AN ANALYSIS OF THE PLANT COMMUNITIES OF MARY'S PEAK, WESTERN OREGON

by

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INTRODUCTION

Plant ecology is the study of the plant in relation to its environment. Autecology deals with the interrelationships between the individual plant and its environment, while synecology is concerned with the rise, development, structure, and the composition of the plant community. A plant community consists of two or more species, usually many, in which there are both compromise and competition in relation to their requirements and what the environment has to offer. The environment is composed of a number of factors which can be grouped in three major categories, namely, soil, climate, and living things. A plant community is an expression of how its component species react to these factors and are arranged to form a series of physical structures by which each species makes the most of its environment. Although the many species in a community may be in more or less harmony with one another, this does not mean that they are all of equal importance. In the plant community, the same as in an animal community, there is a social hierarchy in which some species are dominant and others subdominant, some are permanent and others are transitory, some are abundant and

others are not common, and some are widespread and others are localized. Many other features might be mentioned which form the bases for this complex social structure, including gregariousness, vitality, periodicity, and layering.

When a plant community attains a state of equilibrium and represents the highest type of vegetation possible under the existing climate, it is said to be climax. Its structure will not appreciably change so long as the climate remains constant and no catastrophe occurs to upset the balance and initiate a new cycle of adjustment. Thus, some plant communities are in a state of equilibrium or climax, while others may be in various stages of succession. In many cases it is not possible to make a cursory examination of a community and determine its successional status nor the sociological relationships of the component species. Neither is it possible to even estimate the quantitative relationships between the several species concerned. Certain qualitative characteristics of individuals and the community such as layering, vitality, periodicity, life forms, presence, and others may be noted and provide some basis for determining dominance, succession, and sociological status. European ecologists during the period from 1880-1910, in addition to defining the plant community in qualitative terms, began to employ the use

of quantitative concepts in an attempt to evaluate the sociological relationships of the species, to determine the successional trends, to interpret the social status of the community, and finally to decide upon the degree of equilibrium attained by the community. It was not until the late 1920's, however, that these quantitative methods were critically examined by American ecologists. Because of the vastness of North America and its diversified climax vegetation, a large number of such studies in the many community types will be necessary before the value of the methods can be determined. Much time and painstaking effort are required to obtain the mathematical data essential to express the abundance, frequency, coverage, size classes, basal area, and species-area curves upon a comparative analytical basis. The question arises, is the value of the interpretive conclusions commensurate with the amount of time and effort involved?

The purpose of this study is to test the feasibility of employing quantitative methods combined with qualitative observations in order to define a plant community. More specifically the object of this study is to determine the composition, structure, the sociological status of each species, the trend and stage of succession, and the sociological rank of the entire community. So far as is known there has been no such comprehensive analysis of a plant

community in the Pacific Northwest. Although the results and conclusions may be evaluated in terms of this small community, no final conclusions can be made until many more such studies are made in similar and different types of communities and a comparison made.

PHYSIOGRAPHY AND TOPOGRAPHY

Mary's Peak, rising to an elevation of 4097 feet, is the highest point of the Oregon Coast Range north of the Umpqua River. It is a large mass of fine-grained diorite intruded into Eocene sedimentary rocks (Washburne, 1914). The Peak is located near the western edge of Benton County in western Oregon about 26 miles from the Pacific Ocean. It is about 44°30' north latitude and 123°33' west longitude in T12S R7W of the Willamette meridian and is included in the Mary's Peak and Alsea quadrangles as surveyed by the Corps of Engineers, U. S. Army. It is 15 miles southwest of Corvallis and can be reached by State Highway 34 which branches from US Highway 20 at Philomath, Oregon.

The Oregon Coast Range mountains between the Olympic Mountains on the north and the Klamath Mountains on the south are all included in the Pacific Border Province (Fenneman, 1931). The general aspect of this range is that of a dissected plateau or upraised peneplain. The elevations of the crests range from about 1700 feet in northern Oregon to about 3000-3500 feet near the Klamath Mountains.

The sedimentary rocks are of Tertiary age and generally weak. The volcanic rocks are contemporaneous or intruded into the sediments. These intrusives form the highest peaks, including Mary's Peak, Saddle Mountain in

Clatsop County, and several others (Fenneman, 1931). Sandstones occur above the local volcanics high at about 3000 to 3500 feet or more above sea level on the west and north sides of Mary's Peak, where they are somewhat metamorphosed at their contact with the intrusive dioritic (?) mass that forms the core and summit of the peak. The high flat-topped spur or terrace on the northwest side of the summit of the peak is composed of very hard flinty shale, which has been considerably altered by metamorphism (Washburne, 1914).

The drainage pattern of the Mary's Peak area is radial. The northwest, north, and east slopes drain into tributaries of Mary's River which in turn empties into the Willamette River at Corvallis. The south and southwest slopes drain into the Alsea River, while the west slope is drained by Elk Creek, a tributary of the Yaquina River. The Alsea and Yaquina Rivers enter the Pacific Ocean at Waldport and Newport respectively (Forest Service Map of the Siuslaw National Forest, 1937).

The topography of Mary's Peak above the 2500 foot level includes some very steep slopes below the summit and the ridges. The contour lines indicate a slope of 1000 to 1250 feet vertically to 3000 feet horizontally, or a 33 per cent to approximately 40 per cent slope. Some places, such as the south side of the mountain, have a drop of 1000

feet in 2000 feet for a 50 per cent slope. Locally there are small slopes steeper than this.

CLIMATE

The Coast Range of Oregon has a wet, microthermal climate with adequate precipitation at all seasons according to Thornthwaite's classification of North American climates (1931). This classification is quantitative and attempts to determine the critical climatic limits significant to the distribution of vegetation, and is based upon precipitation effectiveness and temperature efficiency. The climate of Western Oregon is typically marine due to the proximity of the Pacific Ocean and the prevailing westerly winds.

The narrow belt west of the Coast Range has a very equable climate. In this belt there is little freezing weather, and on the rare occasions when snow falls it seldom remains on the ground more than a few hours. The mean annual temperature ranges from about 50° to 52° (Climatic Summary of the United States, 1930). The mean minimum in midwinter is mostly between 36° and 40°, and only a few places in this strip have experienced zero weather. The mean maximum temperature for July ranges between 65° and 70°, and only occasionally does the temperature reach 90°, though a number of places have had a day or two with maxima of 100°. The rainfall in this belt ranges from 50 to more than 100 inches, depending on the height of the Coast Range and the nearness of the hills to the ocean.

Precipitation occurs mostly as gentle rain, and sudden downpours are rare. The number of days with 0.01 inch or more of precipitation ranges from about 125 to nearly 200. Prevailing winds are from the north and northwest during much of the year, but in winter southerly winds prevail. The northerly winds of summer are persistent, but seldom reach destructive force.

The Coast Range has a more varied climate. In general the normal annual temperature is below 50°. There is considerable freezing weather in winter, and in places the snow becomes quite deep at times. The normal annual precipitation ranges from about 50 inches to more than 130 inches. The mean annual number of days with 0.01 inch or more of precipitation ranges from about 100 to 180. Most of this region is heavily forested, but farms have been established in many valleys where the forest has been removed.

The Willamette Valley, occupying the northern portion of the area lying between the Coast and Cascade Ranges, has an equable climate, though ranges in temperature are greater than those experienced on the coast. The normal annual temperature is mostly between 51° and 53° and the normal minimum for January is generally between 31° and 34°. Some freezing weather occurs every winter, and most stations have had minima of zero or lower. The normal

maximum temperature for July ranges from about 78° to 84°, and while maxima above 100° have occurred practically everywhere in the valley, these temperatures are always attended by low relative humidity, and are almost always followed by cool nights. The mean minimum temperature for July ranges from about 48° to 56°. Killing frost seldom occurs in the growing season. The normal annual precipitation ranges from 37 inches in the central portion of the valley to about 70 inches at a few stations. The average annual snowfall ranges from about 7 to 16 inches. There is some showery weather in spring and summer, but most of the precipitation occurs as gentle rain. The average number of days with 0.01 inch or more of precipitation varies from about 130 to 160. Prevailing winds are from the north and northwest in summer and from the south and southwest in winter, but there is a greater variation in wind direction than on the coast. The strongest winds are from the south and southwest. East winds prevail at times in and near the mouth of the Columbia Gorge, being cold in winter and warm at other times. Winds in this region seldom reach destructive force. Much of this region was originally forested, and considerable areas of forest land remain, but most of the land is in cultivation or used for pasture. There is a pronounced dry season in summer. (Climatic Summary of the United States, 1930)

Weather records from the station located at Corvallis since 1889 at an elevation of 266 feet above sea level show this section of the Willamette Valley to have an average annual rainfall of 39.06 inches (Climatological Data: Oregon Section, 1947). This station is in the rain shadow of the Coast Range Mountains. A station at Summit, Benton County, Oregon in the Coast Range about 12-15 miles north of Mary's Peak at an elevation of 720 feet, shows a normal annual rainfall (1909-1919) of 60.10 inches. Supplemental rainfall data at a station of the Corvallis Water Bureau located a few miles southwest of Philomath show an annual rainfall of 70 inches for 1942 only (Climatological Data: Oregon Section, 1942).

The temperature records for 41 years show Corvallis to have a normal annual temperature of 51.0°, an average maximum of 62.4°, and an average minimum of 41.2°. No similar data are available for Summit or the Corvallis Water Bureau Station.

The frost data show that at Corvallis the last killing frost has occurred from late March to early May with a few occurrences in late May. In 1947 the last killing frost occurred on March 6, in the Corvallis area expressed as the latest temperature of 32° F. or lower, as no actual killing frost occurred, and the earliest killing frost occurred on November 22, making a growing season of 260

days (Climatological Data: Oregon Section, 1947). No such data are available for the Summit or Corvallis Water Bureau Stations. At the higher elevations as on Mary's Peak the growing seasons are somewhat shorter as snow falls above approximately 2500 feet soon after the middle of October and disappears approximately late March or early April except for a few pockets on steep north and east slopes. During 1948, however, there are still over two feet of snow about the summit on Mary's Peak on the first of May.

The prevailing winds are westerly and attain a high velocity on the prairie near the summit. This great velocity at times is shown by the bending of a two and one-half inch, 60-foot, steel pipe flagpole at right angles about 10 feet above the ground (Fig. 1). Further evidence of the terrific velocity at this elevation is indicated by the fact that a Forest Service garage was moved almost seven inches out of plumb. (Corvallis Gazette-Times, October 24, 1946)

For the Corvallis area there was an average of about 113 days clear, 129 days partly cloudy, and 123 days cloudy for the year in 1947. There were 141 rainy days for the year of 1947. Records kept at the Corvallis station show evaporation in inches for April, 2.654; May, 5.044; June, 2.976; July, 5.590; August, 5.003, and

Fig. 1. Bent flagpole at Parking Area on Mary's Peak. Looking northeast. April 30, 1946.

September, 4.197 (Climatological Data: Oregon Section, 1947).

Climatological Data for Stations on the Oregon Coast

Stations	Elev.	Av. Temp.	Av. Max. Temp.	Av. Min. Temp.	Av. Ppt.
Astoria	10	51.6	58	45.1	76.33
Brookings	120	52.4	60.3	44.4	74.64
Gold Beach	60	49.2	60.0	43.7	75.67
Newport	128	52.5	57.2	43.7	65.81
North Bend	207	53.9			64.13
Seaside	10	53.2			75.86
Tillamook	23	51.9	59.2	41.9	93.94

Climatological Data for Stations of the Oregon Coast Range

Stations	Elev.	Av. Temp.	Av. Max. Temp.	Av. Min. Temp.	Av. Ppt.
Jewell	600	49.5	59.5	40.1	71.29
Glenora	575	49.2	60.2	38.0	130.53
Deadwood	350	52.0	61.9	42.6	91.81
Valsetz	1150	51.0			116.62

GENERAL FLORISTIC DESCRIPTION

Mary's Peak lies within the cedar-hemlock association of the coast forest (Weaver and Clements, 1938), but neither of these species is very abundant. The principal forest tree species of the Coast Range is Douglas fir (Pseudotsuga taxifolia (Lam.) Britt.). In the cedar-hemlock climax of the Puget Sound region and the southern part of the Olympic Peninsula, Douglas fir is a subclimax species that has persisted as a result of fires that must have occurred periodically throughout postglacial time. In the Coast Range, however, the climate is apparently too dry for western hemlock (Tsuga heterophylla (Raf.) Sarg.) and western red cedar (Thuja plicata Donn.) to thrive, and Douglas fir maintains a climax status in this area. Fire is not necessary in order for it to persist (Munger, 1940). The relative absence of hemlock during the entire postglacial time is denoted by the low proportions of its pollen in peat sections in the Willamette Valley (Hansen, 1947). Other species in the Coast Range, locally abundant where conditions are favorable, are noble fir (Abies procera Rehd.) on some of the higher peaks, lowland white fir (Abies grandis Lindl.) well distributed with local abundance, silver fir (Abies amabilis (Dougl.) Forbes.) at isolated stations in the northern part of the Coast Range of Oregon, and becoming more abundant northward into

Fig. 2. Map of the vegetation of Mary's Peak above the 2500 foot level. Roman numerals refer to the lines of quadrats. Abbreviations refer to the following plant communities; N - noble fir, D - Douglas fir, M - meadow, ND - noble fir-Douglas fir, NHD - noble fir-Douglas fir-hemlock, HD - hemlock-Douglas fir. Arabic numerals refer to locations mentioned in the text; 1 - summit, 2 - present parking area, 3 - the first parking area, 4 - the "Big Curve" in the road at the west side, 5 - Connor's Camp area.

Washington, western white pine at higher altitudes, but rare, and Oregon white oak (Quercus Garryana Dougl.) at lower altitudes on the eastern slope of the Coast Range and into the Willamette Valley to the east. As few peaks of the Oregon Coast Range reach an elevation of 4000 feet, this area lies entirely within the Humid Transition life area, with the exception of a few peaks that extend upward into the Canadian life zone (Bailey, 1936). The Coast Range grades into the Siskiyou Mountains in southwestern Oregon, and here there is a convergence of ranges and of forest tree species representing the Coastal Strip, the Coast Range, the southern Cascades, and northern California.

North Slope

The north slope of Mary's Peak is covered predominantly by western hemlock ranging from seedlings and reproduction size to about 24 inches DBH. Noble fir is most common above 3600 feet elevation and ranges from seedlings to specimens almost 50 inches DBH. An almost pure stand of this species occurs on the north slope below the summit. Below 3600 feet it becomes scattered and below 2500 feet it is very sparse. Western red cedar occurs mostly as small trees on moister sites about springs and along the streams. Douglas fir is frequently represented by

Fig. 3. Hemlock-noble fir on north slope showing young trees of both species.

Fig. 4. Same area near Fig. 3.

scattered giant specimens 45-60 inches DBH.(b). Seedlings on the forest floor consist largely of hemlock below 3600 feet elevation. Other seedlings are those of noble fir and Douglas fir. No effort was made to distinguish the two because in areas where both Douglas fir cones and noble fir scales were found together, all the fir seedlings appeared alike. According to Munger (1940, pg 454), Douglas fir seeds germinate on the forest floor but the seedlings in contrast to those of hemlock do not survive in the shade. In the area of hemlock or noble fir predominance there is no understory of Douglas fir younger than the main stand. Douglas fir is a shade intolerant aggressive tree that forms pure even-aged stands after fire or logging but does not reproduce on the forest floor. Gradually it is replaced by shade tolerant trees which ultimately supplant it where moisture conditions are favorable for their survival.

This successional cycle does not occur in the southern part of the Douglas fir region which is less favorable for hemlock, cedar and the balsam firs (Munger, 1940). The cycle regularly takes place in the Mary's Peak areaon north and west slopes, but on south and east slopes the cycle is not noted except in ravines or valleys.

The south and west slopes of mountainous areas farther inland are generally drier than north and east slopes

because of more direct and longer exposure to the rays of the sun, thus increasing evaporation from the soil and reducing its water content. South and west slopes support more xeric vegetation than at corresponding elevations on the north and east slopes (Weaver and Clements, 1938, pg 365).

However, the situation along the Coast Range is somewhat different. The south and north slopes differ as above, but the moisture conditions on the west and east slopes vary in that the west slopes are windward to the moisture-laden prevailing westerly winds from the Pacific Ocean, and the east slopes are leeward. Thus, the west slopes are moist and support a relatively abundant stand of hemlock and cedar, and drier east slopes support Douglas fir. The old Douglas fir forest on these south and east slopes and in the drier valley and foothill lands is therefore not likely to be replaced by hemlock (Munger, 1940, pg 457).

At about 2500 feet elevation is the upper limit of an old burn that occurred about 1908. The forest here is composed of an impenetrable mass of young Douglas fir, the first tree to appear in this section following fire (Munger, 1940). They are about 30 years old (node count), 4-12 inches DBH, and the stand is very dense. The living trees, snags, and down trees form a tangled mass that can

be penetrated only with great difficulty.

The herbaceous layer of the north slope is composed largely of wood sorrel (Oxalis oregana Nutt.) which often forms a green "carpet" except where hemlock is predominant. Under the hemlock the ground is practically devoid of vegetation and the litter may be 1-3 inches deep in more level areas. Salal (Gaultheria Shallon Pursh.) and Oregon grape (Berberis nervosa Pursh.) are almost entirely absent on this slope.

Various grasses are found in certain small open spaces as Trisetum cernuum Trin., Bromus vulgaris (Hook.) Shear., and certain forbs, especially ragwort (Senecio triangularis Hook.). On one ridge below the road about halfway between the Big Curve (4) and the first parking area (3) at approximately 3000 feet elevation is a meadow about 200 feet in diameter that is floristically similar to the meadow on top.

The most common shrub in open areas and along edges of timber is ocean-spray (Holodiscus discolor (Pursh.) Maxim.). In wet unshaded areas about springs and along streams are thickets of the salmonberry (Rubus spectabilis Pursh.).

East Slope

The east slope is forested predominantly with Douglas

fir which occurs in stands of fairly even-aged trees about 24-36 inches DBH. The stand is composed of Douglas fir on this supposedly moister east slope probably because of fire many years ago and also possibly because of rain shadow effects. Hemlock occurs only as a few scattered small trees about 24 inches DBH maximum size and these only in the moister locations. Also on these moister sites are some reproduction size and small trees of hemlock. Younger specimens including reproduction and small tree sizes of noble fir and Douglas fir are in more open areas. Seedlings of any kind are rare.

The shrub stratum or layer is composed mainly of a very thick stand of salal with Oregon grape generally as a secondary, but often locally as abundant or more abundant plant. The upper altitudinal limit of these species on Mary's Peak is about 3200 feet. However, there are some small patches of them at 3700 or 3800 feet, but the plants are poorly developed. Vine maple (Acer circinatum Pursh.) is quite abundant here in local shaded areas as is ocean-spray in the open patches. Sword fern (Polystichum munitum (Kaulf.) Presl.) occurs in small areas of a few feet in diameter almost to the exclusion of any other understory vegetation.

Fig. 5. Douglas fir with vine maple understory on south slope near Connor's Camp.

Fig. 6. Burned area of south slope showing snags and young Douglas fir trees.

South Slope

The south slope is forested more preponderantly with Douglas fir than the east slope. Hemlock is limited to the valley about Connor's Camp (5) and a short distance up one ravine above this area. Noble fir is limited to a narrow zone at 3000 to 3400 feet elevation on the south slope. Douglas fir is fairly even-aged, about 24 to 36 inches DBH, and forms a rather dense stand of trees.

The shrub layer consists of salal and Oregon grape which forms a dense cover. Approximately 3200 feet elevation is the upper limit of these plants. There is a zone of vine maple at about 3400-3500 feet elevation from the west side at the Big Curve, where the plants are small and very dense, along the south slope, where they are large and dense, to the east slope where the stand thins out.

The western part of the south slope and the west slope were burned over about 1932, and are now in various stages of succession from "weeds" to young Douglas fir reproduction (Fig. 6).

Meadow

The meadow is limited to the top of the mountain and the top of the ridge extending to the north and the ridge to the west of the peak. Grasses are predominantly Idaho fescue (Festuca idahoensis Elm.), and bent grass

Fig. 7. View of meadow from west end looking toward summit. First parking area (3) at road in foreground.

Fig. 8. View of meadow north from summit. Noble fir community in center.

(Agrostis diegoensis Vas.). California sedge (Carex californica Bail.) is co-abundant with them in many places and most conspicuous at its flowering time, during the early part of the season. Other grasses include Elymus glaucus Buckl. which form rather scattered clumps and often small patches; alpine timothy (Phleum alpinum L.) and Danthonia californica Boland. occur as scattered individuals. Bromus carinatus Hook. and Arn. is found in places that have been disturbed. Lupine (Lupinus albicaulis Dougl.) and larkspur (Delphinium menziesii D.C.) occur scattered throughout the meadow as conspicuous early plants. The more inconspicuous early bloomers are Anemone Lyallii Brit., Viola glabella Nutt., Viola adunca Sm., and Collinsia parviflora Dougl. During June and July, flowering plants include mariposa lily (Calochortus Tolmiei Hook and Arn., Achillea lanulosa Nutt., Senecio integerrimus Nutt. Also over much of the meadow the bracken fern (Pteridium aquilinum (L.) Kuhn. var. lanuginosum (Bong.) Fernald becomes conspicuous at this time.

A few hundred yards west and above the first parking area (3) is a patch of bearberry (Arctostaphyllos Uva-ursi Spreng.) consisting of plants that are considerably larger than usual.

Above the 4000 foot level at the summit is a small area of southwest exposure that receives the full impact of the prevailing westerly winds, causing extremely

Fig. 9. Looking west from summit (1) showing meadow and noble fir.

Fig. 10. North from summit. Meadow in foreground. Noble fir community in center and background.

rigorous conditions. The soil on the south side is almost bare of vegetation and consists of gravel and rock derived from weathered igneous rocks. Here are many clumps of the Douglas phlox (Phlox Douglasii Hook.) and tiny specimens of Collinsia grandiflora 1-2 inches high. The more leeward areas of the summit consist of alpine timothy, Gilia capitata Hook., Koeleria cristata (L.) Pers., mountain lupine (Lupinus Lyallii Gray), Ranunculus occidentalis Nutt. which is also common on pastures and old fields in the valleys, and Lomatium Martindalei C. and R.

Fig. 11. Edge of noble fir and meadow near summit showing young noble fir plants invading the meadow.

Fig. 12. Last snow patch, early May 1947, near summit. Also shows snow damage to young noble fir trees.

ANALYSIS OF THE PLANT COMMUNITY

Most plant communities are too extensive to describe in complete statistical detail. It is desirable, however, to determine the ecological structure of a community and the relationships of the species present in both quantitative and qualitative terms. In order to obtain a fairly accurate and representative picture of these characteristics and relationships it is necessary to sample portions of the community, and from these segments develop a picture of the community as a whole. The sample plot or quadrat method is used to acquire these data which when integrated, analyzed, and interpreted will provide a representative picture and mathematical expression of the relationships of the species involved, with a minimum amount of time and effort expended. The sample plot in plant community analysis is used extensively in fields of applied ecology, such as range management, forestry, soil conservation, wildlife management, etc.

Small quadrats provide several types of data concerned with the organization of a community. Analytic data consist of information concerning numbers of species known as abundance or density, the area or space occupied by the aerial portions of the plants of each species called coverage, and the degree of dispersion of each species throughout the stand designated as frequence index or homogeneity.

When the plot method is extended to include several stands of a community type, one obtains, in distinction to the types of analytic data mentioned above, what may be called synthetic data. These data are primarily an extension of the analytic data, but also include new information concerning presence, constancy, and fidelity (Braun-Blanquet, 1932; Cain, 1932). Synthetic data contribute to an understanding of the community type -- a more or less abstract concept whereas the analytic data help in forming a picture of the concrete community.

The analytic data are the only data obtained in the present field work and presented in this dissertation.

Quantitative Analytic Concepts

Analysis of the plant communities on Mary's Peak based on 181 quadrats supplied data for analytical characteristics including quantitative data for the expression of abundance, cover, and frequency.

Abundance: This is intended to express the relative number of individuals of each species entering into the constitution of the plant community. It is based on an estimation and a series of five figures is used to express the abundance (Braun-Blanquet, 1932) and (Cain, 1932).

1- species very rare (very sparse).

2- species sparse (rare).

3- species not numerous (infrequent) or (not very abundant).

4- species numerous (abundant).

5- species very numerous (very abundant).

Whatever is lost by this method of estimating as compared with that of counting exactly the individuals of a species is gained in the survey of a larger area and in the saving of time.

Cover: This concerns the area covered or occupied by each species. In several layered tree and shrub communities the cover must be evaluated for each stratum separately, because the degree of dominance of a species is given by its share in the different layers of the vegetation.

The five-parted scale of Braun-Blanquet (1932) and Cain (1932) is used and one more class is added for species that occupy less than one per cent of the surface.

0- species covering less than 1 per cent of the surface.

1- species covering 1-5 per cent of the surface,

2- species covering 6-25 per cent of the surface,

3- species covering 26-50 per cent of the surface,

4- species covering 51-75 per cent of the surface, and

5- species covering 76-100 per cent of the surface.

Frequency: This concept is concerned with the homogeneity of a stand, or the uniformity of distribution of a species. It is expressed as a percentage relation between the number of quadrats which contain the species and the total number of quadrats employed in the community. For example, 50 quadrats were used in the Meadow and Idado fescue occurred in 46 of them, making a frequency of 92 per cent. Five frequency classes are usually used.

1- species in 1-20 per cent of the quadrats.

2- species in 21-40 per cent of the quadrats.

3- species in 41-60 per cent of the quadrats.

4- species in 61-80 per cent of the quadrats.

5- species in 81-100 per cent of the quadrats.

Discussion: It must be recognized that these three concepts are distinct. For example, a species with a large

number of individuals need not also be of high coverage or high frequency. In the fields around Corvallis, scorpion grass (Plagiobothrys figuratus (Piper) Johnst.) is present in abundant numbers yet, because of its small size, may be of the lowest or near the lowest class of cover. Also it may be of regular distribution throughout the community and have a high frequency, or irregularly distributed in patches and of low frequency. Species that have a high frequency per cent are not necessarily the dominants, because only one individual of a species in a quadrat is necessary to be listed in determining the per cent of occurrence. The species will be a dominant only according to its coverage in its stratum (Cain, 1932, pg 479).

The results of the frequency determinations may be expressed in a graph of 5 frequency classes (Figs. The frequency graphs often show two maxima, one in the highest and one in the lowest frequency classes. Increase in size of the quadrats will cause the highest frequency classes to enlarge while the lowest decrease. Thus it is possible to increase the size of the quadrat to include the entire stand (community) and have all species with a frequency of 100 per cent (Braun-Blanquet, 1932, pp. 40-41).

Expressions of abundance are more common in the literature than of density, which requires actual counts of

the individuals. Generally it is impractical to replace abundance data with density figures because of the time and cost involved and the extent of the vegetation to be considered. It is important that there be some means of standardizing abundance estimates and expression.

Since coverage must be considered separately for each stratum of the vegetation, the cover classes indicated for the species of the community will, in several layered communities, total more than 100 per cent. The percentages are based on the total area covered by the vegetation rather than the total area of land surface.

Qualitative Analytic Concepts

The qualitative concepts of the organization of the plant community do not depend on quadrat studies for their most accurate discernment, but rather on as wide experience as possible with the community. These concepts are called sociability, vitality, periodicity, and stratification.

Sociability: Sociability concerns the grouping of gregariousness of the species in the interior of a given plant community. According to Braun-Blanquet (1932) the estimate of sociability is easily made, and on large sample areas it enables us to form a picture of the plant mosaic in much sharper outlines than would be possible from mere density and coverage estimates. Because it is so easily modified, the gregariousness of many species changes materially during the course of a succession. Cain (1932) states the assignment of sociability classes to species is subject to considerable variation, the limits of the classes by their very nature being somewhat vague and the personal element entering so largely. The limitation of sociability to five classes helps to standardize these data.

1- growing one in a place, singly, isolated,

2- grouped or tufted,

3- growing in numbers, small patches, or cushions,

4- growing in small colonies, in extensive patches,

or forming carpets, and

5- in great crowds, large colonies.

The degree of gregariousness of most species is greatly influenced by conditions of habitat and by competition. In general, vegetative reproduction leads to crowding, that is, to increased sociability. Plant in the lily family bearing bulbs, corms or rhizomes are usually placed in sociability class 1. The dominant species can be placed in sociability class 5. The other 3 classes are often difficult to assign to plants.

Vitality: Vitality concerns the degree of vigor attained by the different species. Three vitality classes are usually recognized.

1- plants germinating accidentally and not able to multiply,

2- plants with their life cycle incomplete but with vigorous vegetative development,

3- plants well developed and accomplishing regularly their complete life cycle, flowering and fruiting.

A species at the margins of its ecologic limits, or possibly in an unfavorable environment may have low vitality. During the course of the field work no examples of any vitality class other than the highest were noted.

Periodicity: Periodicity in a plant community refers to the different aspects of the community during the year.

1- prevernal, early spring.

2- vernal, spring.

3- aestival, summer.

4- autumnal, fall.

5- hibernal, winter.

The flowering period of plants has been most studied from the point of view of periodicity, and is usually diagramed by a line for each species which represents by its length the period and duration of flowering. Some authors (Steiger, 1930) show the peaks in the flowering season by diagraming the total number of species in flower at each week throughout the whole season.

Stratification: Stratification refers to the natural superimposed layers of the vegetation. The number of strata distinguisable vary in different types of vegetation. The forest on Mary's Peak has been divided into four strata.

1- tall tree.

2- small tree.

3- shrub.

4- herbaceous.

Some problems or disagreements occur with low creeping plants as Linnaea borealis L. Immature plants, like tree saplings in the shrub layer, are referred to as "transgressives" since they are "passing" through the lower stratum and will ultimately occupy the higher arborescent

stratum. A diagram can be used to combine stratification and coverage data (Fig. 13).

Quadrat Method

The minimum size of the quadrats and the minimum number of them to be used in the investigation of the plant community should be given careful consideration. The size may range from 0.1 sq.m. to 100 sq.m. depending on the type of vegetation sampled, the 100 sq.m. quadrat being generally employed in the study of trees, while the smaller quadrats are employed for the study of lesser vegetation.

The determination of the minimum quadrat size requires the quadrats to be laid out in sets. Quadrats were located along lines extending up and down the slopes. The lines were numbered with Roman numerals and the quadrats, which were placed about 50 meters apart along the lines, were given Arabic numerals (Fig. 2).

The smallest quadrat was 1/4 sq.m. The size of the quadrat was doubled four times resulting ultimately in a quadrat of 4 sq.m. All species on the 1/4 sq.m. quadrat were listed. Each time the quadrat size was increased the new species encountered were listed. Each successively larger quadrat included all preceding quadrats (Fig. 14-15) (Cain, 1943). The 100 sq.m. quadrat also included all the smaller quadrats.

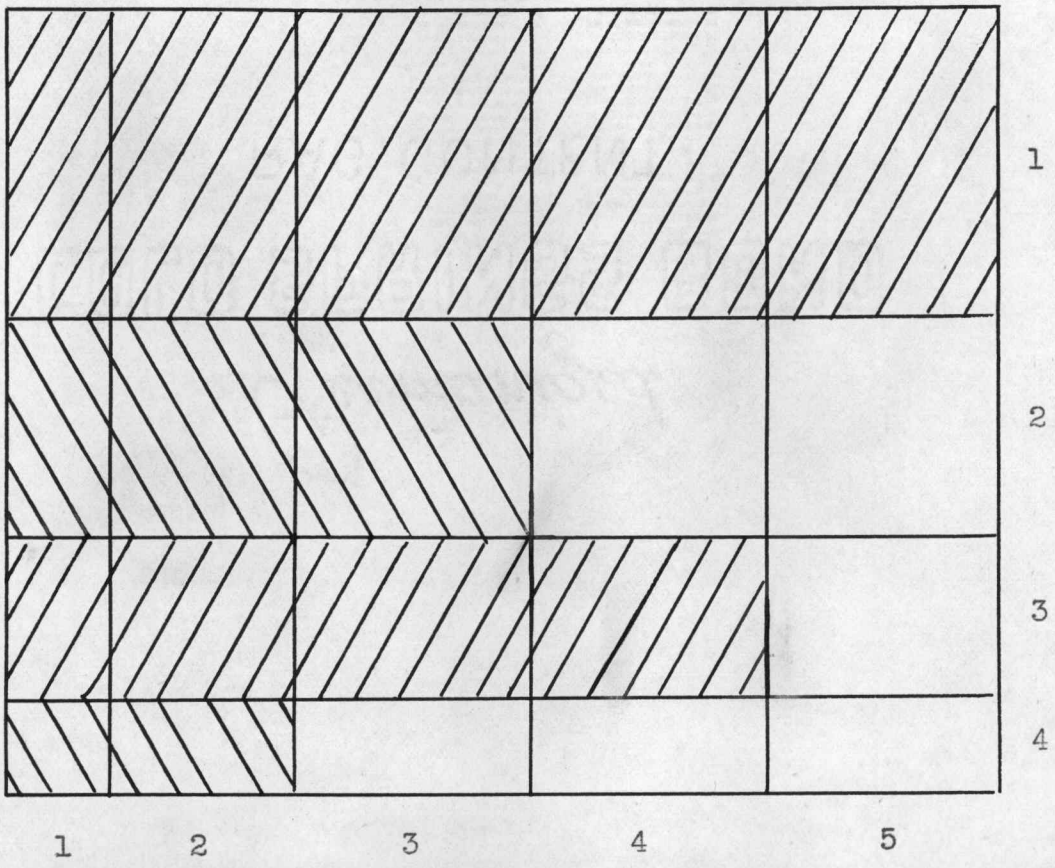


Fig. 13. Diagram of the cover-stratification data for the vegetation of the south slope of Mary's Peak to illustrate the method for presenting these data graphically. The 5 cover classes are drawn horizontally and the 4 stratification classes vertically.

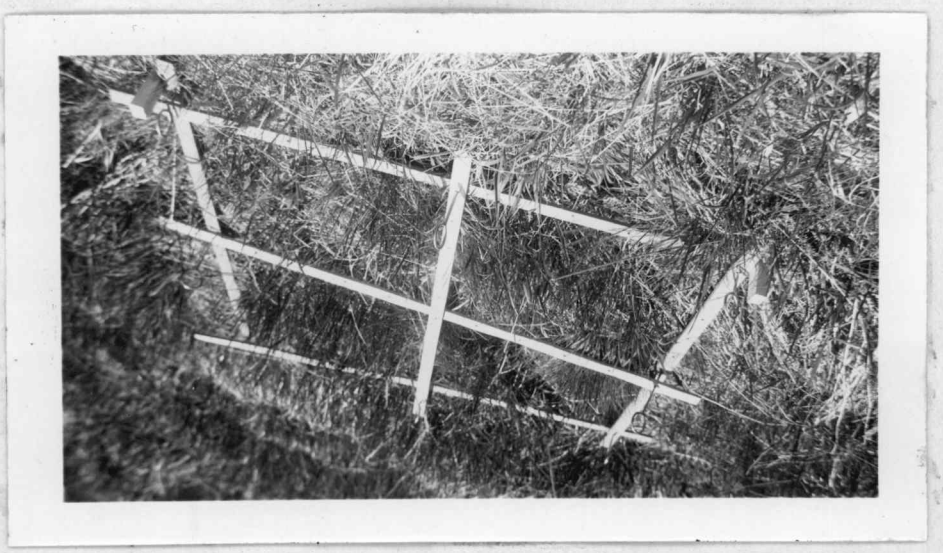


Fig. 14. Quadrat sticks laid out to form 1/4, 1/2, and 1 square meter quadrats.

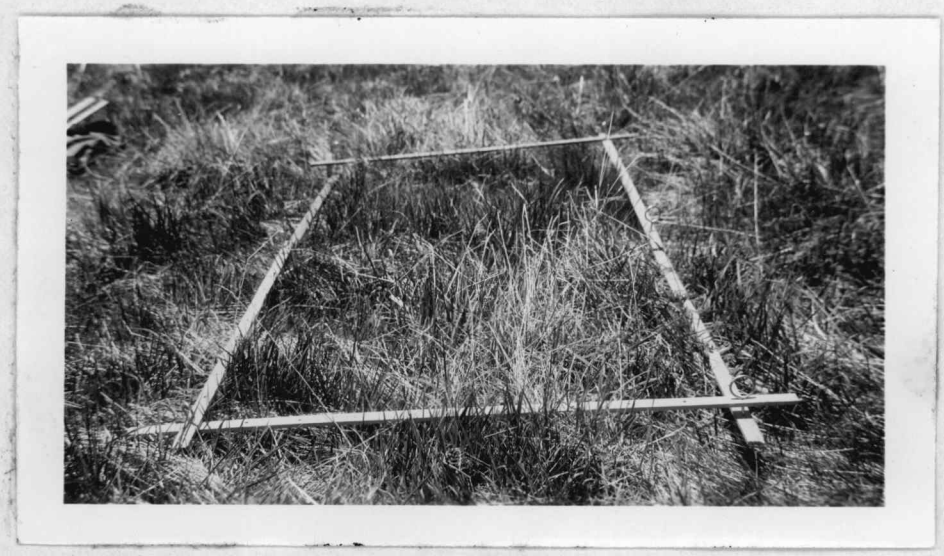


Fig. 15. Quadrat sticks laid out to form the 2 sq.m. quadrat. This quadrat is doubled to form the 4 sq.m. quadrat.

The minimum quadrat size is then determined by plotting the per cent of species sampled along the y axis with the area in sq.m. along the x axis (Figs.17-21). Points are located according to the per cent of species in the corresponding quadrat. The points are connected by a line to make a species curve. The diagram shows that with increasing size of the sample area the species curve first rises rapidly, then swings nearly to the horizontal, and continues with an almost imperceptible rise (Braun-Blanquet, 1932, pp. 54-55).

The point at which the curve flattens out most sharply denotes minimum quadrat size, because with this size the important species have been sampled (Cain, 1943, pg 243). An examination of the curves (Figs.17-21) indicates that in both the meadow and forest communities quadrats larger than 1 sq.m. would not provide further significant data for herbaceous and shrubby vegetation.

Hanson and Love (1930) conclude that the minimum quadrat size in grazing studies should be one, or possibly two square meters. The increased cost of larger sizes precluded their use since there were no corresponding advantages.

The next problem was to determine the least number of minimum-size quadrats that would yield a representative list of species. Data of the meadow and north and south

slopes were plotted and the resulting curves shown in figure 16. The per cent of species is plotted along the y axis and the number of quadrats along the x axis.

The curve for the meadow (A) species indicates that the most important species are sampled with 20-30 quadrats. In this case the curve shows a definite increased horizontal trend flattening out in that part, which indicates that satisfactory frequency percentages and coverage data can be obtained with that number of quadrats. Examination of the graphs shows that the frequency of the species occurring in the one and two square meter plots is more nearly the normal than any others. Therefore the distribution of the species in the meadow is relatively homogeneous.

In the other areas (B and C) over 80 per cent of the species are in frequency class 1, with the highest size classes very low and one class vacant. This indicates a rather heterogeneous distribution and would require more quadrats to secure a representative sample. The south slope (B) has one frequency class unoccupied in the 1 sq.m. quadrat set. The curve indicates that sufficient quadrats were taken to sample most of the species. However, more quadrats would have reduced the high frequency per cent in class 1 and raised the percentage in the higher classes to some extent. The curve indicates that at least 35-40 one-sq.m. quadrats are necessary to sample this stand.

The north slope shows a very high percentage of species in frequency class 1, with all the other classes very low and class 4 not represented. The distribution of shrubby and herbaceous plants on this slope is heterogeneous except for Oxalis oregana. This may be due to the distribution of hemlock. No understory plants are found with hemlock and if this tree is very common, as on this slope, the understory is heterogeneous. Of 36 species on the north slope, 32 are in frequency class 1 in one sq.m. quadrats, 2 are in class 2, 1 Oxalis is in class 5. Only this 1 species is very widely distributed, the rest occurred in only a few quadrats. The curve indicates that 50-60 quadrats are necessary to adequately sample this stand.

Despite the value of techniques such as those described to aid in the determination of minimum small quadrat size and minimum quadrat number, one must still use his judgment and more or less arbitrarily discontinue the field work, when apparently sufficient data are taken (Cain, 1943).

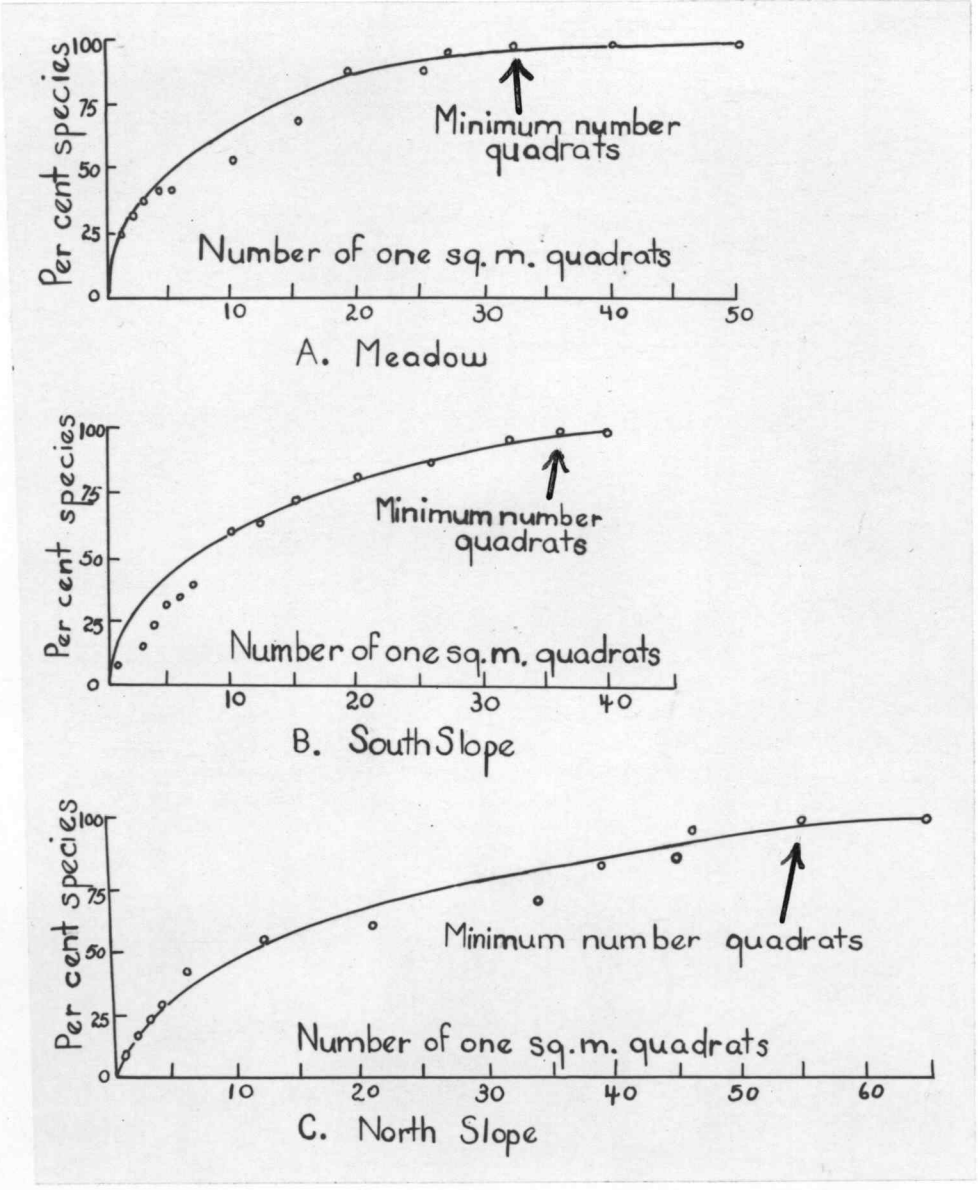


Fig. 16. Minimum number of quadrats as indicated by species-area curve on A - meadow, B - south slope, and C - north slope.

DISCUSSION OF DATA

The quadrat data for the meadow place three species, Idaho fescue, bent grass and California sedge in the highest classes of abundance, frequency, and sociability. These describe their relative numbers as very abundant, evenly distributed over the community and growing in great crowds or large colonies respectively. For this reason and by observation they were each placed in cover class 4 in considering their sociological status in the community. In certain local areas each species was in the highest cover class although in general, two of them, and often all three, appeared to have equal coverage. The total coverage by these species was over 100 per cent but due to interfingering it was evident that each species had a coverage between 50 and 75 per cent.

All these characteristics combined indicate that these three species are codominant. There was, however, a difference in their periodicity. Carex californica flowered in early spring and was more conspicuous at that time than the two grasses. As the season advanced the two grasses became more conspicuous and by their flowering time in summer they had over-topped the sedge which had matured.

Three other plants, wild-rye (Elymus glaucus), yarrow, and bracken fern, were placed in abundance class 3, cover class 2, sociability class 2 and 3 and occurred in frequency

classes 2 and 3. These plants are locally conspicuous, and in a few places the bracken fern may be codominant. Wild-rye and yarrow occur in patches and sometimes small colonies scattered over the meadow community.

Anemone Lyallii was placed in abundance class 4, and grew in numbers and small patches fairly well distributed over the community as shown by its occurrence in frequency class 3. However, because of its small size it was placed in cover class 0 or possibly class 1. This is one of the smaller less conspicuous plants and, with other similar sized plants, such as Arenaria macrophylla, Collinsia grandiflora, and Rumex acetosella, requires that the investigator work close to the ground for their detection.

Bearberry (Arctostaphylos uva-ursi) occurred in one small patch approximately 200 feet in diameter. One of the quadrats fell near the center of the patch. On this spot the plant was very abundant, completely covered the surface of the ground, and as a small patch was placed in sociability class 3. Concerning the entire community, bearberry is reduced to very rare numbers, covers less than 1 per cent of the surface and occurs in frequency class 1, but retains its sociability class 3 which identifies it as a local patch of vegetation.

The remaining species, mostly in abundance classes 1 and 2, cover classes 0 and 1, frequency class 1 and

TABLE 1

Data for the Meadow on Top of Mary's Peak with Abundance (A), Cover (C), Frequency (F), Sociability (S), Periodicity (P), Stratification (St), and Life Form (LF) for Each Species

Species	A	C	F	S	P	St	LF
Festuca idahoensis Elmer	5	4	5	5	3	4	H
Agrostis diegoensis Vasey	5	4	5	5	3	4	H
Elymus glaucus Buckl.	3	2	2	2-3	3	4	H
Achillea lanulosa Nutt.	3	2	2	3	3	4	H
Rubus pedatus Smith	1	0	1	1		3	Ch
Cerastium arvense L.	1	0	1	1-2	1,2,3	4	H
Carex californica Bail.	5	4	5	5	1	4	G
Pteridium aquilinum (L.) Kuhn.	3-4	2	3	3	2	4	G
Lupinus albicaulis Dougl.	2	0	1	1	2	4	H
Rumex acetosella L.	2	0	3	3	1,2,3	4	Th
Arctostaphylos uva-ursi Spreng.	1	0	1	3	2	3	Ch
Fragaria cuneifolia Nutt.	1	0	1	2	1,2	4	H

TABLE 1 (Continued)

Species	A	C	F	S	P	St	LF
Danthonia californica Boland	1	0	1	1	3	4	H
Bromus carinatus H. and A.	1	0	1	1	3	4	H
Viola glabella Nutt.	3	1	2	3	1,2	4	H
Viola adunca Sm.	2	0	1	3	1,2	4	H
Anemone Lyallii Brit.	4	0-1	3	3	1	4	G
Smilacina sessilifolia Nutt.	2	0-1	1	2-3	2	4	G
Luzula campestris (L.) DC.	1	0	2	2	1,2	4	H
Collinsia parviflora Dougl.	1	0	1	3	1	4	H
Delphinium Menziesii DC.	1	0-1	1	1	2	4	H
Arenaria macrophylla Hook.	2	0	1	1	1	4	H
Senecio integerrimus Nutt.	2	1	1	2	2	4	H
Melica spectabilis Scribn.	1	0	1	1	3	4	H
Dentaria tenella Pursh.	1	0	1	1-2	1	4	G
Erythronium grandiflorum Pursh.	1	0	1	1	1	4	G

TABLE 1 (Continued)

Species	A	C	F	S	P	St	LF
Phleum alpinum L.	1	0	1	1	3	4	H
Carex Hoodii Booth.	1	0	1	1	2	4	H
Erythronium oregonum App.	1	0	1	1	1	4	G

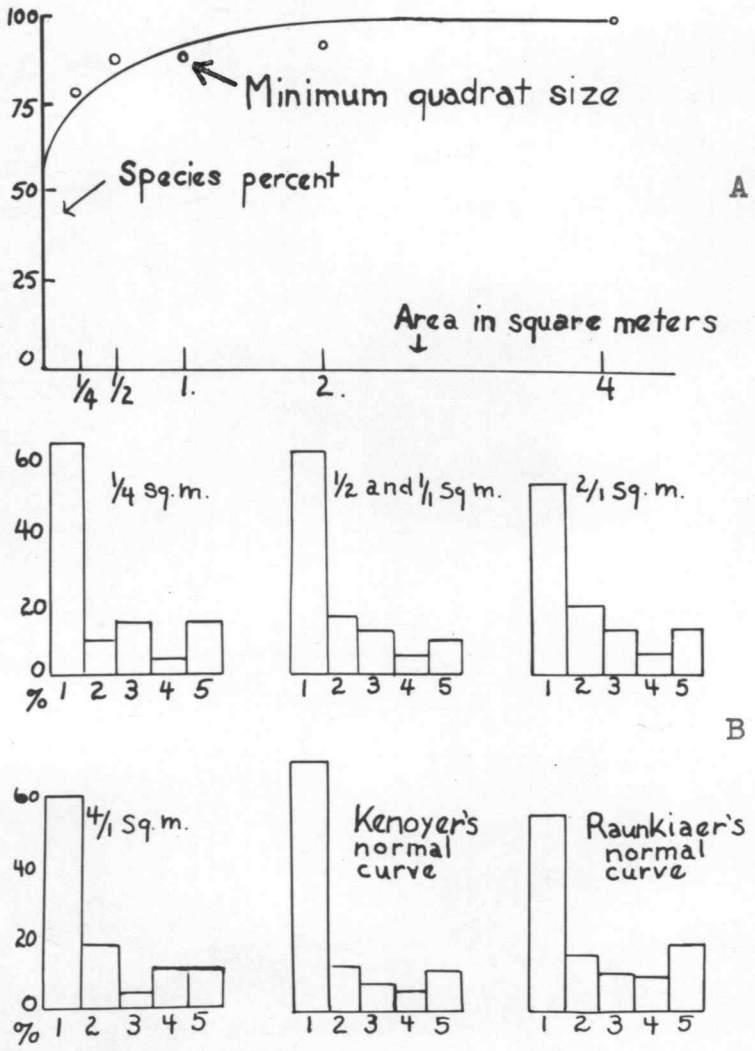


Fig. 17. Meadow

A. Minimum quadrat size as indicated by species-area curve.

B. Frequency class distributions compared with "normals" of Raunkiaer and Kenoyer. Percentages are based on the number of species in each frequency class. Class 1 has 1-20 per cent, etc.

sociability classes 1 and 2, include the greater number of species which are in themselves not so important but in the aggregate contribute materially to the completeness of the plant community.

Table 2 and table 8 for the noble fir community on the north slope below the summit show the size and abundance of noble fir rather than accurately describing the community. The coverage, abundance, and frequency figures show the dominance of noble fir. Noble fir seedlings also are abundant. Hemlock occurs as young trees in one small area, so that in 10 quadrats it had a frequency of 33 per cent. It is represented in only the two smaller size classes (table 8) indicating the seedlings do survive and grow normally. Two hemlock trees were found but not sampled which measured 14 and 22 inches DBH. Wood sorrel and spring beauty (Montia sibirica) were abundant, well distributed, and occurred in extensive patches. Senecio triangularis occurred as a colony, with sociability 4, in an area that is occupied only by large trees. In this colony Senecio triangularis was very abundant, and its coverage was almost 100 per cent, but when these characteristics are projected over the entire community they are relatively less. The classification in sociability 4 indicates the grouping of the plants. The data for vanilla leaf (Achlys triphylla) indicate a similar situation on a

TABLE 2

Data for the Noble Fir Community on the North Slope Below the Summit

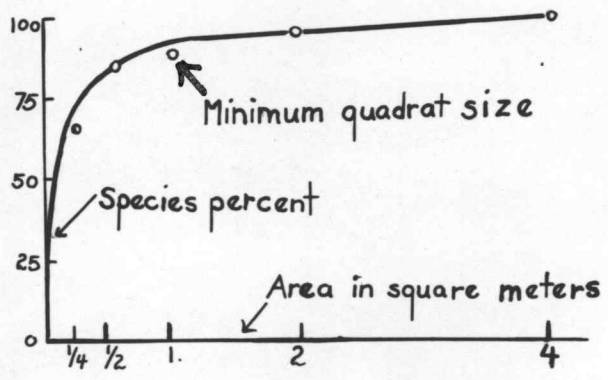
Species	A	C	F	S	P	St	LF
Abies procera Rehd.	180*	5	5	5	-	1	Ph
Tsuga heterophylla (Raf.) Sarg.	12	0	2	3	-	1	Ph
Oxalis oregana Nutt.	4	3	4	4	1	4	G
Montia sibirica (L.) Howell	4	2-3	4	4	1	4	H
Trisetum cernuum Trin.	3	1	2	2	2	4	H
Elymus glaucus Buckl.	2	0	1	2	3	4	H
Coptis laciniata Gray	2	0	2	2	1-2	4	G
Senecio triangularis Hook.	3	3	2	4	2-3	4	H
Abies procera seedling	3-4	0-1	2	3	-	4T**	Ph
Luzula parviflora (Ehrh.) Desv.	3-4	1	3	2	3	4	H
Scrophularia californica C. and S.	2	1	1	3	1-2	4	H
Stellaria crispa Cham. and Schlect.	2	0	1	1	2	4	H
Anemone Lyallii Brit.	1	0	1	1	1	4	G

TABLE 2 (Continued)

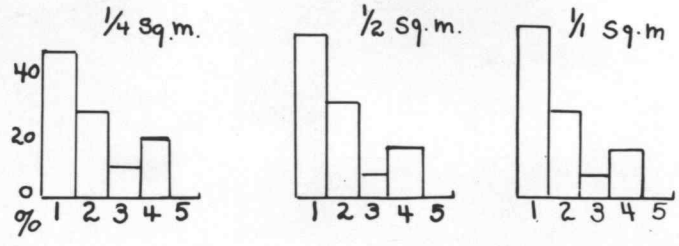
Species	A	C	F	S	P	St	LF
Trillium ovatum Pursh.	1	0	1	1	1	4	G
Tsuga heterophylla seedling	1	0	1	2	-	4T**	Ph
Carex Mertensii Prescott	1	0	1	1	2	4	H
Viola glabella Nutt.	2	0	1	3	1,2	4	H
Achlys triphylla (Sm.) DC.	1-2	0	1	3	1,2	4	G
Carex Preslii Steud.	1	0	1	1	2	4	H

* Abundance of trees expressed in actual numbers.

** Transgressives.



A



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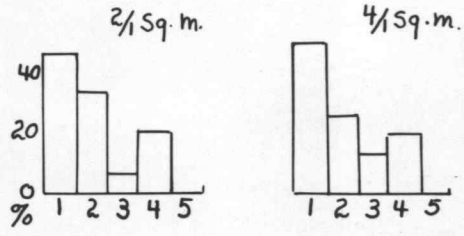

Fig. 18. North Slope Below Summit.
A. Minimum quadrat size for shrub and herbaceous vegetation as indicated by species-area curve.
B. Frequency class distribution.

smaller scale. It grows in small patches. The data for Coptis laciniata and wild-rye indicate low abundance, cover and frequency and that they are grouped in small clumps or tufts. This is caused by their rhizome habit. The data for Trillium ovatum, Anemone Lyallii, and Stellaria crispa show that they are of low abundance, cover and frequency, and occur one in a place or singly as shown by sociability class 1.

The overall cover of the east slope is predominantly Douglas fir and is placed in cover class 5 and sociability 5. It occurs mostly as large trees having 78 per cent of the total basal area (table 7). The next most important upper-story tree is noble fir, which is most important above 3400 feet. It is represented in all the size classes, especially the lower classes. Therefore with an abundance of only 2 specimens less than Douglas fir it makes up only 18 per cent of the basal area. It is reproducing well in the area of its predominance. Douglas fir consists of small trees of 1-3 inches DBH only in areas where older trees had fallen leaving an opening in the canopy. Seedlings were rare in the area at all stations.

Hemlock is found only in a couple of ravines on this slope as explained in the floristic description. Yew consists of 3 small trees in one of the ravines.

Vine maple occurs in small patches of sociability 3

TABLE 3

Data for the East Slope of Mary's Peak

Species	A	C	F	S	P	St	LF
Gaultheria Shallon Pursh	5	4	4	5	2	3	Ph
Berberis nervosa Pursh	5	3	4	4-5	2	3	Ph
Oxalis oregana Nutt.	1	0	1	1	1	4	G
Rosa gymnocarpa Nutt.	1	0	1	1	2-3	3	Ph
Fir seedling	1	0	1	1	-	4T **	
Arenaria macrophylla Hook.	1	0	1	1	2	4	H
Polystichum Lonchitis (L.) Roth	3	1-2	3	4	-	4	H
Anemone deltoides Hook.	1	0	1	2	1	4	G
Coptis laciniata Gray	2-3	1	2	3	1-2	4	G
Vaccinium parvifolium Sm.	1	0	1	1	1	3	Ph
Achlys triphylla (Sm.) DC.	1	0	1	1	1-2	4	G
Galium triflorum Michx.	1	0	1	1	-	4	H
Trisetum cernuum Trin.	1	0	1	1	2	4	H

TABLE 3 (Continued)

Species	A	C	F	S	P	St	LF
Viola glabella Nutt.	1	0	1	2	1-2	4	H
Polypodium vulgare L.	1	0	1	3	-	4	H
Festuca occidentalis Hook.	1	0	1	2	2-3	4	H
Mitella ovalis Greene	1	0	1	1	2	4	H
Montia sibirica (L.) Howell	1	0	1	3	1-2	4	H
Acer circinatum Pursh	248*	2	3	3	1	2	Ph
Holodiscus discolor (Pursh) Maxim.	3	2	1	3	2	3	Ph
Vancouveria hexandra (Hook.) Morr. & Dec.	1	0	1	1	2	4	G
Pseudotsuga taxifolia (Lam.) Britt.	58*	5	5	15	1	1	Ph
Abies procera Rehd.	56*	3	3	4	-	1	Ph
Tsuga heterophylla (Raf.)	11*	1	2	3	-	1	Ph
Taxus brevifolia Nutt.	3*	0	1	1	-	1	Ph

* Abundance of trees expressed in actual numbers of individuals.
** T = Transgressives.

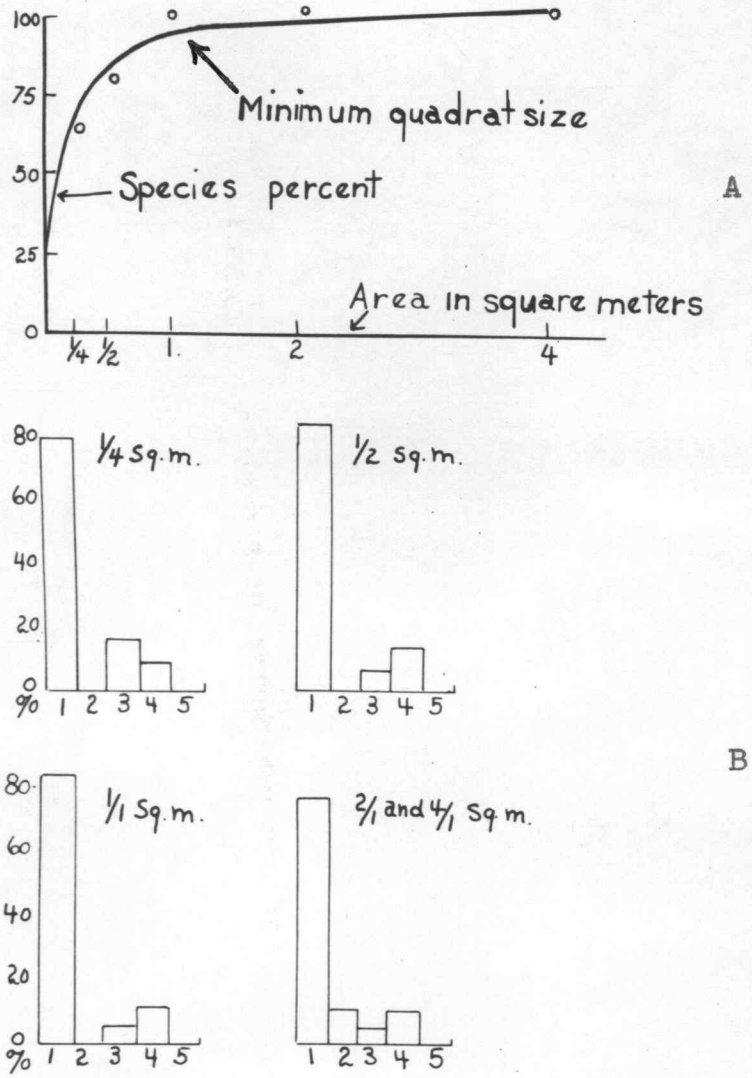

Fig. 19. East Slope
A. Minimum quadrat size for shrub and herbaceous vegetation as indicated by species-area curve.
B. Frequency class distribution.

on this slope. Here it is mostly small plants as indicated by the large number in the smallest size class.

The predominant understory plants are salal and Oregon grape, both about equally abundant, and distributed as shown by abundance class 5, frequency class 4 and sociability 4-5. Salal was placed in cover class 4 and Oregon grape in cover class 3, because a well developed salal plant covers more space than one of Oregon grape.

Oxalis oregana is unimportant here compared with the north slope. Polystichum lanchitis, the sword fern, occurs in rather large patches. Coptis laciniata is scattered over the area in small patches.

Festuca occidentalis, fescue, is a tufted grass growing on the rocky open places in the area. It has low abundance and frequency and sociability class 2 shows its tufted nature.

Anemone deltoidea is placed in sociability class 2 because of its rhizome habit, which results in plants grouped closely. The remaining plants may be mentioned as are the less frequent species in the meadow.

The data for the north slope of Mary's Peak shows that hemlock occurs in greatest numbers with 38 per cent of the total abundance. However, the greatest number of specimens are in the small size classes so that this tree has only 14 per cent of the total basal area (table 6). Noble fir

ranks second in abundance with 29 per cent, but first in basal area with 39 per cent because of the larger trees above 3400 feet elevation. Douglas fir with only 18 per cent abundance ranks close to noble fir in basal area with 36 per cent. This tree is represented in only the 2 largest size classes. Many of the trees are old specimens often reaching 4 or more feet in diameter, which adds up rapidly in basal area. These three tree species are each placed in cover class 3; hemlock because it is dominant below 3400 feet elevation and rather scattered above; noble fir because it is dominant above 3400 feet elevation and more scattered below; and Douglas fir because of the rather scattered large trees. The latter was also placed in sociability class 1 for this reason. All three trees occurred in frequency class 3.

Western red cedar occurs mostly in small patches in moister sites about seepage areas.

Vine maple is patchwise in more open areas or in the few places where Douglas fir provided the canopy. It was not noted under hemlock or noble fir. Willow and yew were found near the seepage areas and springs.

The most widespread understory plant on this slope is the wood sorrel. As stated earlier it is so abundant that it often appears as a carpet. Therefore it is placed in sociability class 5. The sword fern occurred in patches

TABLE 4

Data for the Wooded Area of the North Slope of Mary's Peak

Species	A	C	F	S	P	St	LF
Oxalis oregana Nutt.	5	4	5	5	1	4	G
Montia sibirica (L.) Howell	2	0	1	3	1	4	H
Carex Mertensii Presl.	1	0	1	1	2	4	H
Luzula parviflora (Ehrh.) Desv.	1	0	1	1	1	4	H
Viola glabella Nutt.	3	1	1	3	1	4	H
Dicentra formosa (Andr.) DC.	1	0	1	1	1	4	G
Tsuga heterophylla (Raf.) seedlings	3-4	1	2	3	-	4T	
Disporum Smithii (Hook.) Piper	3	0	1	1	1	4	G
Fir seedlings	4	0-1	3	3	-	4T	
Anemone deltoidea Hook.	2	0	1	1-2	1,2	4	G
Smilacina sessilifolia Nutt.	2	0	1	1	2	4	G
Trientalis europaea L.	1	0	1	1	2	4	G
Achlys triphylla (Sm.) DC.	2	0	1	3	1,2	4	G

TABLE 4 (Continued)

Species	A	C	F	S	P	St	LF
Coptis laciniata Gray	2	0	1	3	1,2	4	G
Polystichum munitum (Kaulf.) Presl.	3-4	2	2	3-4	-	4	H
Galium triflorum Michx.	1	0	1	1	-	4	H
Vancouveria hexandra (Hook.) Morr. & Dec.	1	0	1	1	1,2	4	G
Gaultheria Shallon Pursh	1	0	1	1	2	3	Ph
Berberis nervosa Pursh	1	0	1	1	2	3	Ph
Trisetum cernuum Trin.	2	0-1	1	1	2	4	H
Polypodium vulgare L.	1	0	1	1	-	4	G
Arenaria macrophylla Hook.	1	0	1	1	1	4	H
Lomatium nudicaule (Pursh) C. & R.	1	0	1	1	1,2	4	H
Rosa gymnocarpa Nutt.	1	0	1	1	2	3	Ph
Listera cordata (L.) R. Br.	1	0	1	1	2	4	H
Viola sempervirens Greene	1	0	1	1	1	4	H
Elymus glaucus Buckl.	1	0	1	1	3	4	H

TABLE 4 (Continued)

Species	A	C	F	S	P	St	LF
Scrophularia californica C. and S.	1	0	1	2	1,2	4	H
Senecio triangularis Hook.	1	0	1	1	2	4	H
Trillium ovatum Pursh	1	0	1	1	1	4	G
Melica spectabilis Scribn.	1	0	1	1	3	4	H
Clintonia uniflora Kunth.	1	0	1	1	-	4	G
Mitella ovalis Greene	1	0	1	1	2	4	H
Vaccinium parvifolium Sm.	1	0	1	1	1	4	Ph
Veratrum californicum Durand	1	0	1	1	-	4	G
Stellaria crispa Cham. and Schlect.	1	0	1	1	2	4	H
Oplopanax horridum (Sm.)	1	0	1	2	-	3	Ph
Rubus pedatus Smith.	1	0	1	1	-	3	Ch
Unidentified herb	1	0	1	1	-	4	H
Smilacina racemosa (L.) Desf.	1	0	1	1	1,2	4	G
Pseudotsuga taxifolia (Lam.) Britt.	89*	3	3	1	-	1	Ph

TABLE 4 (Continued)

Species	A	C	F	S	P	St	LF
Tsuga heterophylla (Raf.)	181*	3	3	4-5	-	1	Ph
Salix Scouleriana Barr.	4*	0	1	1	1	2	Ph
Acer circinatum Pursh	41*	0	1	3	1	2	Ph
Taxus brevifolia Nutt.	2*	0	1	1	-	2	Ph
Thuja plicata Don.	25*	1	1	3	-	1	Ph
Abies procera Rehd.	147*	3	3	5	-	1	Ph

* Abundance of trees expressed in actual numbers.

** T = Transgressives.

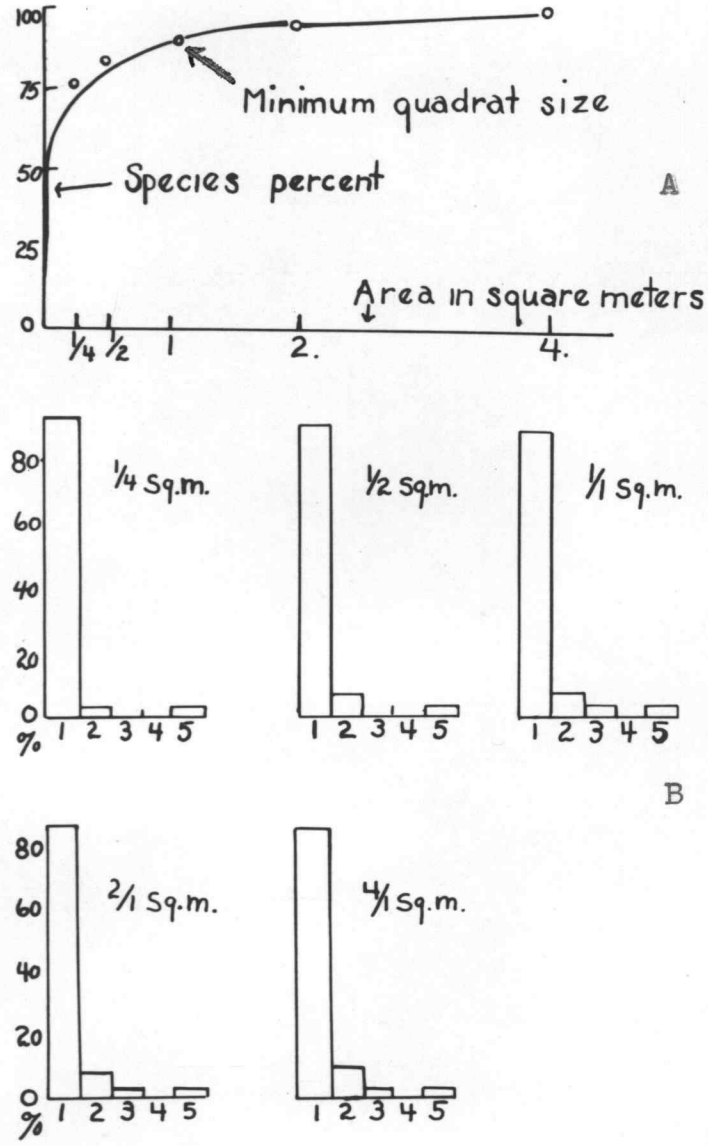

Fig. 20. North Slope
A. Minimum herbaceous size for small shrub and herbaceous vegetation as indicated by species-area curve.
B. Frequency class distribution.

fairly well scattered over the area, especially below 3400 feet elevation. The wood violet and fairy bell (Disporum Smithii) were fairly abundant in small patches, but the patches were distributed in such a manner that the frequency was low. Coptis laciniata, Achlys triphylla, and Montia sibirica were also grouped in small patches.

Seedlings of hemlock were abundant as also were seedlings of "fir". As stated earlier no attempt was made to separate the seedlings of Douglas fir and noble fir. There were no small trees of Douglas fir, but small trees of noble fir were quite abundant (table 6). Salal and Oregon grape are almost absent on this slope.

The remaining species have a low abundance, cover, and frequency. Their occurrence in sociability class 1 indicates single scattered plants and the low frequency shows their limited occurrence. For this reason the flora on this slope is very heterogeneous and would require a large number of quadrats to obtain a representative sample.

The south slope (table 9) is very completely covered by a rather even aged stand of Douglas fir. It occurs in cover class 5, frequency class 5, and sociability class 5. All specimens sampled occurred in the largest size class, over 10 inches DBH.

The only other tree species is vine maple which is quite abundant and occurs in extensive patches. Most of

the specimens are in the lowest size class, less than 1 inch DBH. However, on this slope are many specimens, 10 of which were sampled, in size class 3, 3 to 10 inches DBH.

The shrub species are entirely composed of salal and Oregon grape, both abundant, evenly distributed and in highest cover class up to about 3300 feet elevation which is their upper limit on this slope. The change is abrupt, with only a few feet vertically, between a thick stand and no plants of these species. This zone where these plants are absent reduces their cover value to 4 for salal and 3 for Oregon grape. This is also the reason their frequency class is only 4. Above these two species Montia sibirica and Dentaria tenella are quite abundant, but in the whole community they are rare. Their sociability class 3 indicates they grow in a colony or patch. The remaining plants are those which are infrequent in the community.

TABLE 5

Data for the Wooded South Slope of Mary's Peak

Species	A	C	F	S	P	St	LF
Gaultheria Shallon Pursh	5	4	4	5	2	3	Ph
Berberis nervosa Pursh	4	3	4	5	2	3	Ph
Acer circinatum Pursh	290	3	3	4	1,2	2	Ph
Anemone deltoidea Hook.	1	0	1	1-2	1,2	4	G
Galium triflorum Michx.	1	0	1	1	-	4	G
Polystichum munitum (Kaulf.) Presl.	1	0	1	2	-	4	H
Montia sibirica (L.) Howell	1	0	1	3	1	4	H
Disporum Smithii (Hook.) Piper	1	0	1	1	1	4	G
Viola sp.	1	0	1	1	-	4	H
Achlys triphylla (Sm.) DC.	3-4	2	3	3	1,2	4	G
Synthyris seniformis (Dougl.)	1	0	1	1	1,2,5	4	H
Oxalis oregana Nutt.	1	0	1	1	1,2	4	G
Corallorhiza striata Lindl.	1	0	1	1	2	4	G

TABLE 5 (Continued)

Species	A	C	F	S	P	St	LF
Trillium ovatum Pursh	1	0	1	1	1	4	G
Dentaria tenella Pursh	1	1	1	2-3	1	4	G
Listera cordata (L.) R.Br.	1	0	1	1	2	4	H
Melica subulata (Griseb.) Scribn.	3	1-2	2	1	3	4	H
Douglas fir seedlings	1	0	1	1	-	4T**	Ph
Coptis laciniata Gray	1	0	1	2	2	4	G
Symphoricarpos albus (L.) Blake	1	0	1	1	2	3	Ph
Arenaria macrophylla Hook.	1	0	1	1	1	4	H
Adenocaulon bicolor Hook.	1	0	1	1	3	4	H
Osmorhiza nuda Torr.	1	0	1	1	2	4	H
Iris tenax Dougl.	1	0	1	1	1	4	G
Vaccinium parvifolium Sm.	1	0	1	1	1	4	Ph
Polypodium vulgare L.	1	0	1	1	-	4	H
Rosa gymnocarpa Nutt.	1	0	1	1	2	3	Ph
Pseudotsuga taxifolia (Lam.) Britt.	65*	5	5	5	-	1	Ph

* Abundance of trees expressed in actual numbers.
** T = Transgressives.

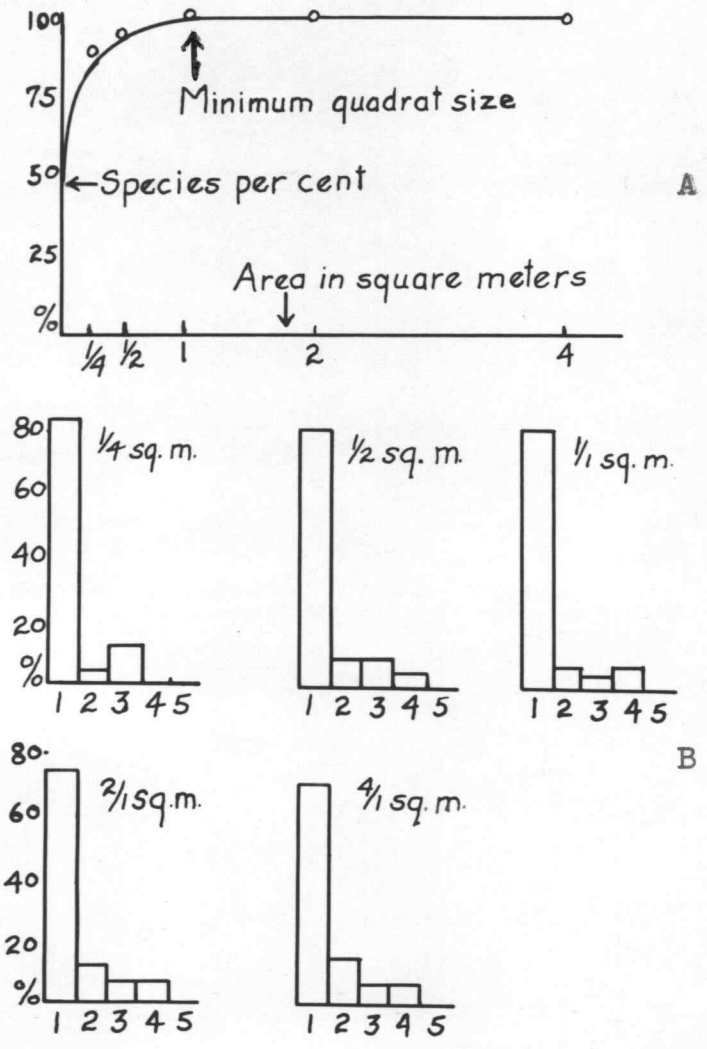

Fig. 21. South Slope
A. Minimum quadrat size for shrub and herbaceous vegetation as indicated by species-area curve.
B. Frequency class distribution.

Biological Spectrum

The life form of a plant is defined as the form which the vegetative body of the plant produces as the result of all the life processes which are affected by the environment.

The term "life form" was devised by Raunkiaer (1934) and first published in 1904. He recognized that there must be some peculiarity by which the plant survived the unfavorable season and chose for the basis of classification the location of the perennating organs during the cold winter or the dry, hot summer. The life form allows the use of vegetation as a test of the climate. Similar regions can be compared and dissimilar regions can be contrasted by means of their vegetation.

Plants with similar morphological characteristics are placed in a life form class. The five general life form classes are as follows (Raunkiaer, 1934):

1. Phanerophytes (Ph) are tall shrubs and trees with the buds more than one foot above the ground. Raunkiaer considered these having the least protected growing points, especially those with no bud covering. They form the bulk of the species in the tropical regions which are constantly warm and moist. They decrease in proportion to the other life forms in less favorable climates

until the far north, high altitudes and dry steppes, the phanerophytes disappear altogether.

2. Chamaephytes (Ch) are characterized by having the survival buds located close to the ground, in some because the shoot lies on the ground, in others because the upper portion of the shoot dies at the beginning of the unfavorable season, leaving only the lowest portion of the shoot with the buds. This life form is most characteristic of the boreal and arctic regions and alpine altitudes in the mountains. Examples are bearberry or kinnikinnick, Linnaea borealis, and various blueberries of the far north.
3. Hemicryptophytes (H) have their surviving buds actually in the soil surface. The aerial shoots survive for only a single vegetative period and die back to the ground. The majority of biennial and perennial herbs, the bulk of the plants in the cold and temperate parts of the earth, belong to this life form.
4. Geophytes (G) have their surviving buds completely under the ground. This life form is well protected against desiccation, and is found in regions with a long dry period, especially steppes, though they are actually less sensitive to climate

than other forms. Many herbs with horizontal rhizomes, and the majority of bulbous and tuberous plants belong to this life form.

5. Therophytes (Th) include plants which complete their life cycle within a single favorable season, and remain dormant in the form of seed throughout the unfavorable periods. Because these plants complete their life cycle in a comparatively short period, often a few weeks, this life form is found most abundantly in steppes and deserts.

The biological spectrum of a region is an expression on a percentage basis of the number of species in each of the life form classes. By means of the biological spectrum the character of the flora can be presented in table form, can be compared with that of other regions, and also can be used as an indicator of the climate.

The normal spectrum was obtained by sampling 1000 representative species of the world flora and determining their life form class. The normal forms an arbitrary base line with which the flora of a region is compared. The class or classes with the greatest positive deviation from the normal is taken to indicate the phytoclimate. The value of the spectra lies in the fact that the life forms of the plants of a flora must be considered a reflection and integration of the climatic conditions (Cain, 1932).

The biological spectrum of the flora of Mary's Peak is compared below with the normal spectrum of Raunkiaer and the spectra of other areas.

Region	No. of Species	Per cent of Species			
		Ph	Ch	H	G	Th
Normal spectrum	1000	46	9	26	6	13
Mary's Peak	124	19	2	54	25	0
Indiana		15	2	50	20	13
Olympic Peninsula	1015	11	6	52	22	9
Connecticut	1400	15	2	49	22	12
Willamette Valley	600	11	2	30	24	33
Death Valley	294	26	7	18	7	42
Spitzbergen	110	1	22	60	15	2
Seychelles	258	61	6	12	5	16

The pronounced positive deviation in the hemicryptophytes and geophytes would classify the flora of Mary's Peak as hemicryptophytic and geophytic. The total of these two classes is 78 per cent of the flora. This may be compared with the flora of Indiana, the Olympic Peninsula, and Connecticut. The flora of these regions shows a hemicryptophyte and geophyte percentage of 70-75 per cent, with a low per cent of chamaephytes, phanerophytes, and therophytes. The lack of therophytes on

Mary's Peak may be explained because only the mature climax communities were sampled. If plants had been included from the disturbed areas a number of annuals would be present. There are very few annuals found in relatively small samples of well shaded mature plant communities as those studied in this work. These plants occur in disturbed areas as along the roads and the edges of the woods and meadow.

The biological spectrum of the Willamette Valley shows relatively high percentages of geophytes and therophytes. The discussion of the life form classes pointed out that geophytes and therophytes are characteristic of climatic regions with a long dry period. The above normal percentage for the therophyte class can be explained by the dry summer. The high percentage of geophytes and near normal percentage of hemicryptophytes can also be explained in this manner. The geophytes here are mostly bulb and rhizome types.

Below normal percentage of all classes except the therophytes which are three times normal is characteristic of extreme deserts as shown by the biologic spectrum of Death Valley.

Spitzbergen at 79° north latitude is characterized by a high percentage of hemicryptophytes and chamaephytes, and a low percentage of phanerophytes and therophytes. A

combination of a high percentage of hemicryptophytes and rhizome geophytes is found in a cool temperate region. However, when a high percentage of chamaephytes is added to this, the climate is characteristically cold temperate (Raunkiaer, 1934).

In the Seychelles, a group of islands in the Indian Ocean, with a moist tropical climate, the biological spectrum reveals a high percentage of phanerophytes, which is typical of such climates. This indicates that a moist, tropical climate is most favorable for this life form.

ARBORESCENT STRATUM

The analytic data for trees are presented separately in addition to the previous discussion of them in the treatment of the plant communities. These data were collected in the forest communities from 10 x 10 meter quadrats as explained in the discussion on methods. All trees were measured at breast height, and those under 1 inch in diameter were counted as small trees. Seedlings with the cotyledons present were not counted for this part but were discussed in the data from the smaller quadrats.

The data are presented both in tabular and graphic form. The graphic presentation is made by means of phytographs first devised by Lutz (1930). The method consists of a polygonal figure formed on four axes representing what are considered the most important criteria for portraying the ecological status of a tree species in a forest community (see standard, fig. 22). The four criteria used are:

1. Abundance: the number of trees of a given species represented as a per cent of the total number of trees of all species over seedling size.
2. Frequency: the per cent of times a given species over seedling size occurs in the total number of sample plots.

3. Size class: size classes in which each species is represented based on DBH.

4. Basal area: basal area of each species expressed as per cent of total basal area of all species.

These four quantitative factors in the same graph for each species present give an integrated and relative picture of the measurements. The mass effect of the graphs of all the species shows their relative importance in the community.

The size classes based on DBH are as follows:

1. Under 1.0 inch DBH
2. 1.0 to 3.0 inches DBH
3. 3.1 to 10.0 inches DBH
4. Over 10.0 inches DBH

The basal area is the cross sectional area of a tree in square feet determined from the DBH measurement. No attempt is made to account for the fact that a tree is seldom a circle in cross-section, except to average diameters at right angles when the tree is especially asymmetrical. Basal area was computed only for trees 1.0 inch DBH and over. In the standard as shown in figure , OA is the per cent of total abundance, OB is the per cent of frequency, OC is the per cent of the four size classes represented, and OD is the per cent of total basal area.

North Slope

The frequency, size classes, per cent of total abundance, and per cent of basal area of each species are shown in table 6, and the phytograph for each species is shown in figure 22). The three most important species are noble fir, hemlock, and Douglas fir. Hemlock is most abundant with 38 per cent of the total, noble fir next with 29 per cent, and Douglas fir the least with 18 per cent. All three are of about the same frequency. Douglas fir is represented in only 2 size classes while hemlock and noble fir occur in all 4. The basal area in this case is the most significant in revealing the ecological relationships of these three species. Douglas fir with the lowest abundance, equal frequency and only 2 size classes has 36 per cent of the total basal area. This indicates that most of the trees must be in the larger size classes. The table and the phytograph show that Douglas fir is not reproducing and will be replaced in the community. Hemlock, on the other hand, is the most abundant tree, occurs in all four size classes, but has only 14 per cent of the total basal area. This indicates, and is shown in the table, that hemlock is abundant in the smaller size classes and is reproducing rapidly. There is also a sufficient number of large trees to consider it a codominant species. The relatively large basal area of noble fir denotes that there is also

TABLE 6

Data Used in Construction of Phytographs of the Trees on the North Slope

Species	Frequency Percent	Abundance in each size class 1	2	3	4	Total	Percent of Total	Basal Area sq. ft.	Percent
Abies procera	52	64	11	12	60	147	29	187.12	39
Tsuga heterophylla	46	68	50	29	34	189	38	64.84	14
Pseudotsuga taxifolia	52	0	0	36	53	89	18	172.66	36
Thuja plicata	20	7	4	6	8	25	5	45.50	9
Taxus brevifolia	2	0	0	2	0	2	0.4	0.33	1
Acer circinatum	3	29	12	0	0	41	8	0.24	1
Salix Scouleriana	5	0	0	4	0	4	0.8	0.40	1
TOTAL						497		476.09	

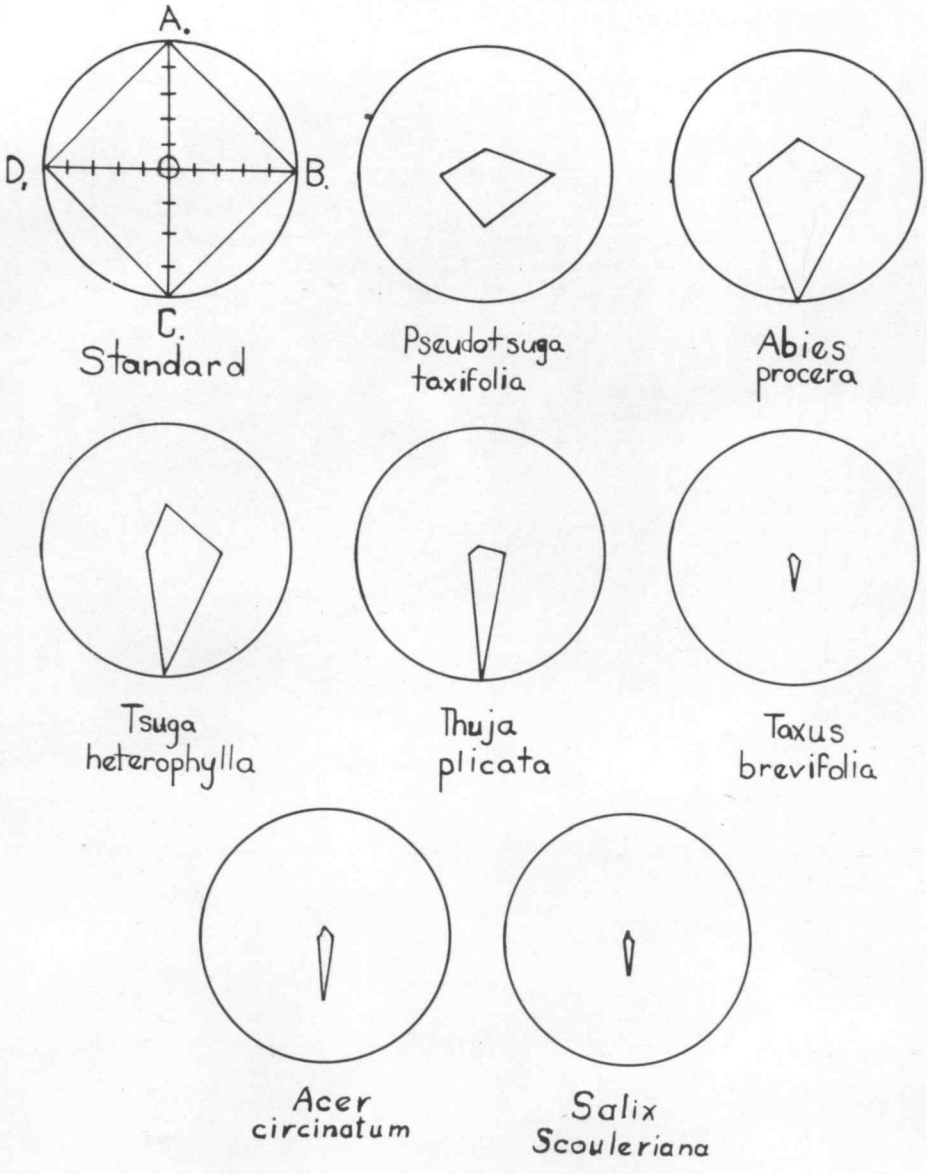

Fig. 22. Phytographs for tree species on the North Slope. Standard - OA is per cent of abundance, OB is per cent of frequency, OC is per cent of total size classes, OD is per cent of basal area.

an abundance of large trees in addition to the smaller sizes.

The phytograph for cedar suggests it is a tree of low abundance, frequency, and basal area. Its occurrence in all four size classes expresses its tolerance of shade and that it is reproducing. It has probably invaded the area much later than hemlock.

The phytographs for yew, vine maple, and willow signify the minor and subdominant role of the small tree species under the canopy of the large ones.

East Slope

The extent to which Douglas fir is dominant on the east slope is shown in table 7 and the phytograph (fig. 23). It has the highest frequency and by far the greatest basal area. The extremely large basal area with low abundance and 3 size classes suggest that the smallest size class is absent, which is verified by examining the table.

Noble fir, with the same abundance as Douglas fir, but a much smaller basal area and occurring in all 4 size classes suggests that it is represented abundantly in the small size classes and is reproducing readily. Hemlock occurs only on the moister sites along ravines and is not generally invading the entire slope.

The small tree species are yew and vine maple. Yew

TABLE 7

Data Used in Construction of Phytographs of the Trees on the East Slope

Species	Frequency Percent	Abundance in each size class				Total	Percent of Total	Basal Area	
		1	2	3	4			sq. ft.	Percent
Abies procera	60	12	32	7	5	56	15	39.17	18
Pseudotsuga taxifolia	95	0	18	6	34	58	15	171.29	78
Tsuga heterophylla	35	0	3	3	5	11	3	7.01	3
Taxus brevifolia	15	0	2	0	1	3	0.8	0.89	1
Acer circinatum	45	201	47	0	0	248	66	0.94	1
TOTAL						376		219.30	

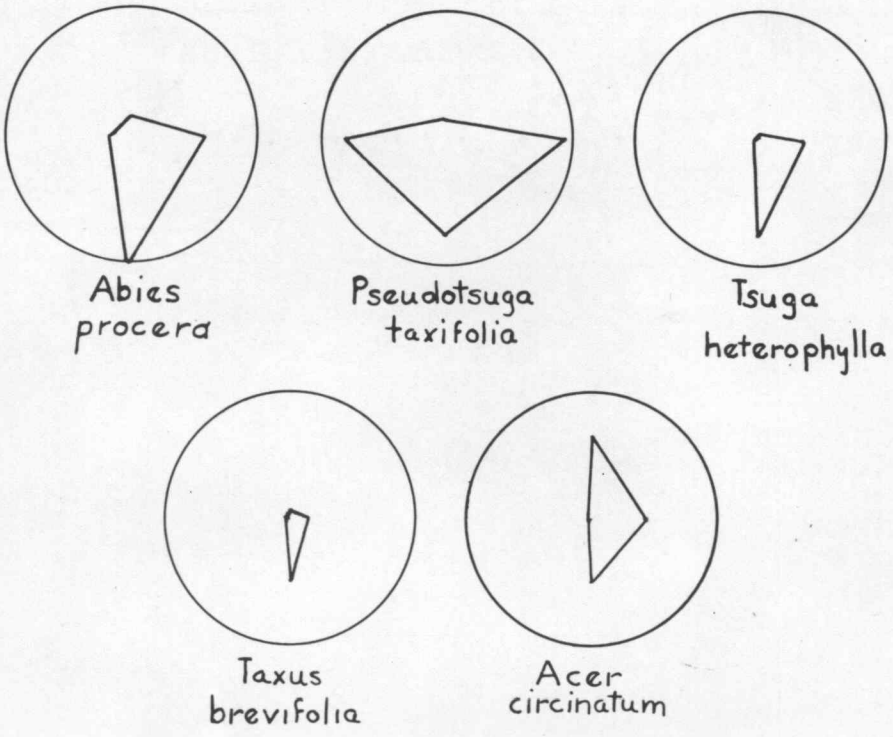

Fig. 23. Phytographs for tree species on the East Slope.

is of slight importance, consisting of only 3 trees. Vine maple is the most abundant of all the species, with a large number in the smallest size class. Its basal area is negligible because of the small size of the plant.

North Slope Below the Summit

Data for this slope are shown in table 8 and the phytographs (fig. 24). Noble fir is predominant here because it is high in all the quantitative factors. The young plants are tolerant of shade and growing vigorously. It is abundant in the lower size classes. This community also supports an abundant population of very large trees. Twenty specimens occur in size class 4 which is an average of 2 large trees in each of the 10 quadrats. Some of these large trees are well over 4 feet DBH.

Hemlock is not abundant but it is apparently both increasing and spreading as shown by the thriving small trees. Two larger trees previously mentioned show that hemlock thrives in this community. However, whether hemlock will ever replace noble fir in this area cannot be answered by the results of this study.

South Slope

The data for the south slope are shown in table 9 and figure 25. Douglas fir is the only species of the

TABLE 8

Data Used in Construction of Phytographs of the Trees on North Slope Below Peak

Species	Frequency Percent	Abundance in each size class				Total	Percent of Total	Basal Area	
		1	2	3	4			sq. ft.	Percent
Abies procera	100	81	52	25	20	180	94	134.16	100
Tsuga heterophylla	33	10	2	0	0	12	6	0.04	0
TOTAL						192		134.20	

TABLE 9

Data Used in Construction of Phytographs of the Trees on South Slope

Species	Frequency Percent	Abundance in each size class				Total	Percent of Total	Basal Area	
		1	2	3	4			sq. ft.	Percent
Pseudotsuga taxifolia	86	0	0	0	65	65	18	342.86	96
Acer circinatum	58	248	32	10	0	290	82	1.62	4
TOTAL						355		344.48	

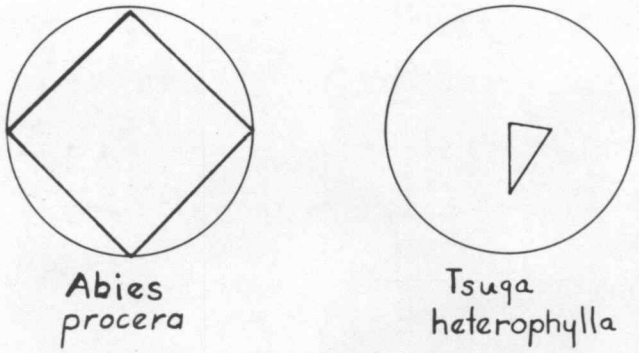

Fig. 24. Phytographs for tree species on the North Slope below the summit.

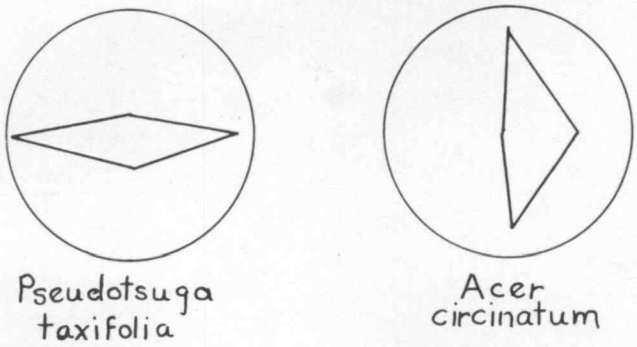

Fig. 25. Phytographs for tree species on the South Slope.

upper tree stratum and vine maple the only species of the smaller tree stratum. The occurrence of Douglas fir in a single size class, its large basal area, and its high frequency indicate a number of large trees. The table shows its occurrence in only the largest size class. There were seedlings in the area but none larger. This supports the statement of Munger (1940) that Douglas fir seedlings do not survive in the shade of older trees. Only when an opening occurs in the canopy and more light enters will young Douglas fir thrive.

Vine maple is abundant and fairly frequent but the basal area is negligible. This area has some large individuals of this species as shown by 10 species in size class 3.

In general, the data from the quadrats in the forest community of Mary's Peak above 2500 feet indicate that on the north slope noble fir and western hemlock are codominant, and Douglas fir is subclimax and is present as a result of fire. On the drier east and south slopes, however, Douglas fir seems to be codominant with noble fir. Recent burning on the west slope has obliterated any evidence for successional relationships between these three species.

SUMMARY

Data were obtained on Mary's Peak in western Oregon during the summer of 1947 to evaluate the application of the several phytosociological concepts concerned in the analysis and description of plant communities. These concepts are based largely on quantitative and qualitative characteristics. Quantitative characteristics are abundance, coverage, and frequency. For trees, basal area and size classes computed from field measurements of diameter at breast height were also considered. Qualitative characteristics include sociability, vitality, layering, periodicity, and life forms.

Mary's Peak is the highest in the Coast Range Mountains between the Olympic Mountains in Washington on the north and the Klamath Mountains in southwestern Oregon.

The Coast Range of Oregon has a wet, microthermal climate with precipitation adequate at all seasons. The proximity to the Pacific Ocean causes a distinct marine climate.

Mary's Peak lies within the cedar-hemlock association of the coast forest. The north slope is covered with western hemlock, red cedar, and noble fir. Douglas fir on this slope consists of scattered large trees but no small trees are present. The east slope is covered with noble fir and Douglas fir with the former abundant above

3600 feet elevation. The others are most abundant below that elevation. The south slope is covered by Douglas fir alone except for a narrow zone of noble fir between 3300 and 3500 feet elevation. The understory on the north slope is predominantly Oxalis oregana, while that of the east and south slopes is predominantly salal and Oregon grape.

The area about the summit of the mountain is covered with a grass land composed of Idaho fescue, Agrostis diegoensis, and California sedge as dominants.

Data for the application of the phytosociological concepts and construction of the species-area curves were obtained from quadrats spaced at intervals in the communities. The minimum quadrat size required to adequately sample the vegetation of the meadow and the herbaceous and shrub vegetation of the forest is shown to be 1 square meter. The 1 square meter quadrat taken between 20 and 30 times was sufficient to sample the meadow vegetation. However, an adequate sample of the herbaceous and shrubby vegetation in the forest required 45 to 60 similar sized quadrats.

The biological spectrum of Mary's Peak based on Raunkiaer's life forms is presented and compared with other sections of the world and the normal spectrum of Raunkiaer. The spectrum compares closely with those of other regions

of the temperate zone.

The data for the tree species are also presented in the form of phytographs, from which dominance and successional trends are interpreted. In general noble fir and hemlock are the chief dominants, while Douglas fir seems to be dominant only on the east and south slopes and probably subclimax on the north slope.

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