of the sampled layers of the representative profiles shown in Figure 31. The upper diagram is of the Douglas fir-subalpine fir substrate and the lower is of the ecotone soil.



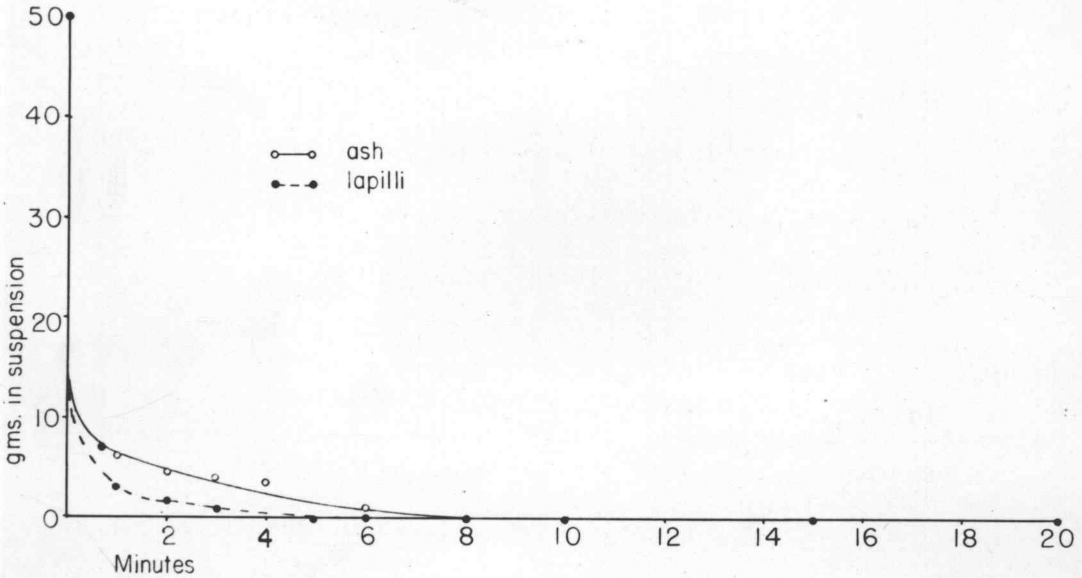


Figure 37. Hydrometric curves of the finer increments of the sampled layers of the representative profiles shown in Figure 31. The upper diagram is of the Douglas fir-grand fir substrate and the lower is of the lodgepole pine ash-lapilli mantle.

texture of layers of the representative association profiles of Figure 31. The shape of each curve indicates the proportions of sands which settle out in 40 seconds, silts which settle out in 15 minutes, and those particles up to 0.008 mm, such as clay and fine silts, which exhibit colloidal properties. The proportion of coarse-particle sizes and the permanent wilting coefficient -- a soil moisture constant regulated by percent of total colloids -- of each layer are shown in Table XX.

The pockets of soil available for plant growth in the block basalts of the Aceretum circinati lavosum have but 14 percent of their total weight of particles above 2 mm. Their curve shows no sand increments and is highest of all samples of all profiles in silt content. The remaining total colloids are high also. This bears out, then, the wind-blown origin of the humus and fine inorganic contents of the pockets. Their permanent wilting coefficient of 2.00 much surpasses those of the other profiles, beyond the climax forest soils, and it is indicative of a favorable water balance.

The most immature soil profile, the interstitial ash-lapilli of the Pseudotsugeto-abietum lasiocarpi, has a low percentage of coarse material (5), and its curve reveals about equal proportions of sand and coarse silt-sized particles. Also, there is an absence of colloidal particles. Thus the water-holding capacity (PWC 0.02) and fertility are low.

The lower layers of the Pseudotsugeto-abietum grandis

Table XX

Permanent wilting coefficients and the upper size class increments[1] of the sampled layers of the representative profiles of the associations (Figure 30).

Association Profile Layers	PWC	% Above 2 mm
Pseudotsugetum taxifoliae tsugosum		
A_1	2.80	15
Yellow glacial till-ash	0.30	10
Aceretum circinati lavosum		
A_1	2.00	14
Pinetum contorti lapillosum		
Ash	0.00	15
Lapilli	0.00	64
Aceretum circinati xerophyllosum		
Fine alluvium	0.03	39
Coarse alluvium	0.30	72
Pseudotsugeto-abietum lasiocarpi		
Interstitial ash-lapilli	0.02	5
Pseudotsugeto-abietum grandis		
A_1	1.10	59
Ash-lapilli-scoria	0.05	75
Scoria-lapilli	0.05	69

PWC - Permanent wilting coefficients.

[1] Percent of sample retained on a 2 mm screen. The texture of the remainder is shown for each sample in the following hydrometer curves.

profile have curves which are similar to the one curve of the above substrate. However, the formation of an A_1 indicates the greater favorableness for seedling and herb establishment. Fifty-nine percent of the sample is composed of coarse material and thus aeration is greater; humus colloids are not much lower. In comparison, these factors together mean less infiltration is lost to percolation, fertility is higher, and any seedling establishment is able to survive the drier portions of the growing season.

The two sampled layers of the climax forest soil show, first in the foot of A_1, 15 percent of coarse materials and a curve of little or no coarse sand content, but mostly one of silt and high colloid content and the highest permanent wilting percentage (2.80). The second layer does have a proportion of colloid increment and is mostly a single-grain coarse silt.

The alluvium layers of the ecotone profile are of coarse structure (39 and 72 percent) with sands and a low silt and colloid content. Finally, the most coarse and least favorable substrate is found in the curves for the Pinetum contorti lapillosum. The ash layer has 15 percent coarse material and the lapilli stratum 64 percent. Their curves show the highest percent of sand and the lowest amounts of both silt and colloids. Correspondingly, they have permanent wilting coefficients that are not measureable. One would expect this, then to be a consolidated substrate that is infertile, has maximum infiltration, percolation, and aeration, but minimum water-holding capacity. Also its temperatures would lag but little behind those of the atmosphere. Moreover, the low chresard is demonstrated in the lodgepole pine root pattern (Figure 38). Their roots spread out just under the surface of the substrate where any slight moisture fall can be absorbed since the lapilli below provides no available water.

pH determinations were also made for each sampled layer (Figure 31) along with the other edaphic factors studied. pH ranged from 5.4 in the upper layer of the climax forest soil to 6.6 in the lapilli of the lodgepole forest substrate. No correlation seems evident.

C. OTHER FACTORS.

Human and animal disturbance of the vegetation is not visible. The highways through the lavas have of course disturbed or altered the floral patterns but little, though many adventives, restricted to the roadsides, have been introduced from the many hay trucks that cross the pass from eastern to western Oregon during the summer. A large area of the lodgepole pine forest south of the highway junction has been cleared as an airstrip. This is kept clear of seedlings and would revert quickly once abandoned.

Evidences of fire are surprisingly absent. The old Douglas fir of the Pseudotsugeto-abietum lasiocarpi have fire-scarred trunks, but younger trees two or three feet in diameter have never been burned. The near replacement of

Figure 38. The arrangement of roots of lodgepole pine near the substrate surface. Soil moisture from slight precipitations forms the major portion of available water since the lower lapilli stratum has no water-holding capacity.

Douglas fir in the climax forest suggests that in this region at least, fire has not altered the vegetation for quite a long time. One spot fire on Lava Trail to Big Spring Bog is around 60 years old as evidenced by the number of rings overlying the edges of fire scars on several trees.

There seems to be evidence that western hemlock requires micorrhizal assistance to ecize. Seedlings occur only on dead wood, their roots covered with a yellow ectotrophic fungus. In some instances, seedlings as dense as 100 per square foot are found on half-buried logs, and are completely absent from the nearby duff which supports lovely fir seedlings. Figure 39 shows this relationship. Note that the line of young western hemlock lies along the axis of an old log.

Physiographic influence is rather uniform since the area slopes to the west. Nash Crater has a dry east-, moist west-facing effect augmented by the east lapilli and the west scoria substrate differences and somewhat lessened by the greater west-facing insolation. Both craters, however, act as resevoirs, and there is seepage from the lower slopes and at their bases. This ground storage continues into the dry part of the growing season and provides a mesic habitat in the otherwise porous substrate.

D. ENVIRONMENTAL CAUSE AND INTEGRATION.

The rather acute delineation of the separate associations, their different species complements, their different structures,

Figure 39. A row of young western hemlock in the climax forest. Its restriction to the old log depicts the dependence of western hemlock upon an ectotrophic, wood-dwelling micorrhiza for its establishment.

dispositions of social organization, and vegetational changes as the effect cannot be interpreted in the light of any one specific cause or environmental factor or factor group, the cause. It has been pointed out that the factors of the "organismo-environmental complex" (1, p.48) act collectively; and any action of any one factor is qualified by the other factors and hence cannot be considered as being a limiting factor (7, pp.17-18). Quantitative environmental data only serve to point the way to rather broad expressions of primary, secondary, or other cause or control of slowly interacting and changing reactions and coactions which eventually lead any vegetation to a near harmony or equilibrium in any particular sere, the climax.

Of the progressive series of linked associations adapted to the lavas, the Aceretum circinati lavosum is the poorest developed, the primary lithoxerosere. Its unions are scattered and show neither any social organization nor a semblance of dependence. Life cycles are quickly completed, and quantitative growth forms are comparatively stunted. It is further characterized by its extreme stability, lack of arborescent invasion, and a high ratio of xeric to mesic adapted forms. Its area has no available formed substrate except for pockets of wind-borne material. These shallow depositions dry out early in the growing season since there is no protective consolidation and temperature or evaporation extremes are high.

The structure and affinities of the remaining three associations, the Pseudotsugeto-abietum lasiocarpi, the Pseudotsugeto-abietum grandis, and the Pseudotsugetum taxifoliae tsugosum tend, respectively, towards greater consolidation of the arborescent union and towards progressive centers of control for mesic species. In the first, the Pseudotsugeto-abietum lasiocarpi, social organization is loose; however, a few dominants of the Castanopsis chrysophylla and Chimaphila umbellata unions of the Pseudotsugeto-abietum grandis are present. The lower strata are made up mostly of species from the Aceretum circinati lavosum which have lower quantitative values.

The Pseudotsugeto-abietum grandis is composed of the greatest species complement of all associations; its species are more mesic than are those of the preceding associations, and on Nash Crater, climax species have become established. Its structure shows beginnings of biotic dependency and organization. The dominants are vital and aggressive.

Certain environmental correlation seems evident. In the Aceretum circinati lavosum, as we have seen, there is no available substrate; however, there are succeeding amounts of finer material in the lavas of the following two associations. The substrate of the Pseudotsugeto-abietum lasiocarpi has a lower permanent wilting percentage, lower water-holding capacity, and thus is less mesic than that of the Pseudotsugeto-abietum grandis. Perhaps this controls initiation, but then the greater consolidated structure of each association augments mesism through successive degrees of solar radiation interception, or shading, retention of the snow pack and ground storage water into the growing season, and alteration of the substrate. In addition, the topographic features of the craters acting as resevoirs interact with the biotic and edaphic influences to form the most favorable habitat on the flows, and their slopes support, to a limited degree, regional climax species.

The most organized and mesic association, the _Pseudotsugetum taxifoliae tsugosum_, or regional climax, is perhaps defined to the greatest extent by interspecific competition. Douglas fir, which is more vital and represented in all size classes in the more open _Pseudotsugeto-abietum grandis_, is unable to continue establishment, and the species with shade tolerant seedlings as western hemlock and lovely fir are replacing it. The lower strata are represented throughout the association by only a few species which are true sciophytes and which owe their existence to the amelioration of the site by the closed forest canopy. No doubt the available deep substrate accounts in part for the presence of the climax forest, but since reaction has given it its present high water-holding capacity, biotic factors overweigh edaphic. It is also probable that western hemlock depends upon a conditioning of the site by preceding Douglas fir forest which is suitable for an associated wood fungus before it can come in.

The observations and collected researches on the characteristics of Pacific Northwest forest trees by Hansen (15, pp.71-77) substantiate these findings and add to an interpretation of their roles in the various associations. Of Douglas fir, he writes:

> ". . . if forest succession in the Puget Sound region were continued uninterruptedly for more than five or six centuries, Douglas fir would be entirely replaced by the climax species. Apparently light has been the limiting factor in this region and, in spite of its greater seed production, lesser moisture requirements, its ability to germinate and thrive on poorer soil, as well as its greater aggressiveness and degree of general adaptability, the intolerance of its seedlings for shade eventually eliminates Douglas fir from the forest complex. . . Judd stated that Douglas fir existed here only as a temporary type, which paradoxically would have vanished long ago if it had not been for the purging effects of holocaustic fires. That such fires must have occurred time and again is evidenced by its high representation throughout the pollen profiles after it had replaced the post-glacial pioneer forests of lodgepole pine."

The characteristics and requirements of two other species of the climax forest are discussed as follows:

> "Perhaps the principal limiting factor in its (western hemlock) distribution is moisture. It is one of the most tolerant Pacific Northwest conifers, and if plenty of moisture is available it will successfully compete with other species. It requires better soil conditions than Douglas fir, but its seedlings will thrive on sterile soil if sufficient moisture is present. It readily reproduces on the forest floor and is thus able to maintain itself continuously as long as there is no interruption by fire, permitting less tolerant species to gain a foothold temporarily. If there is insufficient moisture, other species, chiefly Douglas fir, will be able to compete successfully because light as a limiting factor is supplanted by moisture.
>
> White pine is primarily a montane species, typical of the Canadian life zone. . . Young trees of white pine are shade tolerant, but they demand more light with increase in age. This permits germination of seeds and the development of seedlings, but more tolerant species such as cedar and hemlock inhibit the development of older trees, and the climax develops, gradually replacing white pine through loss of parent trees for continued seed production. This is

somewhat the reverse of the status of Douglas fir whose seedlings cannot thrive on the forest floor."

The two remaining associations, the Carexeto-vaccinetum occidentalis and the Pinetum contorti lapillosum are primary seres with individualistic floras quite different, separate, and syngenetically unaffiliated with the other associations.

The species of the Carexeto-vaccinetum occidentalis are all palustrophytes adapted to the physio-chemical conditions of the peat substrate and the high water table. These conditions likewise restrict infiltration of species from the surrounding communities. Edaphic factors are primary in this hydrosere.

The Pinetum contorti lapillosum has, as does the Aceretum circinati lavosum, scattered lower unions composed of xeric species, and in which mesic species from surrounding areas are unable to exist. The ash-lapilli substrate though deep has the lowest water-holding capacity, and permanent wilting coefficient of all substrates in the area. Colloids which bind nutrient ions are absent. This sere, then, is the most xeric and unfavorable of the seres with available substrates.

The forest canopy of the abundant and frequent single species, lodgepole pine, does not alter the micro-climate of the mantle since this species is short with a narrow open crown. Actually over most of the association, the stunted condition of the trees indicates that lodgepole pine is at its lower limits of tolerance. Its particular xeric adaptations and its plasticity to unfavorable sites, which are restrictive for most Northwest Pacific conifers, explains its presence on this mantle. Hansen (15, p.72) writes:

> "Lodgepole pine is one of the most aggressive and hardy of the western forest trees. . . The characteristics that permit its pioneer invasion of new or disturbed areas are its aggressiveness and adaptability, its early seed-bearing age, sometimes at six years, prolific seed production, retention of viability, and wide range of soil tolerance. . . the seeds find a favorable place for germination in the mineral soil, while abundant light permits the seedlings to flourish. Dense even-aged stands result, growth is slow, and maturity is attained at about 200 years. Its aggressiveness in colonizing areas of edaphic change is shown by its occurrence on the pumice mantle of the southern Oregon Cascades. The deposition of the pumice, which probably destroyed most of the forests in areas of its greatest depth, resulted in an influx of lodgepole pine in a region where the climatic climax is western yellow pine at lower elevations and spruce-fir at higher elevations. On the coast the invasion of sand dunes by lodgepole attests to its aggressive nature in colonizing areas of unstable edaphic conditions. . . Two characteristics of lodgepole pine that inhibit its permanent existence in the climax forest are its extreme intolerance of shade and its relatively short life span. After the soil and physiographic conditions become stabilized, other more tolerant species gain a foothold in the lodgepole stands and gradually crowd it out. These species, which include hemlock, cedar, spruce, Douglas fir, yellow pine, larch, and the balsam firs, are all of greater longevity, and thus outlive the original stand of lodgepole and provide seed for their continual occupancy of the site until fire or some other disturbance permits lodgepole to reestablish itself."

Dead Douglas fir seedlings are scattered throughout the lodgepole association, but this species and its associated flora are able to exist on the small knolls of lava that rise through the ash-lapilli mantle. Such a disposition suggests that in the ash-lapilli, moisture relations are below the tolerance of Douglas fir seedlings, but that the lava affords some measure for their survival. This is explained by the

retention of available water under boulders and in their
pores when the bulk of the soil has dried out which carries the young seedlings through the latter or dry portion of the growing season (22, p.67).

In the final analysis the whole coniferous complex of the mid-Cascades first owes its existence to the Cascadian barrier and the resulting maritime macro-climate, which is orographically modified, and to the exclusion of Polar Continental air. In the Nash Crater area, the sharp ecotones, the three primary, stable seres, and the individuality of the remaining associations suggests that micro-edaphic control is primary -- the different substrates produced by vulcanism which occurred perhaps between 460 to 595 years ago.

Secondarily, this control is modified by forest consolidation or lack thereof which produces differences in microclimate. Of less importance, perhaps, are localized factors such as the topographic alteration produced by the two craters, and intense biotic influence in the climax forest.

VII. SUMMARY

1. Phytosociologic studies were made during the summer of 1949 on several developmental communities located in the northern portion of the McKenzie trough of the mid-Cascades in east-central Linn County, Oregon.
2. This area is comprised of a series of different, young volcanic substrates ejected from two parasitic vents on the lower western slope of the High Cascades. Basaltic magmas flowed west into the McKenzie trough, and in the waning stages of this vulcanism, underground differentiation produced mild explosions of ejecta which built up two symmetric, presently undissected scoria cones, Little Nash and Nash Craters. To the lee of the craters, a deep mantle of ash and lapilli was deposited.
3. At the westernmost penetration of the basalts, the tree ring record of a 638 year old Douglas fir, which was surrounded by the lavas, places this volcanic interim from between 460 to 595 years ago.
4. Seven associations were delineated. In each, three stands were analyzed by nested quadrats along transects for each stratum. These analyses included quantitative measurements of abundance, percent of total abundance, density, frequency, space occupied and the percent of the total, phenology, presence, and distribution of abundance of arborescent species in an arbitrary set of size classes. Such

data help determine dominance, constant or type association species, syngenetical trends, and typification of the whole fabric of each entity. Edaphic and micro-climatic studies were also made for an interpretation of cause.

5. The Aceretum circinati lavosum association is confined to the black block basalts which have large interstices and no available substrate. Its frutescent layer, the Acer circinatum union, is dominated by vine maple (Acer circinatum). The lower strata, as is the upper, are inconsistent, their species xerophytic.

6. Four unions make up the Pseudotsugeto-abietum lasiocarpi association. The arboreal stratum has two dominants, Douglas fir (Pseudotsuga taxifolia) and subalpine fir (Abies lasiocarpa). The shrub, herb, and moss layers are composed of the same species as those of the vine maple association, but the species have lower quantitative values. Furthermore, this association is found on block basalts which have small interstices and an available substrate.

7. The highest developmental association is the Pseudotsugeto-abietum grandis. It has the richest species list and the most consolidated forest cover. Douglas fir and grand fir (Abies grandis) dominate the upper layer, the Pseudotsugeto-abies union. Chinquapin (Castanopsis chrysophylla) dominates the shrub layer or Castanopsis chrysophylla union. The herbaceous layer is occupied by the Chimaphila umbellata union. The available substrate consists of a

more-eroded, softer scoriaceous lava and a range of finer-textured particles.

8. These three associations show some affinities. Interchange of species mark a gradient of mesism from the *Acer-etum circinati lavosum*, the most xeric habitat, through to the *Pseudotsugeto-abietum grandis*, the most mesic habitat on the flows. Texture, degree of profile development, and permanent wilting coefficient determinations of the substrates are closely correlated with these affinities. In the latter association and on the scoria slopes of Nash Crater where drainage supplies available moisture late into the growing season, several species of the climax forest have come in, but their quantitative values are insufficient for them to comprise a significant component of the association.

9. On the glacial tills around the periphery of the basalts, the regional or upper montane climax forest aggregation persists as the *Pseudotsugetum taxifoliae tsugosum* association. Its upper synusia is the Pseudotsugo-tsuga union. Its constant dominants are Douglas fir and western hemlock (*Tsuga heterophylla*). The lower synusiae are discontinuous, only a few of their species have high vitality, and many saprophytic sciophytes are present. This is a closed forest; dependency of many species and stratal developement mark it as a close-knit community. The substrate has been altered by the forest and it is deep and rich.

10. In the climax forest, Douglas fir are large and the lower size classes are lacking. Western hemlock and lovely fir (Abies amabilis), as aggressive species with high reproduction and lower size class percents, are replacing Douglas fir in this highly competitive climax phytocoenosis. Syngenetic trends tie this association rather loosely with the three related developmental associations previously summarized. As reaction ammeliorates principally the substrate and micro-climate, presumably, the climax would occupy the scoriaceous lavas of the Pseudotsugeto-abietum grandis, which in turn would replace the Pseudotsugeto-abietum lasiocarpi. Eventually the latter, then, would take over the block basalts of the Aceretum circinati lavosum, and each stage in turn would prepare the way for the next until climax forest prevailed over all.

11. The two remaining associations of importance, the Carexeto-vaccinetum occidentalis and the Pinetum contorti lapillosum, are distinct primary seres of quite different species complements in which no species from surrounding associations are gaining a foothold. The former association is composed of two equally dominant species densely covering the bog, Carex sitchensis and Vaccinium occidentalis. A salix union forms a belt around the inner edge of the association. The species are hydrophytic, and the sere is controlled by the physio-chemical characteristics of the peat substrate and the high water table. The latter association is comprised

of an arborescent stratum of lodgepole pine, a frutescent synusia, the Ceanothus velutinus union, and a scattered herbaceous union of xerophytic herbs. The substrate is made up of loose ash-lapilli which has the lowest water-holding capacity, relative fertility, and permanent wilting coefficient values of all of the available substrates.

12. The whole coniferous complex owes its existence first to the modified marine macro-climate produced by the Cascadian barrier. The abrupt ecotones, the three primary stable associations of the Nash Crater lava flows suggest that micro-edaphic control is primary. Secondarily this control is modified by degree of forest consolidation which produces both competitive and micro-climatic differences.

VIII. LITERATURE CITED

1. Billings, W. D. The structure and development of old field shortleaf pine stands and certain associated physical properties of the soil. Ecological monographs 8: 437-499. 1938.

2. Blackwelder, E. Pleistocene glaciation in the Sierra Nevada and Basin ranges. American geological society bulletin 42:865-922. 1931.

3. Bouyoucos, G. J. An improvement in the hydrometer method for making mechanical analysis of soils. Journal of the American society of agronomy 27:319-320. 1935.

4. Braun-Blanquet, J. Plant sociology. New York, McGraw and Hill, 1932. 439p.

5. Cain, S. A. The climax and its complexities. American midland naturalist 21:146-181. 1939.

6. ________ Sample-plot technique applied to alpine vegetation in Wyoming. American journal of botany 30: 240-247. 1943.

7. ________ Foundations of plant geography. New York, Harper, 1944. 556p.

8. ________ and William T. Penfound. Aceretum rubri: the red maple swamp forest of central Long Island. American midland naturalist 19:390-416. 1938.

9. Campbell, Ian. A geologic reconnaissance of the McKenzie river section of the Oregon Cascades. Eugene, Oregon, University of Oregon master's thesis (typewritten), 1923. 56p.

10. Conard, H. S. Plant associations on land. American midland naturalist 21:1-27. 1939.

11. Dansereau, P. L'Erabiere Laurentienne, II. Les successions et leurs indicateurs. Canadian journal of research 24:235-291. 1946.

12. Daubenmire, R. F. Plants and environment. New York, Wiley, 1947. 424p.

13. Gilkey, H. M. Handbook of Northwest flowering plants. Revised. Corvallis, Oregon, Oregon State College co-operative bookstore, 1947. 413p.

14. Glock, W. S. Principles and methods of tree-ring analysis. Washington, Carnegie institute of Washington, 1937. 100p. (its publication no. 486)

15. Hansen, H. P. Postglacial forest succession, climate, and chronology in the Pacific Northwest. Transactions of the American philosophical society 37:1-126. 1947.

16. ________ and J. H. Mackin. A pre-Wisconsin forest succession in the Puget Lowland, Washington. American journal of science 247:833-855. 1949.

17. Hodge, E. T. Geology of the lower Columbia river. Geological society of America bulletin 49:848-860. 1938.

18. Oosting, H. J. An ecological analysis of the plant communities of Piedmont, North Carolina. American midland naturalist 28:1-126. 1942.

19. ________ Plant communities. San Francisco, Freeman, 1948. 389p.

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

21. Raunkiaer, C. The life forms of plants and statistical plant geography; being the collected papers of C. Raunkiaer. Oxford, Clarendon press, 1934. 632p.

22. Roach, A. W. The ecology of vegetational change in the foothills ecotone near Boulder, Colorado. Boulder, Colorado, University of Colorado master's thesis (typewritten), 1948. 81p.

23. Thayer, T. P. Geology of the Salem Hills and the North Santiam River Basin, Oregon. Oregon department of geology and mineral industries bulletin 15:20-26. 1939.

24. U. S. Dept. of agriculture. Summary of snow survey measurements in Oregon. Portland, Oregon, Soil Conservation regional office, 1945. 90p.

25. Weaver, J. E. and F. E. Clements. Plant ecology. 2d ed. New York, McGraw and Hill, 1938. 601p.

26. Williams, H. Volcanoes of the Three Sisters region, Oregon Cascades. University of California department of science bulletin 27:37-84. 1944.

27. ________ The ancient volcanoes of Oregon. Salem, Oregon, Condon lecture publication, 1948. 64p.

APPENDIX

Alphabetical species list of all plants encountered in the Nash Crater lava flows and the peripheral climax forest. Life-form designations which precede each species are: Ph - phanerophyte; Ch - chamaephyte; H - hemicryptophyte; Cr - cryptophyte; Th - therophyte.

Ph *Abies amabilis* (Dougl.) Forbes

Ph *Abies concolor* Lindl.

Ph *Abies grandis* Lindl.

Ph *Abies lasiocarpa* (Hook.) Nutt.

Ph *Acer circinatum* Pursh

H *Achlys triphylla* (Smith) DC.

Cr *Adenocaulon bicolor* Hook.

Cr *Agropyron repens* (L.) Beauv.

H *Agrostis hiemalis* (Walt.) B.S.P.

H *Agrostis thurberiana* Hitchcock

Cr *Allotropa virgata* T. and G.

Ph *Alnus sinuata* (Regel) Rydb.

Ph *Amelanchier florida* Lindl.

Cr *Anaphalis margaritacea* (L.) B. and H.

H *Anemone deltoidea* Hook.

H *Anemone oregana* Gray

Cr *Antennaria argentea* Benth.

Cr *Antennaria racemosa* Hook.

Ch *Apocynum androsaemifolium* L. var. *incanum* A.DC.

H *Arabis holboellii* Hornemn. var. *secunda* (How.) Jepson

H *Arabis lyallii* Wats.

Ph *Arctostaphylos columbiana* Piper

Ch *Arctostaphylos nevadensis* Gray

Cr *Arenaria macrophylla* Hook.

Cr *Asarum caudatum* Lindl.

H *Aster ledophyllus* Gray

Cr *Aster radulinus* Gray

H *Aulacomnium androgynum* (L.) Schwaegr.

Ch *Berberis nervosa* Pursh

Th *Bromus arenarius* Thurb.

H *Bromus marginatus* Nees

H *Bromus vulgaris* (Hook.) Shear var. *eximius* Shear

H *Bryum miniatum* Lesq.

Cr *Calamagrostis canadensis* (Michx.) Beauv.

H *Carex disperma* Dewey

Cr *Carex inops* Bailey

Cr *Carex leptopoda* Mack.

H *Carex rostrata* Stokes

H *Carex sitchensis* Presc.

H *Carex sp.* 1

H *Carex sp.* 2

Ph *Castanopsis chrysophylla* A.DC.

H *Castilleja crispula* Piper

Ph *Ceanothus velutinus* Dougl.

Th *Chenepodium album* L.

Cr *Chimaphila menziesii* (R.Br.) Spreng.

Cr *Chimaphila umbellata* (L.) Nutt. var. *occidentalis* (Rydb.) Blake

H *Cicuta douglasii* (DC.) C. and R.

Cr *Clintonia uniflora* (Schult.) Kunth.

Cr *Corallorhiza mertensiana* Bong.

Cr *Cornus canadensis* L.

H *Dactylis glomerata* L.

Cr *Dicentra formosa* (Andr.) DC.

H *Diranum scoparium* (L.) Hedw.

H *Disporum oreganum* (Wats.) B. and H.

H *Ditrichum sp.*

H *Epilobium angustifolium* L.

Th *Epilobium minutum* Lindl.

H *Eriogonum marifolium* Torr.

H *Eriogonum nudum* Dougl.

Cr *Eriogonum pyrolaefolium* Hook. var. *coryphaeum* T. and G.

H *Festuca occidentalis* Hook.

H *Fragaria bracteata* Hel.

H *Gallium triflorum* Michx.

H *Geum macrophyllum* Willd.

Cr *Glyceria pauciflora* Presl.

Cr *Goodyera decipiens* (Hook.) St. John and Const.

H *Habenaria leucostachys* (Lindl.) Wats.

Ch *Haplopappus greenii* Gray

H *Hieracium albiflorum* Hook.

H *Hieracium greenii* Gray

H *Homalothecium nuttallii* (Wils.) Grout

H *Holcus lanatus* L.

Ph Holodiscus glabrescens (Greene) Hel.

H Hypericum anagalloides C. and S.

Cr Hypericum scouleri Hook.

H Hypnum fertile Sendt.

Cr Iris chrysophylla How.

Cr Juncus filiformis L.

Cr Juncus parryii Engelm.

Ch Juniperus communis L. var. sibirica (Burgsd.) Rydb.

H Lathyrus bijugatus White var. sandbergii White

H Leptobryum pyriforme (L.) Schimp.

Cr Lilium columbianum Hans.

Cr Lilium washingtonium Kell.

Ch Linnaea borealis L. var. americana (Forbes) Rehder

H Listera convallarioides (SW.) Torrey

H Lolium multiflorum Lam.

H Lomatium angustatum (C. and R.) St. John

Ph Lonicera involucrata Banks var. ledebourii Jep.

H Lotus douglasii Greene

H Lupinus albicaulis Dougl.

H Lupinus lyallii Gray

H Melilotus indica All.

H Mertensia paniculata (Ait.) G. Don var. borealis (Macbr.) Wms.

Cr Mimulus dentata Nutt.

Cr Mimulus primuloides Benth.

Th Muhlenbergia filiformis (Thurb.) Ryd.

Ph Pachistima myrsinites (Pursh) Raf.

H *Pedicularis racemosa* Dougl.

Cr *Penstemon cardwellii* How.

Cr *Penstemon confertus* Dougl. var. *procerus* (Dougl.) Cov.

Ch *Penstemon menzesii* Hook. var. *davidsonii* (Greene) Piper

Ch *Penstemon serrulatus* Menzies

H *Phacelia californica* Cham.

H *Phleum pratense* L.

Ph *Picea engelmanni* (Parry) Engelm.

Ph *Pinus contorta* Dougl. var. *murrayana* (Balf.) Engelm.

Ph *Pinus monticola* Dougl.

Ph *Pinus ponderosa* Dougl.

H *Plantago lanceolata* L.

Cr *Poa pratensis* L.

Cr *Polemonium carneum* Gray

Ph *Populus trichocarpa* T. and G.

Cr *Polypodium hesperium* Maxon

Cr *Polytrichum juniperinum* (Willd.) Hedw.

Cr *Polystichum lonchitis* (L.) Roth

Cr *Potentilla palustris* (L.) Scop.

Ph *Prunus emarginata* (Dougl.) Walp.

Ph *Pseudotsuga taxifolia* (Lambert.) Britt.

Cr *Pteridium aquilinum* (L.) Kuhn var. *pubescens* Underw.

Cr *Pyrola aphylla* Smith

Cr *Pyrola bracteata* Hook.

Cr *Pyrola dentata* Smith

Cr *Pyrola picata* Smith

Cr *Pyrola secunda* L.

H *Radicula curvisiliqua* (Hook.) Greene

H *Rhacomitrium lanuginosum* (Hedw.) Brid.

H *Rhacomitrium patens* (Dicks.) Heub.

Ph *Rhamnus purshiana* DC.

H *Rhytidiadelphus triguestrus* (L., Hedw.) Wars.

Ph *Ribes viscosissimum* Pursh

Ph *Rosa gymnocarpa* Nutt.

Ph *Rubus parviflorus* Nutt.

Ch *Rubus vitifolius* C. and S.

H *Rudbeckia occidentalis* Nutt.

Th *Rumex acetosella* L.

H *Rumex conglomeratus* Murr.

H *Rumex occidentalis* Wats.

Ph *Salix scouleriana* Barr.

Ph *Salix piperi* Bebb.

Ph *Salix sp.*

Ph *Sambucus racemosa* L. var. *callicarpa* (Greene) Jepson

Cr *Saxifraga integrifolia* Hook.

H *Scrophularia lanceolata* Pursh

Cr *Sedum oregonense* (Wats.) Peck

H *Senecio triangularis* Hook.

H *Sitanion hystrix* (Nutt.) Smith

Cr *Smilacina sessilifolia* (Baker) Nutt.

Cr *Smilacina racemosa* (L.) Desf.

Th *Spergularia rubra* (L.) J. and C. Presl.

Ph *Spiraea douglasii* Hook. var. *menziesii* (Hook.) Presl.

H *Spraguea umbellata* Torr.

H *Stachys ciliata* Dougl.

H *Stipa thurberiana* Piper

Ph *Taxus brevifolia* Nutt.

H *Thalictrum occidentale* Gray

H *Tiarella unifoliata* Hook.

H *Trifolium pratense* L.

H *Trifolium repens* L.

Cr *Trientalis latifolia* Hook.

Cr *Trillium ovatum* Pursh

H *Trisetum spicatum* (L.) Richt.

Ph *Tsuga heterophylla* (Raf.) Sarg.

Ph *Tsuga mertensiana* (Bong.) Sarg.

Ph *Vaccinium occidentalis* Gray

Ph *Vaccinium membranaceum* Dougl.

Ch *Vaccinium myrtillus* L. var. *microphyllum* Hook.

H *Verbascum thapsus* L.

H *Vicia americana* Muhl.

Cr *Viola glabella* Nutt.

Cr *Woodsia scopulina* D.C. Eaton

H *Xerophyllum tenax* (Pursh) Nutt.