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Title VEGETATION-SOIL RELATIONS AS A BASIS FOR RESOURCE MANAGEMENT ON THE OCHOCO NATIONAL FOREST OF CENTRAL OREGON

Abstract approved [redacted]
(Major Professor)

The study was conducted on the Ochoco National Forest in central Oregon. Vegetation-soil relationships were evaluated for the following objectives: 1. Develop a sound ecological foundation on which total land management decisions may be based. 2. Evaluate forest succession, stocking, and growth to improve management. 3. Develop accurate range condition and trend guides.

The concept of non-random distribution of plant communities in a continuum gradient was used to guide the investigation. This philosophy requires sampling the entire spectrum of vegetation and environmental variability in order to determine plant community groupings for classification purposes.

Data were collected on a fifth-acre plot for trees, and on two 100-foot three-quarter-inch loop transects for subordinate vegetation. Forage production was determined on ten 9.6-square foot plots.

Soil profiles were described according to standard procedure.

Only vegetation free from grazing or logging disturbance was sampled.

Vegetation was classified by use of association tables. Mathematical computations included standard errors and correlation analysis.

Non-forest associations were: Artemisia rigida/Poa secunda on about six inches of soil, Artemisia arbuscula/Festuca idahoensis on about 14 inches of clayey soil derived from acid igneous rock, and Artemisia arbuscula/Agropyron spicatum on about 14 inches of clayey soil derived from basic igneous rock. These associations occur as natural openings in the forest zone due to soil properties inimical to tree establishment.

Climax pine associations occurred on 12 to 30 inches of sandy, stony soil. Pinus ponderosa/Purshia tridentata/Agropyron spicatum occurs at lower elevations. Pinus ponderosa/Purshia tridentata/Sitanion hystrix occurs on acid igneous derived soils. Pinus ponderosa/Carex geyeri occurs on basic igneous derived soils. All are grazed by livestock and require open tree stocking for optimum tree growth.

The Abies grandis/Calamagrostis rubescens association occupies more land area than all other forest types combined. It has been maintained in open Pinus ponderosa by natural, recurrent ground fires. With fire control, this association gradually moves toward a climax of fir.

The Abies grandis/Bromus vulgaris association occurs at upper elevations. Dense forest cover makes it unsuitable for grazing. Management is different than for the Abies/Calamagrostis.

Even though the Pinus contorta/Vaccinium scoparium/Calamagrostis rubescens is successional, it was classified as an associes for management purposes. It pioneers on Abies/Bromus sites following conflagration fires.

Four other vegetation associations were briefly described.

Numerical variability within associations poses problems for development of range and forest management guides. In most cases, correlation analysis permits refinement of data. Variability is caused by the continuum effect of vegetation and environment.

The information derived from this study is discussed for application in management. Mapping recommendations include a basic vegetation map with overlays for timber and range management use. Guides are presented for development of range condition and trend standards, interpretation of trend, and evaluation of management. Forestry guides include suggestions for silviculture, stocking and growth, and timber management. In addition, application in watershed and multiple use is briefly discussed.

VEGETATION-SOIL RELATIONS AS A BASIS FOR RESOURCE MANAGEMENT ON THE OCHOCO NATIONAL FOREST OF CENTRAL OREGON

by

FREDERICK COLUMBUS HALL

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

VEGETATION-SOIL RELATIONS AS A BASIS FOR RESOURCE MANAGEMENT ON THE OCHOCO NATIONAL FOREST OF CENTRAL OREGON

INTRODUCTION

Management of non-arable land is based primarily upon harvesting the natural products and realizing other benefits of vegetation. As this management is intensified, knowledge of the nature and characteristics of vegetation must correspondingly increase. Evaluation of vegetation-soil relationships is a method of investigating the wholistic interactions of plants, soils, land forms, and biotic influences.

Timber management requires refined information on forest site, succession, growth, and tree stocking that is accurate for each eco-system which makes up the timber resource. This information is essential for prescribing silvicultural methods, predicting growth, insuring regeneration and planning timber stand improvement.

Livestock and game range management require evaluation of grazing influences on vegetation. These influences are most expeditiously appraised by use of range condition and trend guides in conjunction with utilization data. Useful guides require study of four criteria. First, ecological analysis of climax and succession for interpretation of condition. Second, classification of plant communities to facilitate application of condition and trend and utilization guides. Third, examination of vegetation and soil patterns as a basis for refining condition and trend guide accuracy. Fourth, collection of numerical data.

Watershed management deals with two problems: watershed protection and water production and quality. Protection requires vegetation cover which will prevent erosion. This is tied directly to range condition and timber management practices. Water production and quality is influenced by soil properties and the density and nature of plant cover. The amount of water produced can be materially influenced by manipulation of vegetation, particularly on forested lands.

Thus, timber management, livestock and game range management, and watershed management are tied together by the common bond of vegetation-soil relationships. They require an inventory of their common resources, vegetation and its associated soil. The most desirable inventory method is based upon vegetation mapping. Vegetation maps are the basis for formulating plans in forest, range, and watershed management. These plans include determination of tree growth and animal capacity, layout of timber sales, prescription of grazing systems, improvement of both livestock and game distribution, directions for revegetation and reforestation, and prescriptions for watershed improvement.

The purpose of this study was to evaluate vegetation-soil characteristics as a basis for improvement of land management. The following objectives were established to guide the investigation: 1. Develop a sound ecological foundation on which total land management decisions may be based. 2. Gather information for development of accurate livestock and game range condition and trend guides for forest and non-forest vegetation. 3. Evaluate silvicultural properties, growth, stocking, and harvest alternatives of forest communities.

The Ochoco National Forest was selected as the study area for several reasons. First, the author gained extensive knowledge of the vegetation and soils through his work in range analysis. Second, he became intimately familiar with land management problems of the area during his Forest Service tenure. Third, no vegetation-soils analysis had previously been made in the study location.

Since the objectives of this study point to improvement of land management, sampling methods currently in use by the Forest Service were employed. These include the three-quarter inch loop method for range vegetation, the 9.6 square-foot plot for forage production, and the one-fifth acre plot for tree stocking and growth.

STUDY AREA

Location and Geography

The Ochoco National Forest is located near the geographic center of the state of Oregon. It lies between 44°40' and 43°40' north latitude and 119°10' and 120°50' west longitude (Figure 1).

It is composed of the Ochoco Mountain, Maury Mountain, and Snow Mountain land masses which may be considered a southwestern extension of the Blue Mountains. They are surrounded on the north, west, and south by a semi-arid, *Artemisia*-steppe plateau of about 3000 feet elevation.

History of Land Use

Hodgson (1913) discussed the history of the Ochoco National Forest up to 1913. The Blue Mountains apparently were so named because frequent ground fires cast a constant pall of smoke over the area prior to 1900. He states that migratory Indians used the forest during the summer. At times they set some fires, and campfires occasionally escaped.

The first white settlement in the area started about 1865 with grazing and some farming. This white population gradually increased until irrigation was made available by the Ochoco Dam in the late 1920's. Thereafter the increase became more rapid (U. S. General

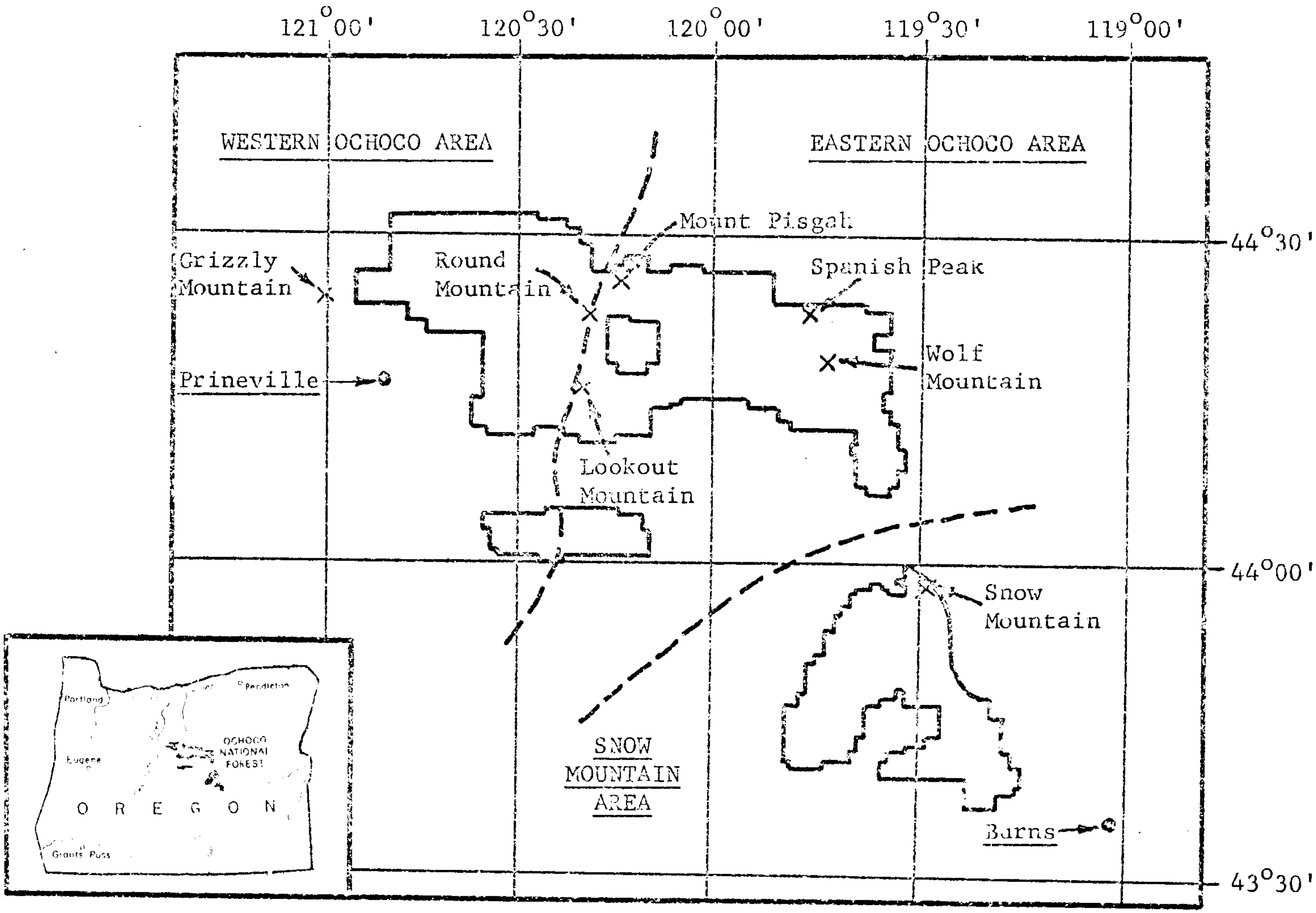


Figure 1. Location of the study area showing topographic - geologic subdivisions.

Land Office, 1874).

The Ochoco National Forest was established in 1905 at the urging of sheep and cattle operators. They felt that the Forest Service would act as a mediator in their grazing disputes (Hodgson, 1913). At the time of establishment, the main purpose of the Forest Service was to control fire, to control use by livestock, and to act as a custodian of the timber resource.

When the Forest was established, 17,900 cattle and 152,000 sheep were permitted to graze (Table 1). Since then, cattle numbers have been reduced 250 percent and sheep numbers have been reduced 900 percent (U. S. Forest Service, 1940). It is quite probable that no area escaped at least some degree of livestock use.

No information is available on deer and elk numbers in 1907; however, in 1925, 1,500 deer and no elk were estimated to be grazing on the Forest. By 1960, there were an estimated 18,300 deer and 360 elk (U. S. Forest Service, 1925). This increase in game numbers was apparently caused by the institution of a buck law and the reduction of livestock use.

Extensive logging commenced about 1940. By 1960, when this study was completed, only 40 percent of the virgin forest had been entered for logging purposes. Logging consisted chiefly of individual tree selection and small group clear cuttings (U. S. Forest Service, 1949). At the present time, four large mills in Prineville and one

Table 1. Livestock and Game Numbers on the Ochoco National Forest

Year	Cattle and Horses No.	Cattle and Horses AUM	Sheep and Goats No.	Sheep and Goats AUM	Deer	Elk
1907	17,900	80,550	152,000	608,000	unk.	unk.
1925	17,769	79,960	91,387	275,661	1,500	0
1940	8,566	33,950	43,187	154,606	12,000	85
1960	7,610	27,649	18,625	53,929	18,300	360

large mill in Burns obtain a majority of their timber from the Ochoco National Forest.

Topography and Geology

The Ochoco National Forest can be divided into three general areas. The Western Ochoco Mountains include the western third of the Maury Mountains. The Eastern Ochoco Mountains include the eastern two-thirds of the Maury Mountains. The Snow Mountain area lies to the south and east of the other two major divisions (Figure 1). These divisions are suggested by topographic characteristics and geology of the areas (Baldwin, 1964). One feature is common to both the East and West Ochoco Mountains--the apparent fault zone and uplift along the northern edge of the Forest (Wilkinson, 1939; Hodge, 1942; Baldwin, 1964). The northern edge of this uplift is characterized by vertical cliffs and very steep slopes. From this fault zone, the land slopes gradually in a southerly direction. The Snow Mountain area is characterized by a similar pattern with higher elevations in the north and a southerly sloping plateau.

Williams (1948), in discussing the ancient volcanoes of Oregon, mentioned wind carried pumice deposited on the Blue Mountains from the eruptions of Mount Mazama and possibly Paulina Mountain. Fine pumice, possibly of this or similar origin, was found in many places on the Ochoco National Forest. Pumice ash depths range from a few inches to several feet. These deposits may be found on any slope currently in timber, but they are often deeper on north slopes.

The Western Ochoco Area

The Western Ochoco Area lies to the west of Big Summit Prairie along a line running roughly north from Lookout Mountain through Round Mountain and Slide Mountain, a few miles west of Mount Pisgah (Figure 1). The relief ranges from rolling to very steeply rolling with occasional slopes in excess of 80 percent (Figure 2). This area is composed primarily of the Clarno Formation which contains much sedimentary rock and occasional lava flows (Wilkinson, 1939; Hodge, 1942). To a large extent, this area has soils a foot or more in depth favoring a rather continuous forest cover except on very steep or talus slopes. The western third of the Maury Mountains is also primarily Clarno and John Day Formations and is included in the Western Ochoco area.

The Eastern Ochoco Area

The Eastern Ochoco Area consists of the eastern half of the Ochoco Mountains and the eastern two-thirds of the Maury Mountains. It generally has undulating to rolling relief (Figure 3). This area is dominated by the Ochoco Lavas of comparatively recent origin and Miocene-age Columbia River Basalt. The recent lava flows

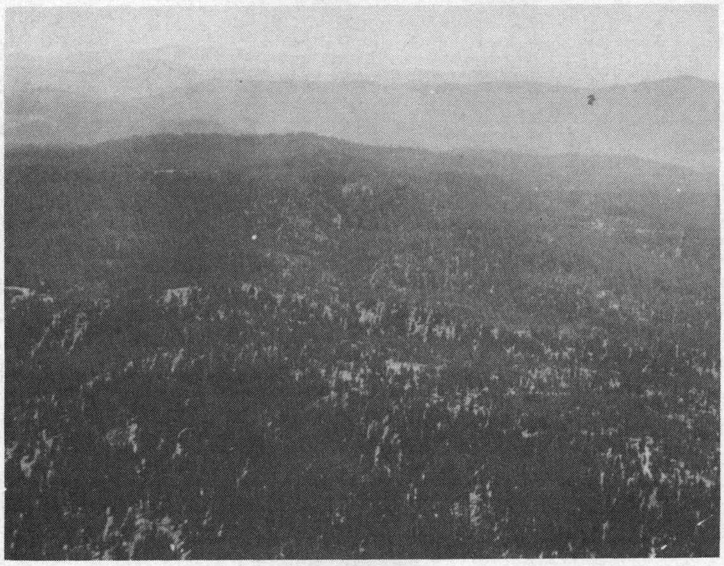


Figure 2. Aerial view of the Western Ochoco area. Note the rolling to steep topography and continuous forest cover. Largely Clarno formation.

Figure 3. Aerial view of the Eastern Ochoco area. Note the undulating topography and the vegetation moziac. Largely basic igneous formations.

apparently weather slowly since soils less than one foot in depth have developed. Two major streams, Black Canyon Creek and Cottonwood Creek, in the northeastern corner of the Eastern Ochoco area have cut deep, steeply dissected canyons across this plateau.

The oldest rocks on the Ochoco National Forest occur in the Sunflower area in the Eastern Ochoco. These formations are of Triassic origin and have been eroded to undulating or rolling land forms (Wilkinson, 1939; Nesbit, 1951).

<u>Snow Mountain Area</u>

The Snow Mountain Area has not been geologically studied according to the literature. Evaluation of parent rock in the course of this study has revealed that a majority of the geological materials are of extrusive igneous origin. Part of the Snow Mountain Area appears to be an undulating rhyolite or tuff plateau which may be similar to the Rattlesnake and Payette Formations (Hodge, 1942; Baldwin, 1964). Basalt buttes such as Dry Mountain and Green Mountain protrude through this plateau. In some places cinder cones such as Bald Mountain and Emigrant Butte are present. Basalt and andesite appear to be more prevalent at upper elevations, particularly as one approaches Snow Mountain itself.

Climate

Prineville, located ten miles west of the Ochoco Mountains, is the closest weather station with long term records. Figure 4 shows a 20-year average of monthly precipitation and temperature (U. S. Weather Bureau, 1965). The average precipitation is 10.14 inches. December, January, and February occasionally have snowfall at the 2,865 foot elevation of Prineville. Summer afternoon humidity is 20 to 30 percent; nights are cool and freezes may occur at any time during the summer. Forest areas have heavy snow and very dry summers. The climate is basically a modified marine climate caused by the Cascade Mountains which cast a rain shadow effect into the vicinity of Prineville. In most cases, the low July, August, and September precipitation is seldom effective because high temperatures cause prompt evaporation of the typically light showers. This causes a pronounced one- to two-month drought season during the summer.

Soil

Soils are directly influenced by the nature of the soil forming material, topography, vegetation, and the variations in mountain climate. In general, few soils in the study area have strongly developed profiles. Dry land soils, those exclusive of meadows, may generally be classified as lithosols and azonal soils resembling Western Brown Forest. Residual soils are shallow, 3 to 24 inches

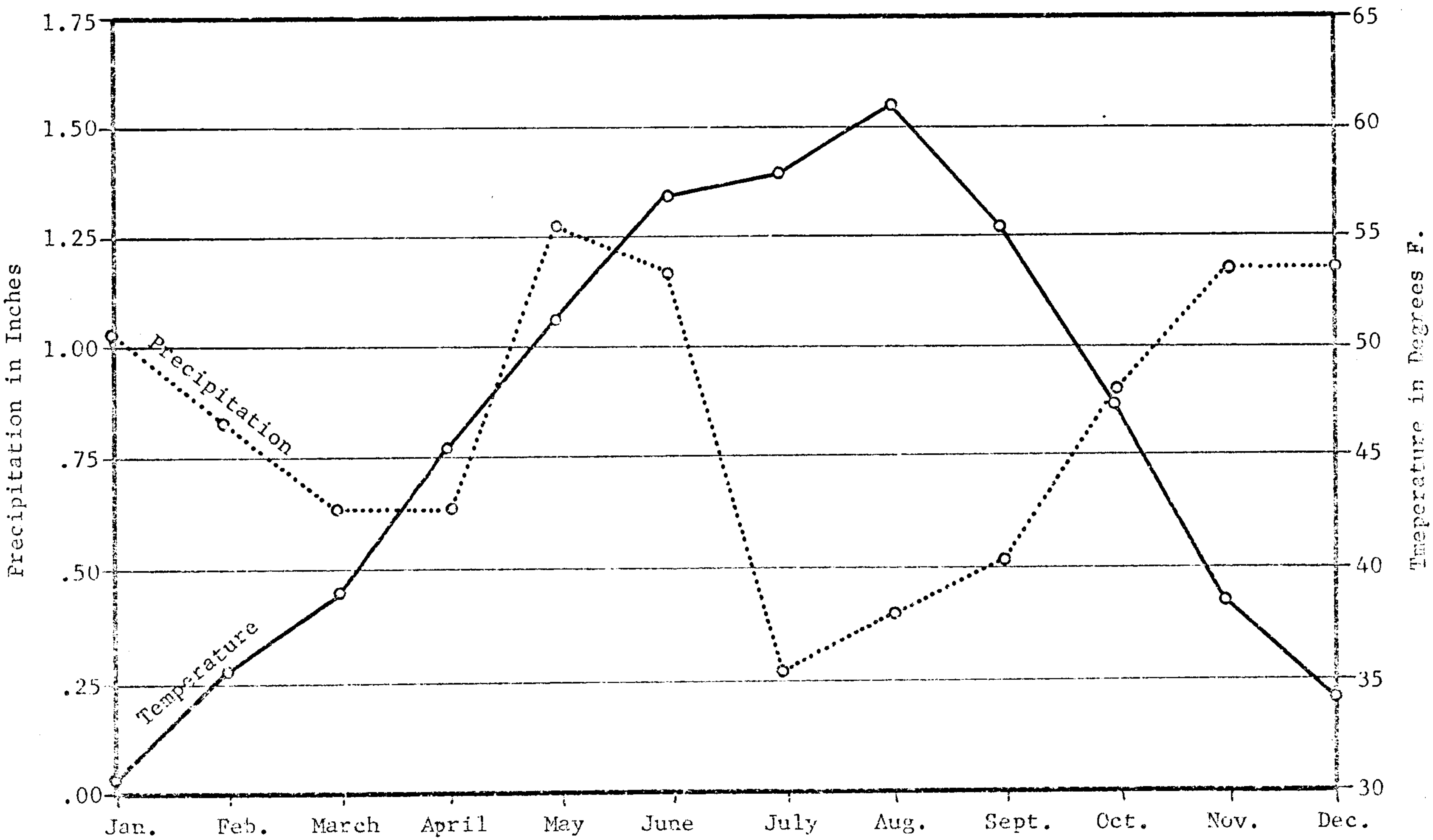


Figure 4. Precipitation - Temperature monthly averages, Prineville, Oregon, 1933 to 1962.

deep, generally quite stoney, and show minimum profile development. Other soils are developing from a pumice ash deposit over bedrock or buried soils. This pumice ash mantle varies from a few inches to two feet in depth and shows virtually no profile differentiation. Soil development on the semi-arid plateau bordering the Ochoco National Forest appears to be more zonal in character.

Vegetation

Vegetation is directly influenced by soil, elevation, and topography. The Western Ochoco area, where sedimentary material is more common, has a rather continuous forest cover (Figure 2). The Eastern Ochoco Area, where basalt and andesite flows are common, is a mosaic of forest and open areas (Figure 3). The Snow Mountain area tends to have a rather continuous forest cover. Of the 840,000 acres in the Ochoco National Forest, 672,000 are forest, and 168,000 are non-forest. Almost all of the non-forest areas are within the forest zone.

In most cases, the boundary between forest and semi-arid vegetation is rather sharp due to abrupt changes in soil. This lower elevation forest vegetation grows largely on a stony azonal soil, while the semi-arid vegetation grows on rather well developed zonal soils.

LITERATURE REVIEW

Ecological Concept and Philosophy

The author's ecological philosophy follows that suggested by Ellenburg (1956), Langenheim (1962), and Goodall (1963). First, I feel that environmental factors influencing plants are infinitely diverse and that plants growing on an undisturbed area do so through a process of natural selection over a long period of time. As a result, the plant community on a given site will tend to indicate the environmental factors operating on that area. Second, I feel that classification of plant communities into various groups is possible and desirable, but that any classification is necessarily abstract, and does not represent a fixed biological entity. Third, sampling should test the continuum possibilities of vegetation to facilitate interpretation of classification units when and if they can be substantiated. This is the concept of non-random distribution of plant communities in a continuum gradient.

Terms used in this paper will be general, such as: plant community--the combination of plant species existing on the ground at a given location; association--a group of plant communities classified together based upon their climax potential; continuum--the tendency of individual plant species to occur in a continually variable combination. This definition does not preclude abrupt changes in vegetation due to equally abrupt changes in the environment (Figure 3).

Concept of Climax and Succession

Climax and succession are concepts which must be considered in ecology and which have important influences in ecological philosophy.

Climax

Most authors do not consider climax as a fixed combination of specific species composition. Rather, it is considered a combination of plants that will remain relatively stable in their presence and dominance over a long period of time providing environmental factors do not change (Shantz, 1940; Daubenmire, 1952; Ellenburg, 1956; Lutz, 1959). These plants remain relatively stable because they are best suited to the site and offer maximum competition, thus preventing other species from colonizing the area. This concept of climax will be used in this paper.

Succession

Succession is a term used in conjunction with climax. It denotes a change in plant composition towards or away from the climax on a given location (Shantz, 1940; Daubenmire, 1952; Lutz, 1959). Succession has sometimes been divided into two groups: Primary succession--the gradual change of vegetation and soil until they come into equilibrium with the climate; and secondary succession--a change from climax vegetation due to some disturbance such as fire, overgrazing, or logging. While primary succession is common in the study area, this paper is concerned only with secondary succession which will hereafter be referred to simply by the term succession.

The concept of succession is important in two ways:

1. By definition it suggests cause and effect relationships between the vegetation and environment that are different from the rather stable, long-term factors of climate and soil (Shantz, 1940; Tisdale, 1957; Ellison, 1959; Lutz, 1959; Major, 1961).

2. It influences one's ecological philosophy, particularly in regard to sampling and classification of vegetation (Goodall, 1963; Daubenmire, 1966).

Generally, use of the continuum concept has not called for separation of climax and successional vegetation. The authors cited above all agree that highly variable combinations of species are possible as a result of different disturbing influences. These combinations can be sampled and classified as a continuum gradient within one association. While this knowledge of a successional continuum is desirable and essential, it should not be allowed to confound classification of vegetation. For this reason, the concept of succession will be used in this paper to denote vegetation that is changing towards or away from some kind of relatively stable vegetation (climax) as a result of some temporary or controllable environmental factor.

Concepts of Condition and Trend

Range Condition

Range condition and trend is based directly upon the concepts of climax and succession respectively. Climax vegetation has been used as the criterion by which range condition is judged (Dyksterhuis, 1949; Ellison, 1956; Hanson, 1957). Condition of the rangeland usually refers to its successional status in relation to climax; excellent condition is climax condition, good condition is a high seral state near climax, fair condition is an intermediate seral state, poor condition is quite low in successional status, and very poor condition means that virtually all of the palatable species present in climax have been eliminated due to overgrazing by livestock. Thus, the concept of climax is useful not only in ecological philosophy, but also in application of ecology to specific grazing management problems.

There are, however, two problems involved in the association of climax with excellent range condition. Natural fluctuations in climate can change the composition and dominance of climax species (Craddock and Forsling, 1938). Therefore, the criteria by which range conditions are judged is not absolute but relative. This is a particular problem since determination of range condition is usually based upon numerical computations relating existing vegetation to species composition and density in climax. Precision may be greatly enhanced if condition standards are periodically adjusted for changes caused by climatic factors.

Another problem of using climax as a basis for range condition is found on forested ranges. Often, optimum forage production occurs in successional communities (Tisdale, 1950; Daubenmire, 1952; Young, 1965). In these cases, range condition must be evaluated on the basis of maximum vegetation possible under the existing density and composition of trees and not on climax.

Range Trend

Range trend is the direction in which vegetation is moving successionally on a given site. For instance, upward trend means a successional movement towards climax; downward trend means a successional movement away from climax (Dyksterhuis, 1949; Costello, 1957; Ellison, 1959).

Range trend means more than simply the direction of succession; it specifically implies cause and effect relationships. This was recognized as early as 1919 (Jardine and Anderson). Lately, it has been given considerable attention by the above noted authors as well as by Ellison (1951), Hanson (1957), Daubenmire (1940), Reid (1941), and Rummel (1951). The cause is assumed to be animal use of certain plant species, and the effect is a change in species dominance, composition, and distribution. These concepts of condition and trend will be used in this paper.

Literature Pertinent to the Study Area

Community Studies

A number of community ecology studies have been conducted in Oregon. Swedburg (1961) studied forest vegetation in a transect from the sagebrush zone to the crest of the Cascade Mountains in north central Oregon 45 miles west of the Ochoco Mountains. He found a continuum in the existing vegetation but felt that much of the gradient was influenced by successional vegetation due to past ground fires. Johnson (1961) studied Black Butte on the eastern foot of the Cascade Mountains adjacent to Swedburg's area. Both authors found that vegetation differences were related to elevation, direction of slope, and degree of slope. More than one kind of community was found to be dominated by *Pinus ponderosa* Laws. Neither of these papers describe communities similar to those found in the southwestern Blue Mountains.

Soil-Vegetation Studies

Dyrness (1960) and Volland (1963) conducted careful soil-vegetation studies in the pumice area southeast of Bend, Oregon, following the polyclimax concept. They described several associations dominated by *Pinus ponderosa* which differ considerably from those found in this study area. By and large, subordinate vegetation was dominated by shrubs with a minor grass component. Correlation with soil series and phases was only moderately good to poor. They found correlations between elevation, degree, and direction of slope and their community groups.

Trappe and Harris (1958) studied Pinus contorta in the northeastern Blue Mountains. This species was often successional to Abies grandis and some Picea englemanni. When it occurs at higher elevations on exposed ridges and slopes above 7,000 feet, it is often associated with Pinus albicaulis. All of the successional Pinus contorta grew on pumice ash over buried soil.

Pinus contorta reacts differently in the pumice region southeast of Bend, Oregon, (Youngberg and Dyrness, 1959). Here it appears to be climax on shallow depressions having a high water table or frost pockets while well drained upland soils support Pinus ponderosa. In many cases, some Pinus contorta is found mixed with Pinus ponderosa on soils of intermediate drainage.

METHODS

Field Methods

The methods used in this study were designed to evaluate forest conditions, range conditions, and correlations of vegetation with soil.

Sample Location

Sample locations were selected on the basis of vegetation and soil homogeneity, lack of grazing, and absence of logging. They were located after extensive reconnaissance and selected to represent the variation in vegetation and soil found on the Ochoco National Forest. In addition, they were distributed in proportion to the acreage occupied by various vegetation-soil combinations. Selection of areas representative of this variation was purposely based on the author's experience gained as a result of allotment analysis with the U. S. Forest Service.

Reconnaissance

Some vegetation on the Ochoco National Forest was too badly deteriorated by grazing or logging, or occurred so infrequently as to make sampling by the methods below impractical. For this reason, meadow vegetation has been excluded from the study. Other dry-land vegetation was sampled by means of a reconnaissance technique suggested by Ellenberg (1956). This reconnaissance had two objectives: First, to sample overgrazed vegetation to evaluate the reaction of various species to grazing. Second, to gather information on minor types of vegetation.

Trees

Trees were sampled on a one-fifth acre circular plot. All trees were listed by species and diameter class to the nearest one inch. Five mature dominant and codominant trees of each species were measured for height, diameter and age to evaluate site index. In addition, two to five young trees were similarly measured to evaluate growth. Tree crown cover was estimated using a homemade vertical viewer. These crown cover data were separated into overstory and understory and recorded by species along each of two 100-foot lines used to measure subordinate vegetation.

Subordinate Vegetation

Subordinate vegetation was measured by the three-quarter inch loop transect method (Sharp, 1955; Parker and Harris, 1959) on two 100-foot lines. This method was selected because it is the Forest Service approved system for evaluating range condition and trend. Some investigators have demonstrated that the three-quarter inch loop over estimates basal area of herbaceous plants (Sharp, 1954;

Johnson, 1957; Huchings and Holmgren, 1959). While this may be a disadvantage in measuring absolute basal area, it does not detract from one's ability to detect change and difference in relative basal area with the loop method (Sharp, 1954; Smith, 1962).

In addition to the loop transect method, ten 9.6 square-foot hoops were placed at random in a 5 by 25 meter plot to measure total forage production. All plant species in the 5 by 25 meter plot were recorded whether they appeared in the loop transect and production measurements or not.

Taxonomic Authority

Nomenclature follows Hitchcock, et al (1955, 1959, 1961, 1964) for dicots and Peck (1941) for all other plants.

Soils

A soil pit was dug beside each sampling location. The profile was described according to standard Soil Conservation Service nomenclature and the pH was determined using a distilled water solution and liquid indicator dyes. (U. S. Bureau of Plant Industry, Soils and Agricultural Engineering, 1951).

Other Features

Other features of the sample location were noted: location according to the standard land survey grid, elevation, degree of slope, direction of slope, position on the slope, geology, land form, macrorelief, microrelief, a general description of climate, and any influences that could be measured such as fire, insects, and disease.

Analytical Methods

Association Tables

Vegetation and selected environmental factors were initially evaluated and classified by use of an association table according to Ellenberg (1956).

After development of the table, tree data were converted into conventional units of basal area, board feet and cubic volume per acre. Diameters were converted to basal area per acre according to Minor (1961). Volume per acre was determined by converting tree height and diameter to board feet, one-fourth inch International Rule, and cubic feet according to Minor (1961). Tree site index was determined by correlating height and age of trees with site index curves: Meyer (1938) for *Pinus ponderosa*, McArdle, et al (1949) for *Pseudotsuga menziesii*, Stage (1959) for *Abies grandis*, and Lemmon, et al (1955) for *Pinus contorta*.

A value relating square feet basal area to cubic foot volume was computed for *Pinus ponderosa*. Acre volume was divided by acre basal area. The value represents tree height in relation to diameter where taller trees will have a higher cubic foot volume per square foot basal area than shorter trees. This reflects site index since better sites usually produce taller trees for a given diameter. Within certain stocking limits, it may be a more useful value than site index because it can be directly applied as a measure of site potential.

Statistical Methods

Means and standard errors were determined for vegetation and environmental data in each association. Wide standard errors suggested the possibility of correlation analysis (Cook, 1960).

Probable correlations were selected by inspection of the association table and rough plotting on graph paper. They were computed on an IBM 650 computer according to a program developed by Gedney, et al (1962).

RESULTS AND DISCUSSION

Classification

Classification of plant communities into groups or associations was necessary to meet the objectives of this study. Range condition, utilization, and other standards are more easily comprehended and more accurately applied if they are based upon specific associations of vegetation within which the effective environment is highly similar. Understanding of forest management is aided when descriptions of silvicultural treatments, growth, and stocking are related to these same natural ecological units that comprise the forest.

Classification of plant communities into associations required consideration of similarities in flora and environment. Floristic data used in classification were species constancy and tree crown cover (Appendix A).

Table 2 demonstrates that many species occur in more than one association but that different constancy levels and occurrence patterns of species groups provide the identifying characteristics of each association. Appendix A illustrates the variability in composition of any individual species within its principal association and in other associations where it occurs. Appendix B shows the variability in environmental factors for each association. These variabilities suggest a possible continuum effect in species as related to environment

Table 2. Constancy of indicator species on ten important associations.

Species in percent constancy (Number of Plots)	Arri/ Pose 10	Arar/ Feid 3	Arar/ Agsp 10	Pipo/ Putr/ Agsp 2	Pipo/ Putr/ Sihy 6	Pipo/ Feid 7	Pipo/ Cage 8	Abgr/ Caru 24	Abgr/ Brvu 10	Pico/ Vasc/ Caru 5
Pinus ponderosa				100	100	100	100	92	30	20
Pseudotsuga menziesii								88	60	60
Abies grandis								59	100	80
Pinus contorta									20	100
Artemisia rigida	* 90		10							
Sitanion hordeoides	100	33								
Artemisia arbuscula	30	100	100							
Trifolium macrocephalum	90	65	60							
Phlox douglasii	20	100	40							
Balsamorhiza serrata	10	100	30							
Festuca idahoensis		100	40	50		100				
Poa secunda	100	100	100	100	33	40				
Agropyron spicatum	20	33	100	100		14				
Sitanion hystrix			80	50	100	71	38			
Purshia tridentata		33	70	100	100	71	75			
Artemisia tridentata				100						
Erigeron eatoni				100	17	12	12	4		
Carex rossii					100	71	37			
Stipa occidentallis					100	57				
Cercocarpus ledifolius					17	14	75	4		
Poa nervosa					33	29	88	20		
Carex geyeri						14	100	92	50	
Arnica cordifolia						14	25	88	80	100
Calamagrostis rubescens						57	25	96	40	80
Lupinus caudatus						14	12	67		40
Hieracium albiflorum								67	100	60
Bromus vulgaris								12	100	
Lupinus latifolius								12	80	60
Mitella stauropetala								16	80	40
Vaccinium scoparium									20	80

*Underlining denotes indicator importance among sampled plant communities. It is evident that any classification of vegetation must accept variability within an association and that this variability in certain characteristics or factors may be as great as variability in the same factors between associations.

Any classification category is an abstraction, not a concrete thing as is the case with a single stand of vegetation--the real biological entity. The abstract nature of these classification categories pose some problems in the interpretation and use of any group of vegetation associations.

First, descriptions of the association must be considered generalized statements and they will not fit all conditions found in the field. Second, variation in species composition within associations and similarity of some environmental factors between associations should be expected. Third, all associations may not be separated for the same reasons. Fourth, some plots suitable for sampling may show characteristics different from the mode of an association. These characteristics may be reasonably well related to another association. This situation does not represent an ecotone, but rather an intergrade between associations due to plant reaction to gradients in the environment. The intergrade between associations is different from ecotones between two different existing stands of vegetation. And fifth, one may expect to find conditions in the field that are not covered by these association tables or descriptions because all the minute components of the vegetation can seldom be practically sampled.

In addition to the associations listed in Tables 2 and 3 and Appendices A and B, reconnaissance data suggests four other kinds of vegetation: (1) Alpine communities of Artemisia tridentata vaseyana/Carex species, (2) Alpine Festuca idahoensis grasslands, (3) Abies lasiocarpa, and (4) a lower elevation shrub type usually dominated by Purshia tridentata. These will be briefly discussed in the following section.

The following key presents identifying characteristics of the associations commonly found in the study area. Detailed characteristics of each association will be discussed in the next section. The soils associated with each of the major vegetation association are shown in Table 3. Soil series are described in Appendix D.

KEY TO VEGETATION ASSOCIATIONS ON THE OCHOCO NATIONAL FOREST

Natural openings in the forest. Juniperus occidentalis may be present. Part One.

Forested areas. Part Two.

Part One. Natural Forest Openings

I. Shrubs dominate the opening.

A. Purshia tridentata and/or Cercocarpus ledifolius are dominant. Artemisia species and Chrysothamnus species may be present. Generally below 5800 feet elevation.

Lower elevation shrub type.

AA. Artemisia species dominate the openings.

a. Shrubs generally more than 24 inches tall, higher elevations and ridge tops. Artemisia tridentata var. vaseyana with Carex species, Umbelliferea, Bromus carinatus, and Stipa columbiana.

Artemisia tridentata var. vaseyana/Carex Association.

aa. Shrubs generally less than 24 inches tall, largely at or below 5800 feet elevation.

1'. Artemisia rigida is the dominant shrub, Poa secunda is generally the dominant herb with Trifolium macrocephalum and Sitanion hordeoides.

Artemisia rigida/Poa secunda Association.

11'. Artemisia arbuscula is the dominant shrub.

Herbaceous vegetation is principally Agropyron spicatum, Sitanion hystrix, Poa secunda, and Bromus tectorum.

Artemisia arbuscula/Agropyron spicatum Association.

Herbaceous vegetation is principally Festuca idahoensis, Phlox douglasii, Balsamorhiza serrata, and Poa secunda.

Artemisia arbuscula/Festuca idahoensis Association.

II. Grasses dominate the opening.

A. Large bunchgrasses are dominant.

Agropyron spicatum dominates the herbaceous layer, often with some Artemisia arbuscula. Poa secunda and Sitanion hystrix are common. Bromus tectorum may be present. Generally below 5800 feet elevation.

Artemisia arbuscula/Agropyron spicatum Association.

Festuca idahoensis dominates the herbaceous layer. Phlox species, Poa secunda, and occasionally Artemisia arbuscula are present. Higher elevations, generally above 6000 feet, or on higher exposed ridges.

Alpine Festuca idahoensis Association.

AA. Small bunchgrasses or annual grasses dominate the opening.

Poa secunda dominates the community, often with Artemisia rigida. Trifolium macrocephalum and Sitanion hordeoides are often present. Umbelliferea may be common.

Artemisia rigida/Poa secunda Association.

Annual grasses and Poa secunda dominate. Some Agropyron spicatum may be present with Sitanion hystrix, Achillea lanulosa and Stipa occidentalis.

Artemisia arbuscula/Agropyron spicatum Association.

Part Two. Forested Areas

I. A single tree species clearly dominates both the overstory and understory.

A. *Pinus* species dominate.

a. *Pinus ponderosa* is the sole forest tree in both overstory and understory. Occasionally *Juniperus occidentalis* may be present.

1'. Shrubs, largely *Purshia tridentata*, dominate the subordinate vegetation.

Herbaceous vegetation is *Agropyron spicatum*, *Sitanion hystrix*, *Poa secunda*, and *Bromus tectorum*. Other shrubs may be *Artemisia tridentata* and *Chrysothamnus* species.

Pinus ponderosa/*Purshia tridentata*/*Agropyron spicatum* Association.

Herbaceous vegetation is a sparse herb layer of *Sitanion hystrix*, *Carex rossii*, *Stipa occidentalis*, and some *Poa secunda*.

Pinus ponderosa/*Purshia tridentata*/*Sitanion hystrix* Association.

11'. Herbs dominate the subordinate vegetation. Shrubs, while sometimes present, are a minor component of the stand.

a'. Bunchgrass, predominately *Festuca idahoensis*, dominates the subordinate vegetation. Minor amounts of *Purshia tridentata*, *Stianion hystrix*, *Carex rossii*, and *Bromus tectorum* may be present.

Pinus ponderosa/*Festuca idahoensis* Association.

aa'. Rhizomatous grasses and sedges dominate.

Carex geyeri is dominant, generally with minor amounts of *Poa nervosa*, *Purshia tridentata* and *Cercocarpus ledifolius*.

Pinus ponderosa/Carex geyeri Association.

Calamagrostis rubescens is present, generally with Carex geyeri and Arnica cordifolia, Lupinus caudatus, and Hieracium albiflorum.

Abies grandis/Calamagrostis rubescens Association.

aa. Pinus contorta is the dominant forest tree. Some fir reproduction may be present. Subordinate vegetation is Vaccinium scoparium, Calamagrostis rubescens, Arnica cordifolia, and often Lupinus latifolius and Hieracium albiflorum.

Pinus contorta/Vaccinium scoparium/ Calamagrostis rubescens Associes.

AA. Tree species other than Pinus clearly dominate both the overstory and understory.

Abies grandis is the dominant tree. Subordinate vegetation is Bromus vulgaris, Lupinus latifolius, Mitella stauropetala, Arnica cordifolia, and Hieracium albiflorum.

Abies grandis/Bromus vulgaris Association.

Larix occidentalis is the dominant tree. Some fir reproduction may be present. Subordinate vegetation is Bromus vulgaris, Lupinus latifolius, Calamagrostis rubescens, Carex concinnoides, Smilacina species, Arnica cordifolia, and Hieracium albiflorum.

Abies grandis/Bromus vulgaris Association.

II. Two or more tree species are represented in the overstory and/or understory.

A. Pinus species are mixed with Abies and/or Pseudotsuga species.

a. Pinus ponderosa is present in varying amounts from dominance in the overstory to scattered remnants of over mature trees. Subordinate vegetation is largely Calamagrostis rubescens, Carex geyeri, Arnica cordifolia, and Hieracium albiflorum.

Abies grandis/Calamagrostis rubescens Association.

aa. Pinus contorta is present in varying amounts from dominance in the overstory to scattered remnants of over mature trees.

Associated trees are Abies grandis, Pseudotsuga menziesii, and at times Larix occidentalis. Subordinate vegetation is Bromus vulgaris, Lupinus latifolius, Mitella stauropetala, Arnica cordifolia, Calamagrostis rubescens, Vaccinium scoparium, and Hieracium albiflorum.

Abies grandis/Bromus vulgaris Association.

Associated tree is Abies lasiocarpa. Subordinate vegetation is a mixture of Lomatium species, Aquilegia formosa, Viola species, Veratrum californicum, and Stipa species.

Abies lasiocarpa Association.

AA. Pinus species are absent; various mixtures of Abies, Pseudotsuga, and Larix species.

a. Pseudotsuga menziesii and Abies grandis dominate the stand.

Subordinate vegetation is Calamagrostis rubescens, Carex geyeri, Arnica cordifolia, and Hieracium albiflorum.

Abies grandis/Calamagrostis rubescens Association.

Subordinate vegetation is Bromus vulgaris, Lupinus latifolius, Mitella stauropetala, Arnica cordifolia, and Hieracium albiflorum.

Abies grandis/Bromus vulgaris Association.

aa. Larix occidentalis is present in varying amounts with Abies grandis, and Pseudotsuga menziesii. Subordinate vegetation is Bromus vulgaris, Lupinus latifolius, Mitella stauropetala, Arnica cordifolia, and Hieracium albiflorum.

Abies grandis/Bromus vulgaris Association.

Table 3. Percent occurrence of ten vegetation associations on seven soil series and phases.

		Series Phase									
		R	H		E	B	S	P			O
Associations	*N		Acid	Basic					Grey	Colluv.	Yellow
Arri/Pose	10	90		10							
Arar/Feid	3		100								
Arar/Agsp	10			100							
Pipo/Putr/Agsp	2				100						
Pipo/Putr/Sihy	6				100						
Pipo/Feid	7				14	29	14	43			
Pipo/Cage	8				37	50		13			
Abgr/Caru	24					12			71	17	
Abgr/Brvu	10										100
Pico/Vasc/Caru	5										100

* Number of plots per association.

Characteristics of the Association

Artemisia rigida/Poa secunda (Arri/Pose)

The Artemisia rigida/Poa secunda association occurs as natural forest openings primarily in the eastern Ochoco area. Small, isolated stands may be found in other parts of the study area.

Elevation and Topography. Elevation varies widely, ranging from 4,000 to slightly above 6,000 feet. Topography is largely undulating. Generally, the association is found on the top and upper portions of slopes which are characteristically less than 10%. They tend to face in a southerly direction (Appendix B).

Soil. Soils of this association have been classified as the R series (Appendix D, Figure 5). They are characterized by abundant surface stones and a well developed gravel pavement. While profile development is minimal and these soils may be classed as lithosols, a vesicular horizon about 2 inches in depth commonly occurs immediately under the gravel pavement (Springer, 1958). Below this vesicular horizon, soil texture is a very stony silt-loam to clay-loam. At times, a clay layer of 1/2 to 1 inch thickness is present over a slightly cracked bedrock. The soil is reddish-brown and ranges from five to eight inches in depth with an average of about 6-1/2 inches.

This very shallow soil coupled with precipitation suitable for

Figure 5. The *Artemisia rigida*/*Poa secunda* Association. (Plot 4a2). Soil series R.

forest growth results in an unusually harsh soil-moisture regime. A few weeks after fall rains begin, the soil becomes saturated and remains so until termination of effective precipitation in the spring. As a result, soil aeration is minimal for about six months of the year. Freezing and thawing during these periods of soil moisture saturation result in extremely active frost heaving causing pedestaling of most grasses and young Artemisia rigida plants. During the summer, these soils tend to dry completely to bedrock. This combination of soil saturation and virtually complete drying coupled with a minimum of moisture holding capacity has a very selective influence upon plant species. A soil of similar characteristics has been described by Burr (1959) in the north-central Blue Mountains and given the series name of Rock Creek. It, however, supports a Poa secunda/ Dauthonia unispicata community without shrubs.

Vegetation Description. The Artemisia rigida/Poa secunda association in climax condition is dominated by the shrub Artemisia rigida with a crown cover of 5 to 15%. Herbaceous vegetation is clearly dominated by Poa secunda with Trifolium macrocephalum, Sitanion hordeoides, and Allium accuminatum in lesser amounts (Figure 5). These five species clearly dominate the vast acreages represented by this association in the eastern Ochoco area (Figure 5). In only a few cases could homogeneous stands be found that represented an integrade from this association to one of the two

Artemisia arbuscula associations. These transitions were clearly identified with greater soil depth and account for the 30 percent constancy of Artemisia arbuscula and 20 percent constancy of Agropyron spicatum (Table 2). While present, they represented a very small land area compared to the acreage occupied by characteristic stands of the association. The Artemisia rigida/Poa secunda association clearly fits the criteria of edaphic climax described by Daubenmire (1952).

Artemisia arbuscula/Festuca idahoensis (Arar/Feid)

The Artemisia arbuscula/Festuca idahoensis association is a natural forest opening which occurs exclusively in the Snow Mountain Area where soils are derived from acid igneous rock, primarily rhyolite and tuff.

Elevation and Topography. Elevation variation is limited to 4,800 to 5,300 feet primarily because this association occurs on the "Rhyolite plateau" of the southern Snow Mountain area. Topography is undulating with slopes less than 10% often facing in a northeasterly direction. The association is limited to the top and upper portions of the gentle hills.

Soil. Soils characterizing this association are the acid igneous phase of the H series (Appendix D). The soil surface is covered with abundant stone and often a gravel pavement. However, a vesicular A horizon is seldom found. The author does not feel that any of the

Figure 6. The <u>Artemisia arbuscula</u>/<u>Festuca idahoensis</u> Association (Plot 4b5). Soil series H, acid igneous phase.

stands encountered were in climax condition. It is possible that this gravel pavement was due to accelerated wind erosion. Eckert (1958), however, felt that desert pavement was normal on an association similar to this at lower elevations where the precipitation was ten to twelve inches. The soils of the study area have moderate profile development with a dark brown silt-loam to clay-loam surface horizon four to six inches in depth and a yellowish brown very stony silty-clay to clay horizon four to six inches in depth to bedrock. Total soil depth ranges from 9 to 16 inches. Bedrock is usually poorly fractured. Soil pH ranges from 6.4 to 7.0.

The soil is occasionally saturated with moisture in the fall, but most characteristically during the winter and spring with the result that aeration is often poor for several months and frost heaving is commonly active. These condtions seem to be inimical to tree establishment and growth.

Vegetation Description. This association is dominated by Artemisia arbuscula with a crown cover that ranges from ten to thirty percent (Figure 6). Herbaceous vegetation is characterized by Festuca idahoensis, Poa secunda, Phlox douglasii, and Balsamorhiza serrata. The values given in Appendix A for Festuca idahoensis may not represent climax conditions in this association because topography, water location, and the history of livestock grazing suggest that no areas were spared from some degree of excessive use.

In spite of this, Table 2 and Appendix A lend credence to classification of this association. The important indicator species are Festuca idahoensis, Balsamhoriza serrata, and Phlox douglasii, and the absence or poor representation of Agropyron spicatum, Sitanion hystrix, and Purshia tridentata. The main environmental factor separating this association from the Artemisia arbuscula/Agropyron spicatum association seems to be geology of the bedrock (Eckert, 1958). It is acid igneous in this association and basic igneous in the Agropyron dominated association.

Artemisia arbuscula/Agropyron spicatum (Arar/Agsp)

The Artemisia arbuscula/Agropyron spicatum association reaches its greatest development in the eastern Ochoco and Snow Mountain area. Occasional, deteriorated examples may be found in the Western Ochoco area with Juniperus occidentalis.

Elevation and Topography. Elevation ranges from 4,000 to 5,500 feet. Topography is primarily undulating. Slopes are less than 25% and may face any direction except northeasterly. The association may be represented on any slope position but tends to be more common on the upper and top locations.

Soil. Soil is the basic igneous phase of the H series (Appendix D). It is derived primarily from basalt and andesite. A similar soil was described by Burr (1959) for the north central Blue Mountains called the Snipe series which supports an Agropyron spicatum/Poa secunda community in which Artemisia arbuscula is absent. The soil surface is characterized by abundant stones but lacks a gravel pavement in near climax condition. Some stands in poor or very poor range condition have been found with the start of a gravel pavement which may be the result of wind erosion. Soil profiles are moderately developed into roughly two horizons. The upper horizon is very dark brown at lower elevations and a dark brown at upper elevations, has a silt loam to clay loam texture, a pH ranging from 6.0 to 7.2 and depth of four to six inches. The lower horizon is differentiated by color which is yellow brown to dark yellow brown and texture which is a very stony silty clay to clay ranging in depth from four to six inches. Total depth varies from 9 to 18 inches to moderately cracked bedrock (Figure 7).

Soil moisture conditions are similar to other natural forest openings. The soil becomes saturated in the late fall or early winter and remains so until spring. This results in poor aeration and active frost heaving. By mid-summer, the soil profile dries almost to bedrock. These conditions appear inimical to tree establishment and growth.

Vegetation Description. The vegetation is dominated by the bunch form of Agropyron spicatum. Artemisia arbuscula is present in all stands; however, it ranges in crown cover from 1 to 30 percent.

Figure 7. The *Artemisia arbuscula*/*Agrpyron spicatum* Association (Plot 1b5). Soil series H, basic igneous phase.

This crown cover is highly significantly correlated with elevation. Starting at 4,000 feet, each 100 foot increase in elevation is associated with a 1.5 percent increase in Artemisia Arbuscula crown cover and accounts for 75 percent of the variability in crown cover (Appendix C). This suggests some interrelationship between Artemisia arbuscula dominance and climate. Other important indicator species are Poa secunda and Purshia tridentata. Purshia, however, is very low in dominance having a crown cover ranging from just a trace to 6 percent. This site seems to be barely within the ecologic amplitude of Purshia tridentata (Nord, 1959). Juniperus occidentalis occasionally occurs at upper elevations. A similar association has been described by Eckert (1958) at lower elevations around the Snow Mountain area.

Summary of Artemisia Associations

These three associations occur as natural openings within the forest zone of the study area. They are devoid of trees primarily due to soil conditions. These soil conditions are periodic moisture saturation with related poor aeration; fine texture which, under dry soil conditions, may be a physical barrier to tree root elongation; and nearly complete soil moisture exhaustion by mid-summer. Soil conditions also seem to be the major factor causing differences in vegetation in these openings. Soil depth separates the Artemisia rigida/Poa secunda from the Artemisia arbuscula associations and geology seems to separate the Artemisia arbuscula/Festuca idahoensis from Artemisia arbuscula/Agropyron spicatum.

Pinus ponderosa/Purshia tridentata/Agropyron spicatum (Pipo/Putr/Agsp)

The Pinus ponderosa/Purshia tridentata/Agropyron spicatum association has been, in general, severely deteriorated by grazing. Only two locations could be found representing what appeared to be near climax condition. In spite of this, indications suggest that the association is well distributed through the lower elevations over the entire study area. In many cases, it seems to be the transition between the forested Blue Mountains and the surrounding Artemisia steppe. Appendix B represents only conditions found in the two sample plots and does not depict the true distribution of this association.

Topography. Topography varies from undulating to steeply rolling with slopes of 0 to 40 percent usually of southerly exposure.

Soil. Sample plots occurred on the B series. However, it also appears to grow on the S and E series. In general, the soils are 12 to 24 inches in depth, range from a dark yellowish brown to very dark brown in the upper horizons, and vary from stony sandy loam to silt loam in texture. Occasional stones may occur on the surface. In general, moisture infiltration rate is good, retention is moderate, frost heaving is minimal, and summer drying is rather severe.

Vegetation Description. The association is dominated by a very open stand of Pinus ponderosa which fits the description of a savanna (Figure 8). Subordinate vegetation is dominated by the rhyzomatious

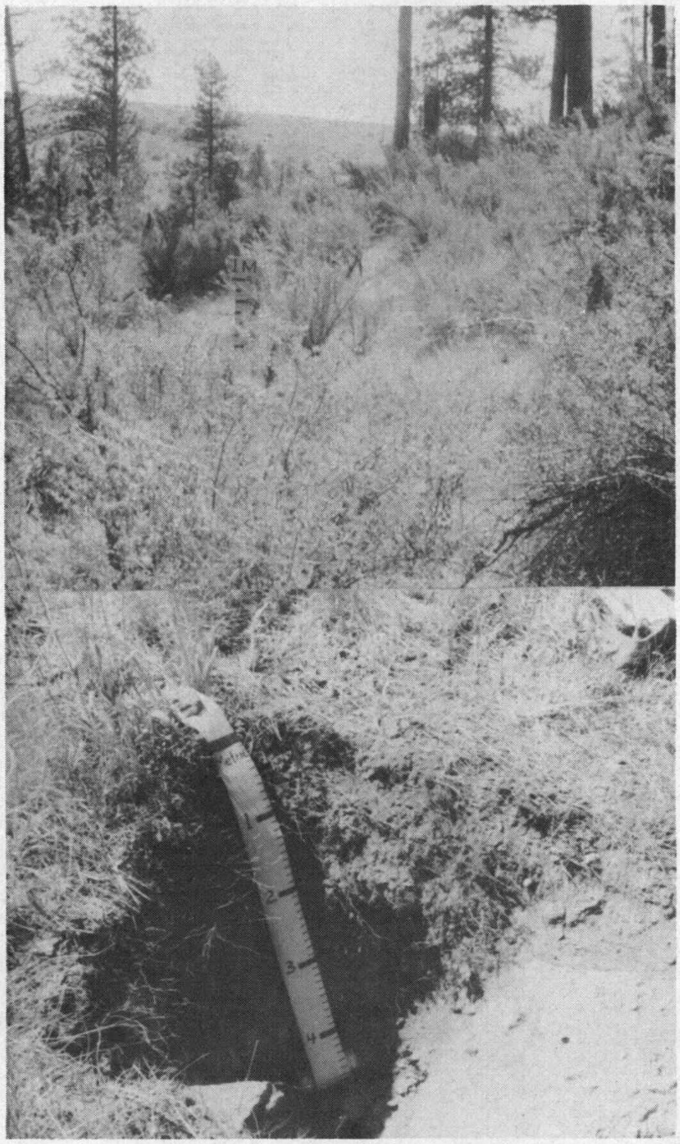


Figure 8. The Pinus ponderosa/Purshia tridentata/ Agropyron spicatum Association. Soil series B Plot 6x1).

form of Agropyron spicatum which apparently is a different strain from that in the Artemisia arbuscula/Agropyron spicatum association (Passey and Hugie, 1963). Purshia tridentata is moderately dense with a 10 to 25 percent crown cover. Artemisia tridentata is usually present and may tend to replace Purshia at lower elevations. Poa secunda, Sitanion hystrix, and Erigeron eatoni are also characteristic of the association.

Ground fires appear to have been common. They tend to eliminate Purshia and Artemisia leaving subordinate vegetation clearly dominated by Agropyron spicatum.

Pinus ponderosa/Purshia tridentata/Sitanion hystrix (Pipo/Putr/Sihy)

The Pinus ponderosa/Purshia tridentata/Sitanion hystrix association occurs exclusively in the Snow Mountain area. It is limited to the "rhyolite plateau" on the southern one-third of the area. It seems to be the most representative vegetation on this plateau.

Elevation and Topography. Elevation ranges from 4,800 to 5,300 feet. Topography is undulating with slopes usually less than 10 percent which may face any direction except northeasterly. The association is generally distributed over the landforms common in the area.

Soil. Soils are exclusively series E (Appendix D). Parent material is acid igneous rock composed primarily of tuff and rhyolite flow. There are no stones on the soil surface. Very little profile development is apparent. What may be termed an upper horizon is

<u>Figure 9</u>. The <u>Pinus ponderosa</u>/<u>Purshia tridentata</u>/<u>Sitanion hystrix</u> association (plot 6c6). Soil series E.

brown in color, has a stony, gravelly sand to sandy loam texture, and is often two to four inches in depth. The lower horizon, which lies on a well cracked bedrock, is light grey brown in color, has a very stony, sandy loam to loam texture, and ranges from 10 to 14 inches in depth. Total soil depth varies between 9 to 18 inches. The soil has a high infiltration rate, a low water holding capacity, and a pH of 6.4 to 7.0 (Figure 9).

Vegetation Description. This is a climax *Pinus ponderosa* association (Figure 9). Pine crown cover averages 42 percent. Subordinate vegetation is clearly dominated by *Purshia tridentata*. Herbaceous cover is quite scant and is composed of *Sitanion hystrix*, *Carex rossii*, and *Stipa occidentalis*. Highly competitive bunchgrasses or sodgrasses, characteristic of other associations, are absent.

Ground fire has been common averaging five to six fires per sample plot (Appendix E). Presumably, these fires would have a detrimental effect on *Purshia tridentata*. This would give the forest floor a rather barren appearance.

Since herbaceous vegetation is dominated by species often considered low in palatability, this association appears to be in fair range condition even when in excellent ecological condition. Its classification as an association is supported in two different ways. First, soils appear to be derived from rhyolite and tuff which are considered low in potential fertility. In addition, soils are shallow, stony, and coarse textured. These qualities suggest that herbaceous vegetation might be low in density. Adjacent forest stands growing on basalt or andesite derived soils are Pinus ponderosa/Carex geyeri which suggests that herbaceous species composition and dominance are also affected.

Second, a review of the literature points out two factors. First of all, Dyrness (1960) and Volland (1963) have described somewhat similar vegetation in Oregon growing on very coarse pumice soils. They, too, found a difference in soil parent material between their Pinus ponderosa/Purshia tridentata associations. Stipa and Sitanion formed a sparse stand on course pumice while Festuca idahoensis formed a moderately dense stand on sandy to sandy loam soils. A second item of literature is even more convincing (U. S. General Land Office, 1874). The Snow Mountain area was surveyed in 1874 by Gesner and Thurston. They described the townships T20S, R25E and T20S, R26E on the rhyolite plateau respectively as: "This township is only valuable for the timber on it. The lands in this township are well watered and covered with a fine growth of yellow pine; the northwest corner has some excellent grazing lands." Except for the northwest corner, these are townships in which samples of the Pinus ponderosa/Purshia tridentata/Sitanion hystrix association are located. Above these townships, parent material changes from acid igneous to basic igneous rock, primarily basalt with some andesite. In these upper townships, T19S, R26E, and T19S, R27E, the same men described the vegetation respectively as follows: "This township contains an excellent growth of pine and fir timber, and is valuable also for grazing purposes. This township is valuable for its excellent growth of timber, also for grazing purposes.' What these men were describing are the Pinus ponderosa/Carex geyeri and the Abies grandis/Calamagrostis rubescens associations. These Land Office descriptions by the same people, in the same year, clearly demonstrate that the appearance of forest vegetation on the rhyolite plateau did not suggest excellent grazing. With Purshia tridentata removed due to periodic ground fires, the Pinus ponderosa/Purshia tridentata/Sitanion hystrix association would not appear to be desirable for grazing compared to other types with more lush herbaceous growth. It would appear, therefore, that this association in climax condition, is not capable of growing anything more than the Stipa, Sitanion, and Carex rossii which were found dominant but in sparse cover in this study.

Purshia tridentata crown cover averaged about 15 percent with a standard error of 5.2 percent (Table 5). The variability was highly significantly accounted for in a correlation relating Purshia tridentata cover to the number of townships east of the western edge of the Snow Mountain area. Each township reduced Purshia cover by 7.8 percent and accounted for 85 percent of the variability.

Cause and effect relationships for change with geographic distance are extremely difficult to evaluate. Due to a lack of weather stations in the area, and no significant correlations with soil, tree cover, or elevation, the author is unable to suggest possible causes. It may be a combination of factors which were not measured during the course of the survey. It does illustrate a geographic continuum gradient.

Pinus ponderosa/Festuca idahoensis (Pipo/Feid)

The Pinus ponderosa/Festuca idahoensis association may be found distributed over the entire study area but is best represented in the Eastern Ochoco area. It does not occur as a major, widespread plant community, but occurs in small groups and patches of a few acres in size, often within the other climax pine associations.

Elevation and Topography. Stands suitable for sampling were found generally between 4,800 to 5,500 feet elevation with a few distributed down to 4,000 feet. This, however, may not represent the general distribution. The Pinus ponderosa/Festuca idahoensis looks very similar to the Pinus ponderosa/Purshia tridentata/Agropyron spicatum association in poor condition. Vegetation and soil evidence suggests that Pinus ponderosa/Festuca idahoensis is more important at lower elevations than Appendix B suggests. It seems to grow in climatic conditions only slightly more moist than Pinus ponderosa/Purshia tridentata/Agropyron spicatum. Topography is undulating to rolling with slopes usually less than 25 percent which face in all directions except northeasterly. Average slope direction is southwest. Stands are often located on the lower portions of slopes.

Soils. Soils are more variable in this association than any other. Depth ranges from 12 to 36 inches with an average of about 18 inches. Texture may range from fine sandy pumice ash (Series P) to stony loam (Series B) to clay loam (Series S). They may be derived from acid or basic igneous rock, pumice ash, alluvium or sedimentary rock.

Vegetation Description. This is a climax Pinus ponderosa

Figure 10. The Pinus ponderosa/Festuca idahoensis Association (Plot 6ca7). Soil series P.

association (Figure 10). In virgin conditions, trees are widely spaced resulting in an average crown cover of about 41 percent (Table 5). Subordinate vegetation is clearly dominated by Festuca idahoensis. This single species averages about 57 percent composition which is one of the highest for any single species in the associations studied. In spite of this, the associated flora is extremely rich and contains representatives of six other associations. For instance, Agropyron spicatum and Sitanion hystrix are fairly common and represent more xeric associations while Calamagrostis rubescens, Carex rossii, and Carex geyeri represent more mesic associations. This floristic diversity can be easily seen in Table 2. Purshia tridentata occurs in a number of stands but is limited to pumice ash soils and residual soils of coarse texture.

Excellent fire scars were available for analysis in five of the seven stands studied (Appendix E). They showed an average of about seven fires occurring at roughly 15- to 20-year intervals. One tree recorded fires as early as 1709. Fire scar evidence terminates shortly after establishment of the Ochoco National Forest about 1905. This fire control, coupled with overgrazing, probably played an important part in causing dense stagnated reproduction on many areas representative of this association.

Classification of the Pinus ponderosa/Festuca idahoensis association is somewhat unique. First, it does not fit easily into a classical continuum curve. Second, it does not occur in large acreages but in small islands. Therefore, it has been separated mainly because of the dominance of one species, Festuca idahoensis. While classification of a vegetation unit based on this criteria may not generally be desirable, the unique nature of this kind of plant community seems to make its separation justifiable (Daubenmire, 1966). There must be some reason for the clear dominance of Festuca idahoensis; there must be some reason why this association appears as islands within other Pinus ponderosa associations, and finally, management considerations in this association are somewhat unique.

Pinus ponderosa/Carex geyeri (Pipo/Cage)

The Pinus ponderosa/Carex geyeri association is well distributed throughout the study area.

Elevation and Topography. Elevation ranges from 4,000 to 6,000 feet. However, many stands occur in the 4,800 to 5,500 foot elevational zone. Elevational ranges shown in Appendix B encompass the variation of this type but probably do not represent its actual distribution. Many stands of the Pinus ponderosa/Carex geyeri association occur below 4,800 feet in poor and fair range condition.

The topography is generally undulating to rolling according to Appendix B. However, this association is quite prevalent on steeper topography in the Western Ochoco area but was not in good enough condition for sampling. It is more prevalent on southerly exposures.

Soils. Soils are predominately Series B, which are derived from basic igneous rock and some Series E, which is derived from acid igneous rock at higher elevations (Figure 11). Surface stoniness ranges from 0 to 15 percent. In general, horizon development is weak on these residual soils. The upper horizon is a dark brown, gravelly

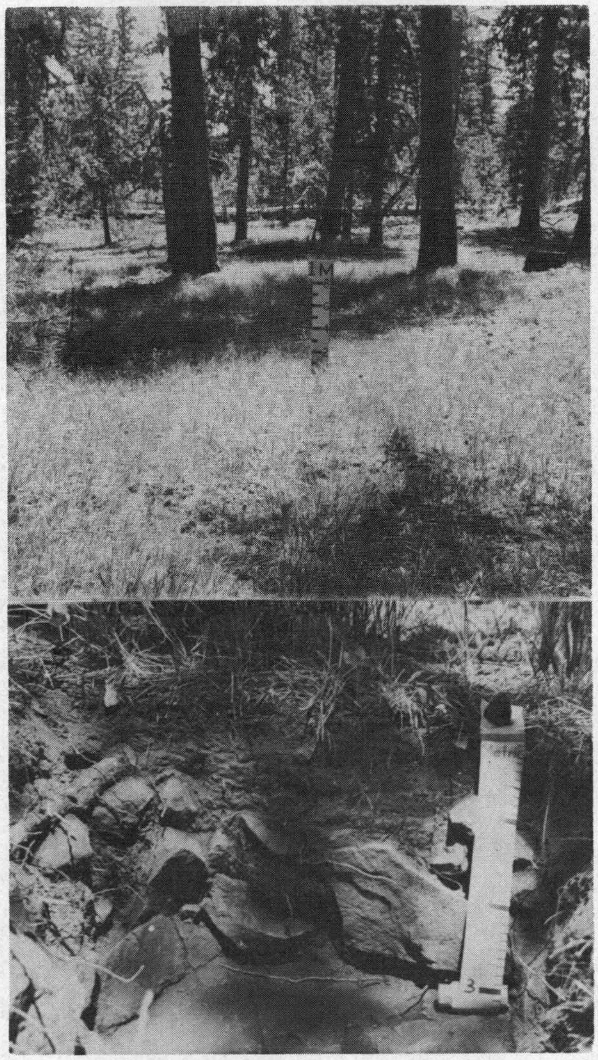


Figure 11. The *Pinus ponderosa*/*Carex geyeri* association (Plot 6b7). Soil series B.

sandy loam to stony loam in texture, four to five inches in depth, with a pH ranging from 6.2 to 6.8. The lower horizon is pale brown to brown, a stony to very stony sandy loam to loam, and 6 to 18 inches in depth. Total soil depth ranges from 9 to 28 inches to moderately cracked bedrock. Infiltration is good and moisture holding capacity is moderate.

Vegetation Description. Pinus ponderosa is climax with an average crown cover of 49 percent (Figure 11). Subordinate vegetation is clearly dominated by Carex geyeri which averages 55 percent composition. Other important species are Poa nervosa, Cercocarpus ledifolius with a crown cover of 0 to 20 percent and Purshia tridentata with a crown cover of 0 to 24 percent (Appendix A).

Fire scars are universal on all stands studied and show an average of 3 to 8 fires. Histories dating to 1741 indicate an average of 10 to 12 years between fires (Appendix E).

This association is rather similar to the Abies grandis/Calamagrostis rubescens association since Pinus ponderosa and Carex geyeri may dominate on both. It is separated by several factors. First, fir reproduction is lacking. Second, Purshia tridentata, Cercocarpus ledifolius, and Poa nervosa are indicator species of this association whereas Arnica cordifolia, Calamagrostis rubescens, and Lupinus caudatus are usually absent and tend to separate it from Abies grandis/Calamagrostis rubescens. Third, the soils in this association are nearly always residual. This, however, cannot be used as a sole criteria because some residual soils, primarily Series B, do occur in the Abies/Calamagrostis association.

According to vegetation and soils, the *Pinus ponderosa*/*Carex geyeri* association would appear to be at the xeric end of a continuum gradation of *Abies grandis*/*Calamagrostis rubescens*. This continuum tendency is best demonstrated by the correlation of *Pinus ponderosa* site index with soil depth. When data from *Pinus ponderosa*/*Carex geyeri* are combined with the *Abies grandis*/*Calamagrostis rubescens* association, variability of site index accounted for by soil depth increases from 26 to 52 percent, and correlation line standard error is reduced from 63 to 37 percent of the mean.

Summary of Climax Pinus Ponderosa Associations

Classification. The four associations classified as climax *Pinus ponderosa* were so designated because *Pinus ponderosa* was not only the sole dominant tree, but composed all of the tree reproduction. Fir reproduction was universally absent even though representatives of these *Pinus ponderosa* associations occurred adjacent to communities with fir reproduction and within suitable distance of a fir seed source. This lack of fir reproduction is supported not only by the data in Appendix A, but also by observation gained through allotment analysis. Even in fair and poor condition, where competition of herbaceous vegetation with tree reproduction is minimal, stands representing these associations showed no evidence of fir regeneration.

Reproduction. Tree reproduction in these climax *Pinus ponderosa* associations seems to occur primarily as a result of rodents. While evaluation of seedling germination and survival was not a part of this study, recorded observations suggest that 80 to 90 percent of germinating pine seedlings emerged from seed caches planted by rodents such as chipmunks and golden mantled ground squirrels.

Abies grandis/Calamagrostis rubescens (Abgr/Caru)

The Abies grandis/Calamagrostis rubescens association is the dominant kind of vegetation on the study area. It composes about 40 percent of the forest vegetation in the Snow Mountain area and 60 percent or more of the forest vegetation on the East and West Ochoco areas.

Elevation and Topography. Elevation ranges from 4,000 to 6,300 feet with best development in the 4,800 to 5,500 foot belt. Topography varies from undulating to rough. Appendix B suggests that 40 percent of the area is rough topography. This represents the Western Ochoco area. Slopes range from 0 to over 40 percent and may face in all directions. In general, however, the association is not so prevalent on southwesterly slopes. It may occur on any slope position.

Soil. This association encompasses a wide variety of soil conditions. About 12 percent of the soils are residual, Series B and E, which closely resemble those of the Pinus ponderosa/Carex geyeri association. They are similar to the Klicker series (Burr, 1959). For the Abies/Calamagrostis association they range from 18 to 24 inches in depth, are a stony sandy loam, and occur largely at upper elevations (Figure 12).

Eighty-two percent of the soils are wind deposited pumice ash over buried soil and have been classed as the O Series which are

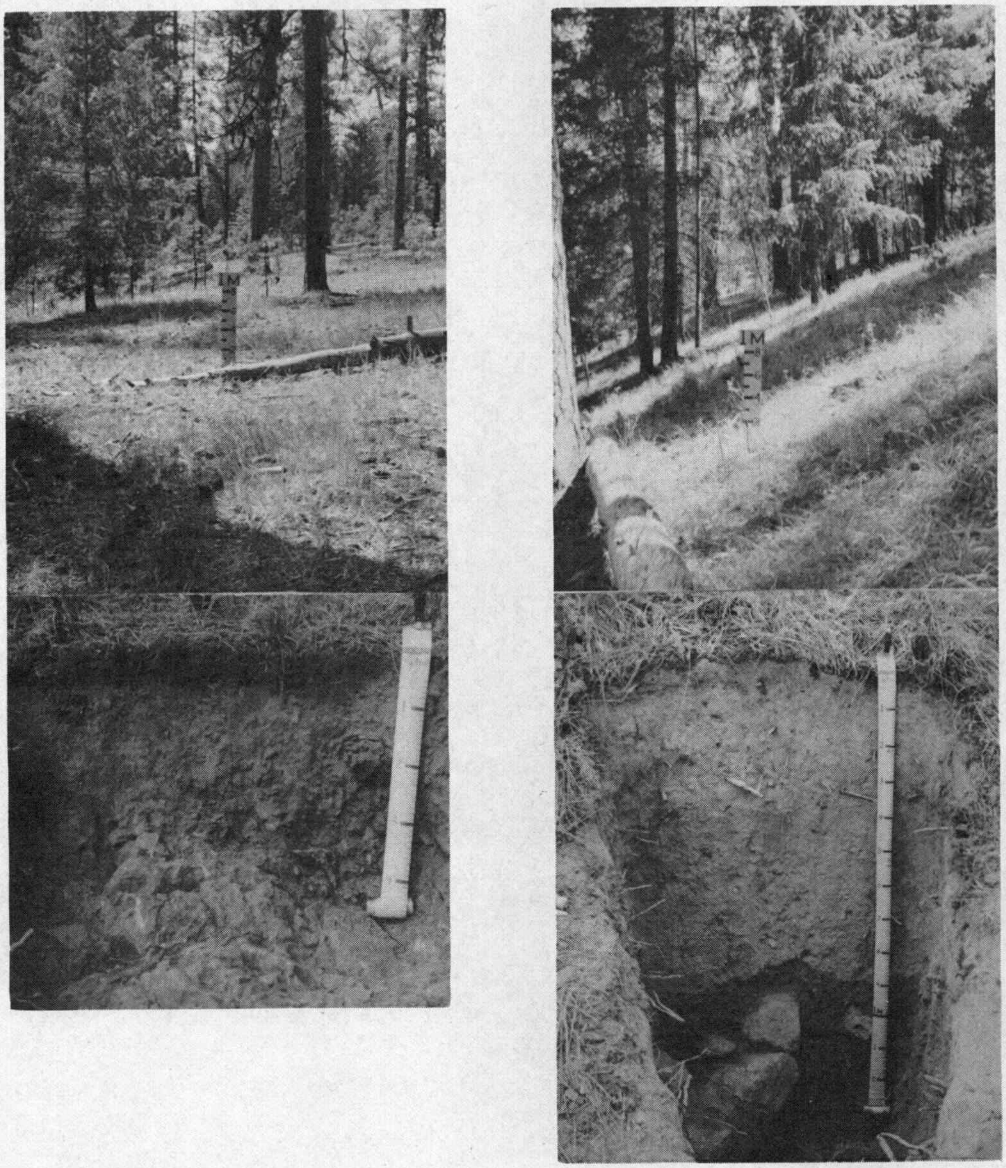


Figure 12. Seral conditions in the *Abies grandis*/*Calamagrostis rubescens* association. At left, shallow residual soil (Series B, plot 6b7) and pumice ash over buried soil on the right (Series 0, plot 6d8).

similar to the Tolo series in the north-central Blue Mountains (Burr, 1959). Two different phases are important. The grey phase is pure wind deposited pumice ash with little horizon development. It is grey-brown in color, fine sandy loam texture, and ranges in depth from four to 36 inches. Buried soil is dark brown, usually sandy clay loam to silt loam in texture, and 2 to 24 inches in depth. The total depth of these soils is 24 to 54 inches (Figure 12).

The colluvial phase of the O series is a pumice ash-rock mixture with little profile development. It is grey-brown to pale brown in color, fine sandy loam with 10 to 30 percent stone, and 24 to 50 inches to bedrock or well packed colluvial stone.

Lower elevational occurrence of this association is often related to natural forest openings. Due to spring saturated moisture conditions in these openings, sub-irrigation of the forest soils at the bottom and lower portions of the slope is common. This may be one reason for the low elevation extension of the _Abies_/_Calamagrostis_ association.

Vegetation Description. Stands characteristic of this association may be dominated by _Pinus ponderosa_ (Figure 12) nearly pure _Abies grandis_ (Figure 13) and all mixtures of _Pinus ponderosa_, _Pseudotsuga menziesii_, and _Abies grandis_ (Figure 12). Tree crown cover ranges from 30 percent to 114 percent.

Reproduction of _Abies grandis_ and/or _Pseudotsuga menziesii_ is present in nearly all cases. _Pinus ponderosa_ reproduction is often present but suppressed in growth.

Fire has been universal in all stands studied. Fire scars were present on 22 of the 24 plots studied and charred remnants of trees or stumps were present on the other two plots. Fire scar analysis showed an average of six fires per plot with a range of 15 to 20 years between fires. One scar recorded fire history to 1635 (Appendix E).

Ground fires have apparently maintained Pinus ponderosa and discouraged fir reproduction. This is demonstrated by two correlations. First, the basal area of fir is reduced 9.28 square feet for each recorded ground fire, significant at the 98 percent level and accounting for 38 percent of the variability in fir basal area. Second, the basal area of fir increases at the rate of one square foot for each two years since the last recorded ground fire, significant at the 95 percent level and accounting for 21 percent of the variability in fir basal area. In addition, the trend from Pinus ponderosa to fir dominance has been demonstrated by a correlation where each 10 percent increase in fir cover is associated with a reduction of 3.15 percent in Pinus ponderosa cover, significant at the 99 percent level and accounting for 39 percent of the variability in pine cover.

These data demonstrate a shift from Pinus ponderosa to Abies grandis and Pseudotsuga menziesii. They also demonstrate some of the reasons why Pinus ponderosa was maintained as the dominant tree prior to fire control. Since fire control, the trend in tree composition and cover has been steadily changing from pine to fir. This is strongly supported by age class distribution of Abies and Pseudotsuga, most of which are 70 years of age or younger. It also suggests that Abies grandis with some Pseudotsuga menziesii will dominate the non-fire climax in this association.

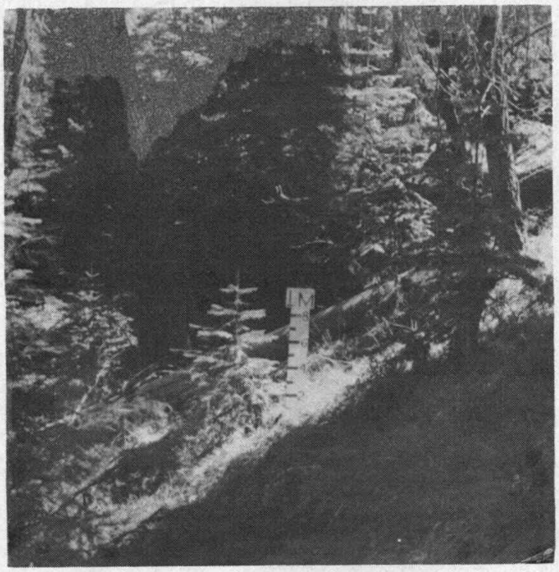


Figure 13. Near climax Abies grandis/Calamagrostis rubescens (Plot 6e8).

A description of climax conditions in this type must be suppositional. Due to the incidence of fire, most stands have never attained climax status under the existing climate. Climax will apparently be dominated by Abies grandis on deeper soils. On shallower soils, Pseudotsuga menziesii would probably be important. Pinus ponderosa is not producing sufficient reproduction to maintain itself. Due to its intolerance of shade, there will be less chance for Pinus ponderosa regeneration as the firs increase in crown cover (Meagher, 1950; Foiles, 1959).

Under open Pinus ponderosa with a crown cover less than 60 percent, Calamagrostis rubescens and Carex geyeri in combination clearly dominate, averaging about 80 percent composition in subordinate vegetation (Figure 12). Other important species, making up roughly 20 percent of the composition, are Arnica cordifolia, Lupinus caudatus, and Hieracium albiflorium. Increasing tree cover causes a reduction in both density and composition of Calamagrostis rubescens, Carex geyeri, and Lupinus caudatus. Climax conditions would probably be represented by a scant herbaceous layer of Arnica cordifolia, Hieracium albiflorum, Carex, and Calamagrostis.

Classification Problems. This association was separated from the climax pine types according to the presence of Calamagrostis rubescens, Lupinus caudatus, and Hieracium albiflorum with fir reproduction. In addition, the preponderance of pumice ash soils helps separate it from climax pine associations which are usually on residual soils. It was separated from the Abies grandis/Bromus vulgaris association by the lack of Pinus ponderosa, Calamagrostis rubescens, and Lupinus caudatus. Important species indicating Abies/Bromus were the presence of Larix occidentalis, Bromus vulgaris, Lupinus latifolius, Mitella stauropetala, and Pyrola secunda. Soils are not a reliable criteria for separating the Abies/Bromus association from Abies/Calamagrostis.

Sampling in the Abies/Calamagrostis association was distributed over all successional stages for two reasons. First, suitable climax conditions could not be found due to persistent ground fires. Second, analysis of successional changes in subordinate vegetation is essential for range management. For these reasons, the data presented in Appendix A for the Abies/Calamagrostis association represents natural successional stages whereas data in most of the other associations represent climax conditions. This introduces classification problems when association tables are used. Another problem in classification of Abies/Calamagrostis deals with the variability of environmental factors such as soils, elevation, slope, topography, and geographic area. This variability suggests the possibility of a continuum within the association. Due to a lack of climax communities, analysis of the effects of this variability is hardly possible. The author could not separate the continuum in succession from a possible continuum in climax vegetation.

Abies grandis/Bromus vulgaris (Abgr/Brvu)

The Abies grandis/Bromus vulgaris association occurs in the East and West Ochoco areas. It is restricted largely to the vicinity of the fault line along the northern edge of these areas.

Elevation and Topography. Elevation varies from 5,800 feet to timberline near 7,000 feet. Stringers of this association may occur in canyon bottoms at lower elevations. Topography varies from undulating to rough with slopes generally less than 50 percent. The association is best developed on northerly facing slopes and occurs from the upper third to bottom locations. In most cases, the top of the slope is alpine forest or alpine open.

Soils. This association occurs exclusively on the O Series. In a few cases, the colluvial phase of the O Series is present. However, a majority of the sample plots were located on the yellow phase. The soil is primarily a pumice ash mantle with little horizon development, yellow brown in color, very fine sandy loam texture, and 1 to 4 feet in depth to buried soil. The pH ranges from 5.7 to 6.6. Occasionally, some rocks are present in the profile. The buried soil is derived from basic igneous or sedimentary materials, is dark brown in color, silt loam to clay loam in texture, and often 18 inches or more in depth. Total soil depth is always greater than three feet, and may reach depths of 5 to 6 feet (Figure 14). These are the same soil conditions found in the Pinus contorta/Vaccinium scoparium/Calamagrostis rubescens associes.

Evidence of fire was found in one-half of the stands studied. These fires appeared to be conflagrations rather than ground fires as evidenced by charred stumps and trees rather than fire scars.

Vegetation Description. A number of stands appeared to be in

Figure 14. Near climax Abies grandis/Bromus vulgaris association (Plot 6f6). Yellow phase of the O Series. Arrow indicates depth of pumice ash.

climax or near climax conditions as evidenced by age class distribution of trees and lack of fire evidence. In these cases, Abies grandis was the sole dominant with a crown cover of 90 to 107 percent. The range in crown cover of 50 to 107 percent (Appendix A) represents a combination of seral and climax conditions. Subordinate vegetation in climax is very scant and is composed largely of Bromus vulgaris, Hieracium albiflorum, Arnica cordifolia, Lupinus latifolius, Mitella stauropetala and Pyrola secunda (Figure 14).

Natural succession after fire in the Abies/Bromus association is quite different from Abies/Calamagrostis. In Abies/Bromus, pure stands of Pinus contorta are usually first to colonize fire devastated areas (Trappe & Harris, 1958; Tackle, 1959). At times, Larix occidentalis will be an initial fire species (Roe, 1956; Boe, 1958). Seed source apparently influences selection of pioneer species. Shortly after these initial fire species have grown tall enough to modify microclimate, reproduction of Pseudotsuga menziesii, Abies grandis, and at times Picea engelmanni, become established. Pinus contorta is apparently eliminated in the successional cycle after about 100 years. However, Pseudotsuga menziesii and Larix occidentalis may persist for several hundred years due to their long life span. This is demonstrated by their presence in many sample plots. They do not, however, satisfactorily reproduce under the typically dense shade of Abies grandis.

Classification. The Pinus contorta/Vaccinium scoparium/Calamagrostis rubescens associes noted in Appendices A and B and Tables 2, 3, and 5 is the initial successional stage after fire in the

Abies/Bromus association. This has been demonstrated by similarity of soil and location of the Pinus contorta/Vaccinium scoparium/Calamagrostis rubescens stands within an Abies/Bromus stand. No reason for the sharp demarcation line between the stands of vegetation could be found except for the presence of fire charred logs and stumps in the Pinus contorta areas. In addition, reproduction under the Pinus contorta stands was invariably Abies grandis and Pseudotsuga menziesii.

Separation of the Abies/Bromus association for classification purposes is somewhat arbitrary. It appears to be a mesic portion of a continuum gradient on pumice ash soils from Abies/Calamagrostis to Abies/Bromus where elevation and precipitation are the primary continuum gradient scalers. An exact line of demarcation between these two associations is somewhat difficult to place as may be noted in Appendix A. Many indicator species of Abies/Calamagrostis are also present in the Abies/Bromus association and at times are of major importance in composition. Some of these are: Pseudotsuga menziesii, Carex geyeri, Calamagrostis rubescens, Arnica cordifolia, and Hieracium albiflorum. On the other hand, several species of importance in the Abies/Bromus also occur in varying amounts in the Abies/Calamagrostis association. These are: Osmorhiza purpurea, Bromus vulgaris, and Lupinus latifolius. In addition, both associations would be dominated in climax by Abies grandis.

While separation for classificational purposes seems somewhat difficult according to Appendix A, this continuum gradient is not usually found in the field between adjacent stands. In many cases, Abies/Calamagrostis is found on south slopes with a rather sharp

Figure 15. The Pinus contorta/Vaccinium scoparium/Calamagrostis rubescens (Plot 6fc1). This associes is seral to the Abies grandis/Bromus vulgaris association. Soil Series 0, yellow phase.

break to Abies/Bromus on north slopes. Field separation does become difficult however, on northwest and southeasterly slopes where stands representing these associations tend to merge.

Pinus contorta/Vaccinium scoparium/Calamagrostis rubescens (Pico/Vasc/Caru)

This associes is located in the same area as the Abies grandis/Bromus vulgaris association. Topography, elevation, and slope are also similar because Pinus contorta/Vaccinium scoparium/Calamagrostis rubescens is a pioneer community after fire in the Abies/Bromus association. As one may expect, soils are also identical (Figure 15). Pinus contorta has been found on similar soils in the central and northern Blue Mountains (Trappe & Harris, 1958).

Vegetation Description. This associes is dominated solely by Pinus contorta with a crown cover ranging from 30 to 65 percent (Figure 15). Reproduction of Pseudotsuga menziesii, Abies grandis, and Larix occidentalis is almost always present. Under less dense crown cover, Pinus contorta shows some evidence of reproduction. As time passes, and the Pinus contorta stands mature and disintegrate, they will be replaced by the fir and larch reproduction which will eventually develop into the Abies/Bromus association.

The basic justification for classifying this purely successional plant community is to aid land management.

Minor Vegetation Associations

Several additional kinds of vegetation may be found on the study area which are not presented in tables and appendices. These associations were not sampled for two reasons. First, in almost every case, no stands were found that could be classed in good or better range condition. Second, some of the associations were too small for satisfactory sampling. A brief description of these communities is given below.

Shrub Communities. These shrub communities are dominated generally by *Cercocarpus ledifolius* and *Purshia tridentata*, often with an understory of *Bromus tectorum*, *Poa secunda*, and *Sitanion hystrix*. Occasionally, *Juniperus occidentalis* and *Pinus ponderosa* are present. They are limited primarily to the Western Ochoco area on rather shallow, stony, sandy loam soils and rock outcrop positions. Dominance between *Cercocarpus* and *Purshia* varies tremendously, and at times *Chrysothamnus* and *Artemisia* species are present. The differences or similarities of climax composition in these stands is unknown.

Alpine *Festuca idahoensis*. Stands dominated by *Festuca idahoensis* with occasional *Artemisia arbuscula*, *Phlox* species, *Poa secunda*, and *Achillea milefolium* may be found in pseudo-alpine conditions on mountain tops such as Spanish Peak, Snow Mountain, and Grizzly Mountain (Figure 16). Species composition closely resembles some *Festuca* associations at lower elevations. However, the alpine variety occurs above 6,000 feet and is separated from lower elevational *Festuca* associations by several miles of timber and more than 1,500 feet elevation. Soils are often 18 to 24 inches in depth, moderately stony, and loam to silt loam in texture. *Festuca idahoensis* would probably dominate the stands in climax conditions.

Artemisia tridentata vaseyana/*Carex* species. The most

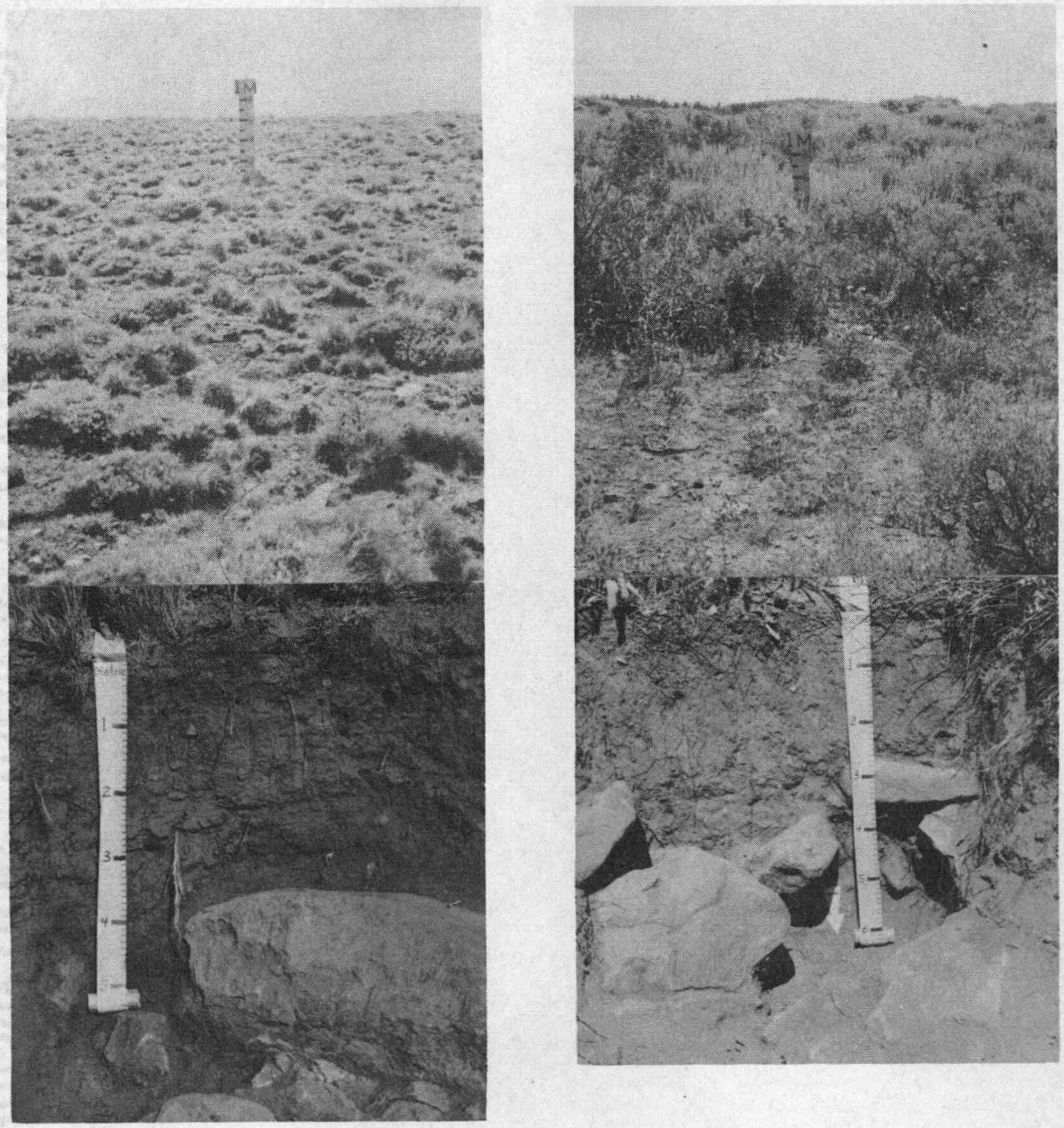


Figure 16. Major pseudo-alpine natural open associations. On the left is Festuca idahoensis, on the right is Artemisia tridentata var. vaseyana/Carex.

predominant type of alpine opening above 6,000 feet in the study area is the *Artemisia tridentata* var. *vaseyana*/*Carex* species association. The best indication of potential climax was found on Lookout Mountain (Figure 16) where a short sedge, apparently *Carex geyeri*, and a taller sedge, which could not be identified due to lack of flowering parts, were found. This *Artemisia tridentata* var. *vaseyana* association dominates the pseudo-alpine openings on Lookout Mountain, Pisgah Mountain, Wolf Mountain, and most of the ridges leading to Spanish Peak.

Reid (1941), in discussing subalpine grasslands, has suggested that most of the Blue Mountain alpine openings were at one time dominated by *Festuca viridula*. The author could find no evidence of this in the study area.

Abies Lasiocarpa Association. In most cases, the *Abies lasiocarpa* association contains some *Pinus contorta* and occurs as a narrow belt bordering sub-alpine opens at elevations of 6,200 to 7,100 feet. In all cases, it has been excessively grazed and subordinate vegetation is virtually absent. The only area where the *Abies lasiocarpa* association was found as a continuous forest stand was on the northeast slope of Lookout Mountain (Figure 17). In this case, it was clearly dominated by *Abies lasiocarpa* with occasional *Pinus contorta*. Numerous open stringers were interwoven through the stands where the soil surface was covered by gravel and stone. This entire area was excessively grazed by sheep prior to 1930 resulting in destruction of subordinate vegetation. Soils appear to be a brown to dark brown loam to silt loam, often with abundant stone, and usually 2 to 3 feet in depth.

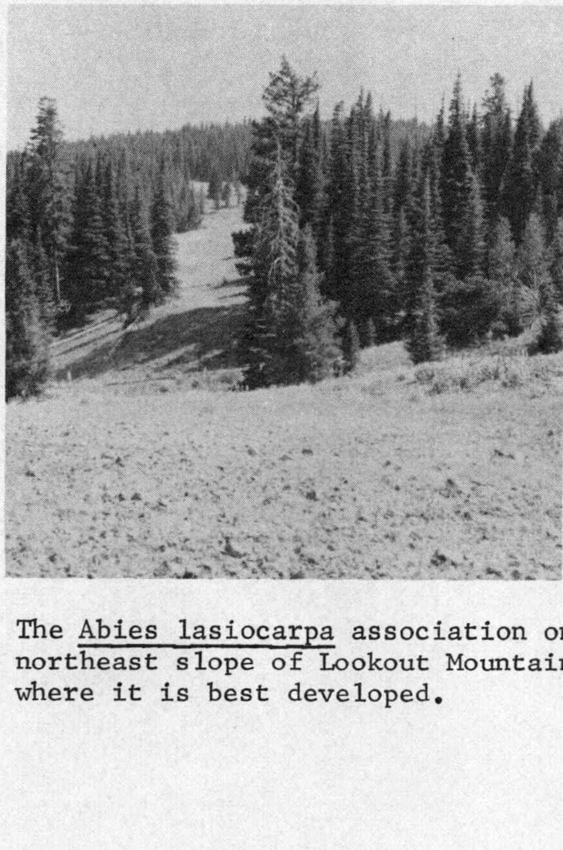


Figure 17. The Abies lasiocarpa association on the northeast slope of Lookout Mountain where it is best developed.

Vegetation Patterns

Vegetation patterns in the study area vary considerably due to geologic formations and land form. For this reason, vegetation mosaics will be described by the three geographic divisions.

Western Ochoco Area

Lower Southerly Elevations. The transition from Artemisia steppe to forest is often a poorly developed savanna occupied by the Pinus ponderosa/Purshia tridentata/Agropyron spicatum association. Pinus ponderosa/Festuca idahoensis or Pinus ponderosa/Carex geyeri are often predominant and do not form a well defined savanna. This is due primarily to soil and topography. In many cases, forest soils are rather shallow, stony, and lie upon a well cracked bedrock compared to Artemisia steppe soils which are finer textured, deeper than forest soils and less stony. The Abies grandis/Calamagrostis rubescens association may sometimes be found on steep north slopes which are adjacent to the Artemisia steppe. On these hill masses, Juniperus occidentalis and Artemisia tridentata often co-dominate the ridge tops and south slopes.

Mid-elevations. The Abies grandis/Calamagrostis rubescens association becomes increasingly dominant as elevation increases. However, Pinus ponderosa/Carex geyeri is very common on southerly slopes with shallow soil. Abies grandis/Calamagrostis rubescens appears on deeper soils on south slopes and on virtually all north slopes. Some *Pinus ponderosa*/*Festuca idahoensis* and shrub associations occur on limited areas which seem to be special conditions of soil and topography.

Upper Elevations. In general, the *Abies grandis*/*Calamagrostis rubescens* association is predominant on south slopes and the *Abies grandis*/*Bromus vulgaris* association is most prevalent on north slopes.

Numerous small rock outcrops are occupied by shrub associations. This mosiac continues to the pseudo-timberline of peaks above 6,300 feet where the Alpine *Festuca idahoensis*, *Artemisia tridentata* var. *vaseyana*/*Carex*, and *Abies lasiocarpa* associations occur.

Northern Forest Edge. At about 4,000 feet elevation along the Northern edge of the Western Ochoco area, the *Abies grandis*/*Calamagrostis rubescens* association changes rather abruptly, with a change in soil, to the *Artemisia tridentata*/*Agropyron* shrub steppe vegetation. Few areas could be found which would represent a climax *Pinus ponderosa* zone transitional to the steppes.

Eastern Ochoco Area

Lower Southerly Elevations. The *Artemisia* steppe-forest transition is an irregular, sharply defined, intricate pattern due to major soil differences. Forest vegetation grows on stony, coarse textured soils one to two feet in depth over well cracked bedrock, whereas the steppe is predominantly on fine textured soils two to three feet in depth. In many, but not all cases, the forest is composed of climax *Pinus ponderosa* associations. *Abies grandis*/*Calamagrostis rubescens* often occurs adjacent to the *Artemisia* steppe on northerly slopes or in drainage bottoms which are sub-irrigated from natural forest openings. Part of the irregular transition pattern is caused by natural forest openings which occupy 50 to 30 percent of the land area at the forest edge. They are largely the *Artemisia rigida*/*Poa secunda* and *Artemisia arbuscula*/*Agropyron spicatum* associations.

Mid-Elevations. Natural forest openings are still important and occupy about 30 percent of the land area. They are dominated largely by the *Artemisia rigida*/*Poa secunda* association with a decreasing proportion of *Artemisia arbuscula*/*Agropyron spicatum*. Forest vegetation is largely *Abies grandis*/*Calamagrostis rubescens* interspersed with stands of *Pinus ponderosa*/*Carex geyeri* and *Pinus ponderosa*/*Festuca idahoensis* on southerly exposures due to shallower soils.

Upper Elevations. The *Abies grandis*/*Calamagrostis rubescens* association predominates on southerly slopes with *Abies grandis*/*Bromus vulgaris* on northerly slopes. Many ridges between 5,800 and 6,300 feet are open and appear to be poor or fair condition *Artemisia rigida*/*Poa secunda*. These open ridges occupy 10 to 15 percent of the land area along the fault line at the northern edge of the study area. Alpine communities occur above 6,500 feet.

Northern Forest Edge. Forest transition north of the fault line is often sharp with Abies grandis/Calamagrostis rubescens terminating rather abruptly in the Artemisia steppe due to soil. A climax Pinus ponderosa transition is absent or very poorly developed.

Snow Mountain Area

Lower Southerly Elevations. Transition from Artemisia steppe to forest is sharply defined along the edge of the "rhyolite plateau." The forest is almost exclusively Pinus ponderosa/Purshia tridentata/Sitanion hystrix on shallow, coarse textured, stony soils over well broken bedrock. Artemisia steppe soils are generally fine textured, and two to three feet deep. Within this forest association, occasional natural openings of Artemisia arbuscula/Festuca idahoensis occur as well as small islands of the Pinus ponderosa/Festuca idahoensis association. When parent material changes from rhyolite or tuff to basalt, forest vegetation promptly changes to the Pinus ponderosa/Carex geyeri association. Excellent examples are found on Dry Mountain and Green Butte.

Mid-Elevations. Soil is a major factor influencing vegetation on the undulating topography. Deeper soils support Abies grandis/Calamagrostis rubescens, shallower soils support Pinus ponderosa/Carex geyeri, and finer textured, shallow soils support Artemisia arbuscula/

Agropyron spicatum, often with some Juniperus occidentalis, which may reach 10 to 15 percent crown cover.

Upper Elevations. Abies grandis/Calamagrostis rubescens is the dominant association to "timberline" at the summit of Snow Mountain itself where alpine Festuca idahoensis occurs.

Northern Forest Edge. North of Snow Mountain, topography abruptly breaks into rather steep north slopes. Here the Abies grandis/Calamagrostis rubescens association often abuts on the Artemisia steppe. Climax pine associations, predominantly Pinus ponderosa/Festuca idahoensis may occur on shallower soils.

Concept of Climax

Climatic Climax

Climatic climax has generally been defined as fully developed soil and vegetation under a given climate. Unfortunately, conditions meeting these criteria could not be found in the study area for two reasons. First, many soils were too shallow, stony, and poorly developed to qualify as fully developed under the existing climate. Second, soils in excess of two or three feet were not residual soils developed under the existing climate, but were quite young soils composed of wind deposited pumice ash over buried soil.

A third problem complicates appraisal of climatic climax vegetation in the study area. In most cases, forest vegetation ends abruptly at the Artemisia steppe due to sharp soil differences instead of forming a gradual transition in response to gradual changes in climate and soil.

Concept of Climax Vegetation

All references to climax in this paper refer to the interaction of climate with a specific soil and the resulting, apparently stable, vegetation. It is for this reason that openings within the forest zone have been designated as climax. All conditions studied may be considered to represent edaphic or topo-edaphic climax areas according to Daubenmire (1952).

It is the author's opinion that forest vegetation, particularly on the Eastern Ochoco and Snow Mountain areas, extends further into the Artemisia steppe than precipitation would warrant due to soil conditions. These conditions are the sandy, stony nature of the soil, and the well cracked bedrock presumably would tend to increase moisture available for woody species, such as trees. Similar precipitation in a fine textured soil appears to favor herbaceous plants with fiberous roots such as bunchgrasses.

Vegetation Zones

Concept

Vegetation zones are due primarily to differences in climate, basically precipitation and temperature (Daubenmire, 1952). These differences in climate tend to change vegetation. For instance, in the study area, the change from Artemisia steppe at 4,000 feet and 10 inches precipitation to mesic forest at 6,000 feet should theoretically progress from Pinus ponderosa savanna, to moderately dense climax Pinus ponderosa through Pseudotsuga climax, to mesic Abies grandis climax. However, the discussion of vegetation patterns has suggested that this kind of zonation is very poorly developed in the study area.

Zonation

Any attempt to assign definite vegetation zones would tend to be misleading due to the modification of soils and topography on climate and the resulting mosaic of vegetation. However, three very general zones might be proposed. First, a lower elevation zone from 4,000 to 4,800 feet which is predominantly, but not exclusively, Pinus ponderosa climax. Second, a zone from 4,800 to 6,800 feet predominantly, but not exclusively, Abies grandis climax. Third, a predominantly pseudo-alpine zone of 6,300 feet and higher. In proposing these zones, one must be cognizant of soil influences which cause natural openings in the forest and constant intermeshing of associations across what could be zonal boundaries.

APPLICATION OF RESULTS

Land management requirements should be considered in application of ecological material. For example, interpretation of changes in herbaceous vegetation is greatly facilitated if the relative palatability of individual species is known. These species may then be classified according to their reaction to grazing.

Species Reaction to Grazing

Plant species in each association were characterized according to their reaction to grazing as follows:

Decreasers: Species which are most palatable to grazing animals and which will be most easily damaged or killed by excessive grazing.

Palatable Increasers: Species which are generally low in palatability. These plants tend to increase in percent composition as the more palatable species are damaged by over-use. With persistent over-grazing these plants, too, will eventually be reduced in composition and density.

Unpalatable Increasers: Species which are generally unpalatable to grazing animals. They will persist under prolonged, excessive use that eliminates all traces of decreasers and severely reduces palatable increasers.

Intensive investigation of species reaction to grazing was not conducted in this study. Therefore, the data in Table 4 and Appendix F must be considered tentative. Appendix F was developed from fence line contrasts of good and poor range condition using the loop transect method supplemented by reconnaissance data.

Table 4 lists some of the more important decreasers and palatable increasers. Notice that an individual species may act as a decreaser in one association and a palatable increaser in another. One example is Poa secunda; it is a decreaser in the Artemisia rigida/Poa secunda association and a palatable increaser in the others; Sitanion hystrix is a decreaser in the Pinus ponderosa/Purshia tridentata/Sitanion hystrix association and a palatable increaser in the other associations in which it occurs. For this reason, one should not use Table 7 as a basis for comparing means and standard errors of similar groups of species. Each association has its own list of species in each group.

Table 7 can be used, however, to evaluate the relative proportion and density of these three groupings of plants. In most cases, the ten associations can be separated according to the proportion of decreasers, palatable increasers, and unpalatable increasers. This separation is further exemplified by Table 4 which illustrates the differences in species reaction to grazing. Here is an example of using management criteria as an aid in classification.

Table 4. Important decreasers and palatable increasers in ten vegetation associations.

Reaction to grazing use D= decreaser PI=palatable increaser	Arri/ Pose	Arar/ Feid	Arar/ Agsp	Pipo/ Putr/ Agsp	Pipo/ Putr/ Sihy	Pipo/ Feid	Pipo/ Cage	Abgr/ Caru	Abgr/ Brvu	Pico/ Vasc/ Caru
Poa secunda	D	PI	PI	PI 1/	PI	PI				
Trifolium macrocephalum	D	PI								
Artemisia rigida	D		D							
Sitanion hordeoides	D	PI								
Festuca idahoensis		D	PI	PI 1/		D				
Agropyron spicatum	D	D	D	D 1/		D				
Sitanion hystrix			PI	PI 1/	D	PI	PI			
Purshia tridentata		D	D	D 1/	D	D 1/	D			
Carex rossii				PI 1/	D	PI	PI 1/	PI		
Stipa occidentalis					D	PI				
Cercocarpus ledifolius					D 1/	D 1/	D 1/			
Poa nervosa					PI	PI	PI	PI		
Carex geyeri						D	D	D	D 1/	
Calamagrostis rubescens						D	D 1/	D	D	D
Lupinus caudatus						PI		PI		PI 1/
Hieracium albiflorum								PI	D	PI
Bromus vulgaris									D	
Lupinus latifolius									PI	PI

1/ Classification by reconnaissance data only.

Vegetation Characteristics of the Associations

Each association tends to have certain characteristics which set it apart from the others. On the other hand, some characteristics are shared by several associations. Since no simple statement will satisfactorily elucidate these traits, they will be discussed for each association.

Artemisia rigida/Poa secunda association

Spring soil moisture saturation limits grazing use of stands representing this association. Livestock should not be permitted on these wet soils to prevent serious trampling damage.

A majority of the vegetation in this association is palatable to animals. Table 4 shows that all dominant species react as decreasers under grazing. This palatability, however, is strongly affected by season of use. Herbaceous species are palatable when green or in the early dry stages which limits their palatability to spring and very early summer. Occasionally, Poa secunda is used in the fall if regrowth appears. For this reason, interpretation of the 100 to 190 pounds of herbaceous production must be tempered with season of use.

Artemisia rigida becomes highly palatable after mid-summer when flower stalks are produced. This palatability ceases in the late fall when leaves are shed. Preference for flower producing twigs appears to have a detrimental effect on reproduction of this shrub.

The palatability of Artemisia rigida/Poa secunda stands is often quite different from adjacent vegetation. They are often preferred over forest range in the early spring and fall and are seldom grazed during the summer. Thus, another dimension is added to species palatability and reaction to grazing: that of associated vegetation. While a plant such as Poa secunda may be classed as a decreaser in the Artemisia rigida/Poa secunda association, it may react as a palatable increaser on this association under summer grazing.

Artemisia arbuscula/Festuca idahoensis association

Saturated soil moisture conditions in the spring limit early livestock use. In many cases, Festuca has grown well past range readiness by the time soil conditions will support the weight of livestock.

The most palatable species on the Artemisia/Festuca association is Festuca idahoensis (Table 4). Where they occasionally occur, Agropyron and Purshia are also classed as decreasers. Note also in Table 4 that in this association, Poa secunda, Trifolium macrocephallum, and Sitanion hordeoides are palatable increasers whereas they were decreasers on the Artemisia rigida/Poa secunda association (Tueller, 1962).

Herbage production, composed primarily of Festuca idahoensis, ranges from 210 to 325 pounds. Unfortunately, while Festuca is classed as a decreaser in this association, it is generally lower in palatability than most species in surrounding forested range. For this reason, and the apparent early spring preference for Festuca, this this forage production is seldom effectively utilized.

In poor range condition, Poa secunda and Balsamorhiza serrata dominante the herbaceous vegetation under Artemisia arbuscula. Bromus tectorum is seldom important. These conditions do not correspond well with descriptions given by Eckert (1958) or Tueller (1962) for a similar kind of vegetation at lower elevations.

Artemisia arbuscula/Agropyron spicatum association

Spring soil moisture conditions in this association are similar to those of other natural forest openings. Grazing should be deferred past vegetative readiness to prevent trampling damage on the saturated soil.

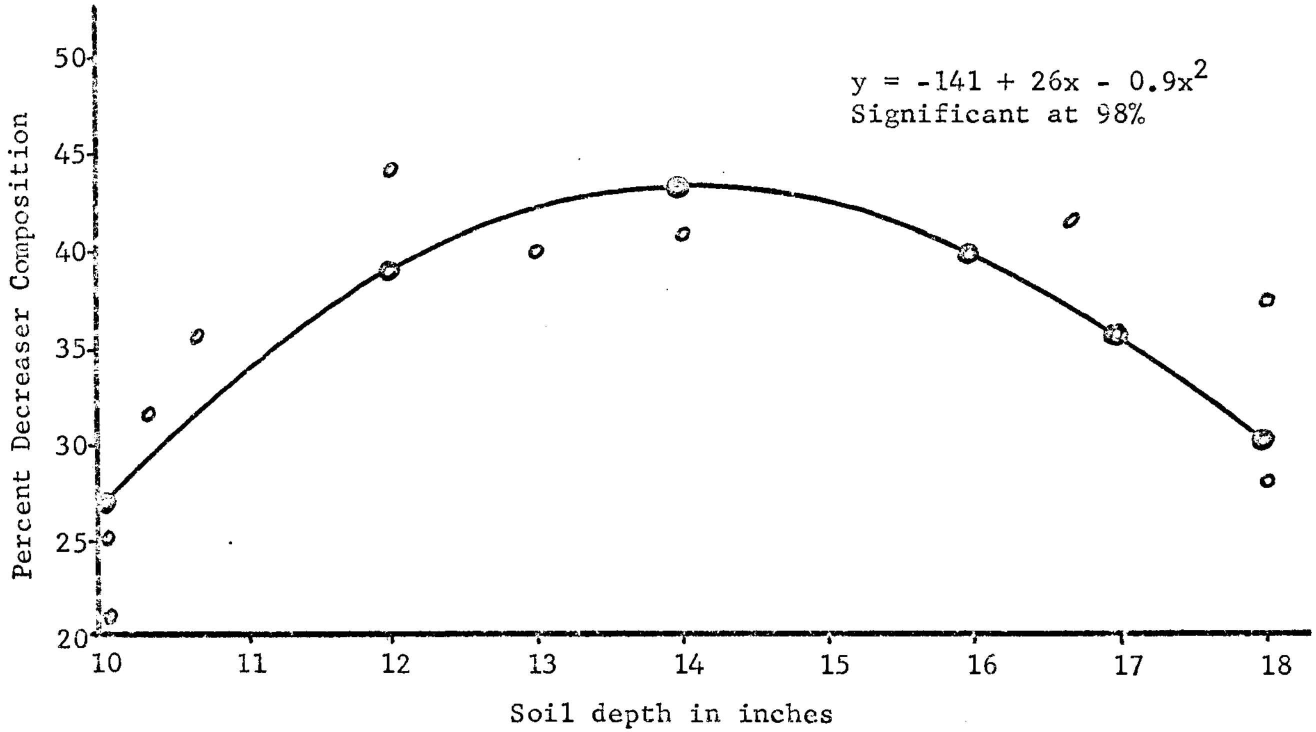
Some species occur in different palatability categories in this association. Note that Festuca idahoensis, a decreaser in the Artemisia arbuscula/Festuca idahoensis association, is here classed as a palatable increaser. The three species classified as decreasers are Agropyron spicatum, Purshia tridentata, and the very occasional Artemisia rigida. Poa secunda, Trifolium macrocephallum, Festuca idahoensis, and Sitanion hystrix are palatable increasers.

Note from Table 7 that decreasers average 45 percent composition with a standard error of 19 percent. Correlation analysis has shown that soil depth accounts for 72 percent of the variability in decreaser composition according to a curvilinear equation (Figure 10). Optimum soil depth for maximum decreaser composition is about 14 inches. Shallower and deeper soils result in lower decreaser composition.

Herbage production averages about 512 pounds with a standard error of 138 pounds (Table 5). This is influenced by several factors. First, soil depth significantly accounts for 52 percent of this variability where each inch of soil increases production 26.2 pounds. Elevation is highly significant influence accounting for 83.5 percent of the production variability where each 100-foot increase in elevation reduces production 23.8 pounds. Third, production is significantly influenced by the percent composition of decreasers plus palatable increasers. Each percent increase in composition increased production 10 pounds and accounts for 51 percent of the variability.

These correlations illustrate several points. First, there are reasons for the variability within a classified unit of vegetation. Second, they demonstrate the continuum nature of vegetation and environment. Third, they demonstrate that refinement of numerical data is possible within a vegetation association. One must be cautious, however, when interpreting causes and effects. The fact that elevation accounted for 75 percent of the variability in *Artemisia arbuscula* cover and 83 percent in herbage production does not mean that elevation itself was the

Figure 18. Relationship of soil depth to decreaser composition on the *Artemisia arbuscula*/*Agropyron spicatum* association.



cause of increasing Artemisia and decreasing production. Some of the real causes reflected in increasing elevation may be shortened growing seasons, lower temperatures, increased cloudiness, changing soil moisture conditions, and increase in snow precipitation.

Pinus ponderosa/Purshia tridentata/Agropyron spicatum association

Insufficient samples prevent an accurate description of the volume, growth, and site index of this association. Table 5 lists the variation found on the two plots established. In general, all values except pine site index are considerably below other forest associations.

Decreasers are Agropyron spicatum and Purshia tridentata. The more important palatable increasers include Poa secunda, Festuca idahoensis, Carex rossii and Sitanion hystrix. Reaction of species to grazing is quite similar to the Artemisia arbuscula/Agropyron spicatum association. Herbage production averages 250 pounds.

This association appears to be the most palatable forest range within the study area. This is the reason difficulty was experienced in finding suitable sample locations.

Subordinate vegetation in poor range condition is dominated by Bromus tectorum, Poa secunda, and Artemisia tridentata. Purshia may be present, but it is closely hedged and reproduction is absent.

Pinus ponderosa/Purshia tridentata/Sitanion hystrix association

Volume of wood per acre in this association is 19,000 board feet with a standard error of 8,200 board feet. Cubic volume averages 2,886 cubic feet with a standard error of 1,132 cubic feet. Basal area averaged 101 square feet with a standard error of 29 square feet. No correlations could be found relating this wide variability of volume and basal area to measurable environmental factors. Pine site index averages 67 with a standard error of 10. Again, no correlations could account for this variability. The basal area volume value was 28 with a standard error of 3 cubic feet. These values, due to their large standard errors were not significantly different from most other Pinus ponderosa associations.

Herbage production averages 172 pounds with a standard error of 24 pounds. This is the lowest production for any forest association studied. No correlations could be found accounting for the variability.

Table 4 lists the classification of decreasers and palatable increasers. Note the difference in classification for Sitanion hystrix, Carex rossii, and Stipa occidentalis. In this association, they are classified as decreasers along with Purshia tridentata and Cercocarpus ledifolius. The palatable increasers are Poa secunda and Poa nervosa. In general, this association is lower in palatability than other forest or non-forest associations except Pinus ponderosa/Festuca idahoensis.

In poor condition, stands of this association appear as closely hedged Purshia tridentata growing on a forest floor dominated by tree needles.

Pinus ponderosa/Festuca idahoensis association

Cubic foot volume of the Pinus ponderosa/Festuca idahoensis association averages 4,800 cubic feet with a standard error of 1,300 cubic feet. This is significantly higher than the Pinus ponderosa/Purshia tridentata/Sitanion hystrix association, not different from the Pinus ponderosa/Carex geyeri association, and highly significantly lower than the Abies grandis associations (Table 5). The average of 28,000 board feet was not significantly different from the other climax pine associations. However, all the climax pine associations were significantly lower than the Abies associations. Several correlations were attempted in the Pinus ponderosa/Festuca idahoensis association to relate board foot or cubic foot volume to measurable environmental factors such as soil depth but none were significant.

Basal area averages 130 square feet per acre. Neither basal area nor tree stocking was significantly different from the other climax pine associations. Number of trees per acre greater than seven inches DBH averaged 45 with a standard error of 23 and was not significantly different from the other climax pine associations or from the Abies grandis/Calamagrostis rubescens association. It was significantly

Table 5. Means and standard errors of selected items on ten associations.

Item	Arri/ Pose	Arar/ Feid 1/	Arar/ Agsp	Pipo/ Putr/ Agsp 1/	Pipo/ Putr/ Sihy	Pipo/ Feid	Pipo/ Cage	Abgr/ Caru	Abgr/ Brvu	Pico/ Vasc/ Caru
					Association					
Stand volume per acre										
1000 board feet				¼-9	19±8	28±17	20±9	49±16	48±22	
100 cubic feet				1-13	29±11	48±13	32±12	66±23	69±32	20±9
Basal area				13-47	101±29	131±45	118±31	184±53	211±74	98±43
2/ Basal area/volume value				8-27	28±3.0	34±3.5	29±3.1	38±3.2		
Stocking per acre										
Less than 6 inches DBH				40-130	520±244	497±45	420±327	247±151	390±288	597±285
Larger than 6 inches				15-25	53±26	45±23	74±41	63±21	105±36	165±97
Site index										
Pinus ponderosa				70	67±10	68±7	63±4	77±8		
Pseudotsuga mensiezii								85±8		
Abies grandis								93±6	75±10	
Pinus contorta										66±7
Tree crown cover in percent				4-12	42±4	41±7	49±15	72±22	83±21	65±9
Pounds of herbage per acre	144±53	210-305	512±118	250	172±24	284±91	326±81	347±159	208±287	258±59
Soil depth in inches	6.8±1.2	11-27	13±3.1	15-24	15±2.6	21±3.4	21±8.4	36±11	49±9	54±7

1/ Insufficient samples for determination of standard errors. Values given are ranges.
2/ Determined for *Pinus ponderosa* only.

lower than on the *Abies grandis/Bromus vulgaris* association.

The basal area-volume value was 34 cubic feet per square foot basal area with a standard error of 3.5 cubic feet. This value was not significantly different from the other climax pine associations but was significantly lower than that of *Pinus ponderosa* growing in the *Abies/Calamagrostis* association.

Pinus ponderosa site index averaged 68 with a standard error of 6.8. This again was not significantly different from the other climax pine associations but was significantly lower for *Pinus ponderosa* on *Abies/Calamagrostis*. Soil depth is significantly related to site index and accounts for 71 percent of the variability. Site index increases one foot with each inch increase in soil depth with limits from 18 inches to 30 inches soil depth. This correlation is highly significantly different from that obtained for *Pinus ponderosa* in the *Abies/Calamagrostis* association.

Herbage production averages 285 pounds with a standard error of 137 pounds. The variability was not related to tree crown cover but was highly significantly related to cubic foot volume which accounted for 86 percent of the variability in forage production. Each 1,000 cubic feet of volume reduces herbage production 100 pounds. This association was only one of two in which loop transect hits on herbage producing species was significantly correlated with herbage production. In this case, each hit represents 25.3 pounds of herbage, significant at the

98 percent level accounting for 36 percent of the variability between hits and herbage production. As one would expect, these hits on palatable species were significantly related to cubic foot volume. Each 1, 000 cubic foot of volume caused a reduction of 3. 5 hits and accounted for 75 percent of the variability in hits.

Classification of species according to their grazing reaction is somewhat difficult for this association. While Festuca idahoensis has some palatability for livestock, its palatability is rather low compared to other species growing in the study area. It was classified as a decreaser because of its dominance in the stand and because livestock have caused it to decrease under certain conditions. It is however considerably less palatable than the other decreasers listed in Table 4 for the association. These more palatable decreasers are Agropyron spicatum, Purshia tridentata, Carex geyeri, and Calamagrostis rubescens. In general, the Pinus ponderosa/Festuca idahoensis association is lower in palatability than any of the other forest associations.

In deteriorated condition, stands representing this association seem to violate the closed community concept because the forest floor tends to assume a litter covered, desert type of appearance rather than being dominated by an abundance of unpalatable vegetation. This lack of herbaceous vegetation is a serious handicap, particularly for the untrained eye, when one attempts to classify a forest stand in very poor condition into an association.

Some field evidence suggests that Festuca idahoensis growing in the Pinus ponderosa/Festuca idahoensis association is a different strain from that growing in the Artemisia arbuscula/Festuca idahoensis association. The Artemisia arbuscula strain weathers to a silver grey color, while Festuca growing with Pinus ponderosa weathers to a light yellow color. No other morphological characteristics could be found to support the thesis of genetic difference. There are, however, very significant differences in environment. Festuca growing with Artemisia arbuscula must tolerate full sunlight and wind desiccation as well as periodic soil moisture saturation. These factors are not present in the Pinus ponderosa situation. Landers (1958) and McMillan (1959) have found that less drastic environmental differences may be responsible for genetic selection in grasses. Bohmont and Land (1957) have shown a relationship between palatability and morphological characteristics no more dramatic than the dry color phase described above. The relative palatability of Festuca in this study could not be evaluated because the two associations in which it is important seldom occur side by side.

Pinus ponderosa/Carex geyeri association

As noted in previous discussions, board feet, basal area, site index and the basal area/volume value are not significantly different from other climax Pinus ponderosa associations. They are significantly different from the Abies grandis types. The averages are: 20,000 board feet per acre, 3,239 cubic feet per acre, 118 square feet basal area per acre, and a basal area/volume value of 29 cubic feet (Table 5). Pinus ponderosa site index averages 63 (Table 5).

Forage production averages 325 pounds per acre with a standard error of 81 pounds. None of this variability could be accounted for with tree cover, cubic volume, soil depth, or any other factor tested.

The dominant decreaser species in this association is Carex geyeri. When they occur, Purshia tridentata, Cercocarpus ledifolius, and Calamagrostis rubescens are also decreasers. Palatable increasers are Sitanion hystrix, Carex rossii, and Poa nervosa (Table 4). Under current Forest Service management, the Pinus ponderosa/Carex geyeri association is very resistant to grazing. During an average growing season, 40 to 50 percent use of Carex geyeri results in a stubble height of about one and one-half inches. This corresponds roughly with the height to which cattle will graze freely. Thus, Carex geyeri is seldom overused, a factor apparently fostering improved range condition since reduction of livestock numbers in the 1930's. This is fortunate because Pinus ponderosa/Carex geyeri is the most palatable forest association in the study area. It ranks very close in palatability to Artemisia arbuscula/Agropyron spicatum. Where stands of these associations are adjacent, which is common, livestock seem to spend the spring and early summer on the Artemisia arbuscula/Agropyron spicatum association and then voluntarily move into Pinus ponderosa/Carex *geyeri* as the season progresses.

In poor condition, one is impressed by the cinnamon red bark pine growing on a desert of pine needles. This association, like other forest associations in the study area, appears to violate the closed community concept in subordinate vegetation. However, it is most probable that *Pinus ponderosa* utilizes the moisture made available by the lack of herbaceous vegetation.

Summary of Climax *Pinus ponderosa* associations

Tree Growth. The *Pinus/Purshia/Agropyron* association was excluded because of insufficient samples. Analysis of height and age data of the other associations revealed two interesting phenomena. First, regeneration tends to occur at 15- to 25-year intervals. Second, the reproduction under stands of 40 to 50 percent crown cover is growing very slowly. Summer insolation under these conditions is 70 to 30 percent of full sunlight measured with an incident light meter and should be adequate for normal growth (Curtis and Lynch, 1957).

In general, about 450 trees per acre less than six inches DBH are present with an overstory of 45 to 70 trees per acre over seven inches DBH. Considering all diameter classes, these stands are stocked at approximately 80 percent of normal according to Meyer (1938). Increment borings of old growth trees indicate 10 to 15 rings per inch in the center of the tree. Saplings on these same sample plots showed an average of 40 to 60 rings per inch. A majority of Pinus ponderosa saplings had grown only six to eight feet in height at 40 years of age.

Tree Stocking. This slow sapling growth suggests that Meyer's (1938) Stand and Stock Tables are not suitable. Climax pine sites with their shallow soils are fully occupied by trees when crown cover reaches about 45 percent (Berndt and Gibbons, 1958; Curtis, 1961; Barrett, 1965).

To obtain satisfactory growth of reproduction, a wide spacing would be essential. This would probably not only entail reducing overstory crown canopy below 45 percent, but also maintenance of a wide spacing in reproduction. An indication of this spacing may be inferred from the forms of mature and over mature trees which suggest that pristine stands developed under very open stocking (Figure 12) (Weidman, 1921). In many cases, branches two to three inches diameter inside bark may be found 10 to 15 feet above the ground. These branches could not have grown to this diameter if the stand had developed under the classical concept of normal stocking. It would appear that a stand currently containing 60 to 70 trees over 7 inches DBH had grown most of its life at about this density as a result of periodic thinning by ground fires. Current reproduction density is probably the result of fire control. In many cases trees 7-18 inches DBH were growing satisfactorily (12 to 20 rings per inch) only in stands of 45 percent crown cover or less. Where crown cover was above 50 percent all trees in the stand had 30 or more rings in the outer inch. Studies of *Pinus ponderosa* thinning tend to support these findings (Weidman, 1921; Wilson, 1951; Roe, 1952; Barrett, 1965).

Recommendations for stocking require a definition of forest management objectives. For purposes of illustration, assume pulpwood, dimension stock logs, and commercial saw logs as products from a three-cut, 120-year rotation. Under these conditions, initial stocking should be about 150 well established trees. Pulpwood harvest should remove about 50 trees and the intermediate cut should remove an additional 50 trees leaving about 50 free to grow into sawlogs. These sawlog trees would require pruning for quality.

Abies grandis/Calamagrostis rubescens association

Stand volume is significantly higher than climax *Pinus ponderosa* associations (Table 5). Averages per acre are 49,000 board feet, 6,638 cubic feet, and 184 square feet basal area. Tree crown cover averages 72 percent which varies widely according to seral conditions. While stocking is quite similar to climax *Pinus ponderosa* associations, the greater volume is accounted for by increased basal area and a significantly higher basal area/volume value. This value averages 38 cubic feet per square foot basal area with a standard error of three cubic feet.

Pinus ponderosa site index averages 77 with a standard error of

8.5 and is significantly higher than its site index in climax pine associations. It is highly significantly related to soil depth where each 2.6-inch increase in soil depth increases pine site index by one foot with limits at 18 inches and 55 inches of soil depth. This correlation accounts for 26 percent of the variability in *Pinus ponderosa* site index and has a standard error of 56 percent of the mean for a sample of 20 observations. When data from the *Pinus ponderosa*/*Carex geyeri* association is combined with the *Abies*/*Calamagrostis* association, sample size increases to 28 observations which should increase accuracy by 13 percent. Instead, accuracy is about doubled: 52 percent of the variability in site index is accounted for and the standard error of the mean is reduced to 37 percent. In this correlation of combined associations, each 1.7 inches of soil increases pine site index by one foot. It is highly significantly different from a similar correlation in the *Pinus*/*Festuca* association. This suggests a continuum effect of environment on tree growth both within and between closely related associations. It also demonstrates differences between dissimilar associations.

Since combining the *Pinus*/*Carex* with the *Abies*/*Calamagrostis* increased site index correlation accuracy, these two associations were again combined in relating basal area/volume values to *Pinus ponderosa* site index. This correlation showed that each 10-foot increase in site index increased the basal area/volume value by

5.46 cubic feet per square foot basal area. It accounts for 52 percent of the variability in the basal area/volume value for Pinus ponderosa and was significant at the 99.9 percent level.

Site index for Pseudotsuga menziesii averaged 85 with a standard error of 7.6. For Abies grandis it averaged 93 with a standard error of 6.5. The Abies grandis site index was significantly higher than Pinus ponderosa site index. Analysis of diameter and height increment of fir saplings further demonstrates their superior growth rate compared to Pinus ponderosa (Gedney, 1959). Unfortunately, there was an insufficient distribution of Pseudotsuga and Abies for developing significant correlations with soil.

Old growth Pinus ponderosa apparently developed under open stocking conditions. This is indicated by large lower limbs and a crown canopy seldom exceeding 50 percent in these stands (Figure 12). Stand development seems to have been similar to climax Pinus ponderosa associations (Weidman, 1921).

Pinus ponderosa reproduction seems to be mainly from individual seed rather than from rodent caches as in the climax pine associations. Under existing tree cover it grows very slowly often averaging 30 to 40 rings per inch and two to four inches height per year. In all cases, both Pseudotsuga and Abies reproduction grows considerably faster in both height and diameter than Pinus ponderosa. Optimum growth of Pinus ponderosa could probably be attained with a sliding scale of tree stocking in relation to site index and soil depth. Table 6 lists stocking recommendations for a three-cut, 120-year rotation. The table is based upon adaption of Barrett's findings (1965) and Meyer's (1938) stand and stock tables modified by tree growth data collected in the study area.

Pinus ponderosa growing in the Abies/Calamagrostis type is probably a different genetic strain from that in climax pine associations (Callahan and Liddicoet, 1961; Squillace and Silen, 1962). In fact, it may be genetically different in each of the climax pine associations (Mason and Langenheim, 1961). These genetic differences may be important for reforestation.

Pseudotsuga menziesii often dominates fir reproduction in the East and West Ochoco areas. It is followed closely in density by Abies grandis. The Snow Mountain area is a notable exception because Abies grandis clearly dominates all fir reproduction. In this area, Pseudotsuga is significantly lacking, even on the shallower residual soils within the Abies/Calamagrostis association. Pseudotsuga reproduction grows well at higher stocking density than is suitable for Pinus ponderosa. Stocking recommendations based on soil and site index for a three-cut, 120-year rotation are contained in Table 6.

Table 6. Recommended stocking in the _Abies grandis/Calamagrostis rubescens_ association for a three-cut, 120-year rotation.

	Site Class		
	III	II	I
	Site 66-73	Site 74-80	Site 81 +
Stocking	Soil depth 18-24"	Soil depth 25-40"	Soil depth 40"+
Pinus ponderosa			
Initial	170	210	250
Pulp cut residual	115	140	170
Pole cut residual (sawlogs)	55	65	75
Abies grandis and _Pseudotsuga menziesii_			
Initial	200	250	300
Pulp cut residual	130	170	200
Pole cut residual (sawlogs)	65	75	100

Abies grandis reproduces well under Pinus ponderosa and Pseudotsuga menziesii. Reproduction often grows at the rate of 12 to 18 inches in height per year and 10 to 15 rings per inch. This growth rate seems to be maintained to an 18 to 24 inch diameter. Stocking recommendations are the same as for Pseudotsuga menziesii (Table 6).

Unfortunately, heartrot is a serious problem with Abies grandis (Hubert, 1955; Foiles, 1959; Gedney, 1959; Maloy and Gross, 1963). In the Abies/Calamagrostis association, heartrot develops at a very early age, usually about the time heartwood forms. This will probably modify harvest methods for Abies grandis. A strong possibility exists that heartrot losses may preclude growing Abies to commercial saw log size (Young, 1965).

Herbage Production. Herbage production averages 347 pounds per acre with a standard error of 159 pounds. Much of the variability is inversely related to tree cover. A highly significant straight line correlation with limits of 40 and 110 percent tree cover showed that each 10 percent increase in tree cover reduced production 39 pounds and accounted for 31 percent of the variability in herbage production. Young (1965) working in the foothills of the Wallowa Mountains, Oregon, found a similar straight line correlation where each 10 percent increase in tree cover reduced herbage production about 40 pounds. Both these correlations are different from those developed by Pase

(1958) in the Black Hills who found a curvilinear relationship between tree cover and herbage production. Several curvilinear correlations were automatically evaluated through automatic data processing but were not significantly more accurate than the straight line correlation.

Optimum production is about 500 pounds under 40 to 50 percent crown canopy of Pinus ponderosa on three feet of soil (Figure 12). Production is generally lower on shallower soil. Minimum production occurs under dense fir and seldom exceeds 50 pounds (Figure 13). Decreaser plus palatable increaser loop transect hits are highly significantly related to herbage production. Each hit represents about 45 pounds production and accounts for 58 percent of the variability between hits and production.

Species Reaction to Use. Important decreasers are Calamagrostis rubescens and Carex geyeri. Under moderate tree cover these species dominate the subordinate vegetation and supply a majority of the herbage. Palatable increasers include Lupinus caudatus, Carex rossii, and Poa nervosa. Since cattle graze freely to a stubble height of about two inches, moderate overuse may cause Calamagrostis to decrease prior to Carex geyeri because Calamagrostis average proper use stubble height is between three and four inches compared to one and one-half for Carex. In poor condition the Abies/Calamagrostis association is characterized by a litter covered soil surface under open tree canopies. The community is not usually closed by herbaceous species. It may be dominated by Arnica cordifolia and Fragaris species under denser tree cover.

Classification Problems. Calamagrostis rubescens and Carex geyeri, which usually dominate subordinate vegetation, are classified as decreaser species (Table 4). The percent composition and hits on decreasers combined with palatable increasers are highly significantly associated with tree cover. Each 10 percent increase in tree cover reduces the percent composition of decreasers and palatable increasers by 3.1 percent and accounts for 32 percent of the variability in composition. Each 10 percent increase in tree cover reduces hits on decreasers plus palatable increasers by one and accounts for 31 percent of the variability.

The correlation of decreasing Pinus ponderosa cover with increasing fir, and the correlation of increasing tree cover with decreasing hits and composition of decreasers and palatable increasers demonstrates what might be termed a "successional continuum." In addition, these correlations illustrate the difficulty of classification and evaluation of apparently undisturbed plant communities. Finally, these correlations demonstrate the need to separate the "successional continuum" from the continuum in climax vegetation caused by variations in climate and soil. This is one of the most important reasons for basing vegetation classification on the climax concept rather than existing vegetation.

The Abies/Calamagrostis association is an illustration. Using existing vegetation, one could develop a beautiful continuum curve supported by mathematical analysis showing a gradual transition from the Pinus/Carex association to dense Abies. However, there are several very important things it would ignore. First, one does not find a continuum gradation on the ground from Pinus/Carex on residual soil to the Pinus with Pseudotsuga, Calamagrostis, and Carex on slightly deeper residual soil. In all cases, stands of the Pinus/Carex association and stands of the Abies/Calamagrostis association on residual soil are separated by elevation and distance even though they are closely related on a continuum gradient. When stands of these associations are adjacent, they are characteristically separated by soil differences and ten to exhibit rather sharp transitions from one stand to another.

Second, a continuum gradient based upon existing vegetation would fail to emphasize the successional nature of Pinus ponderosa in the Abies/Calamagrostis association, and the successional change in subordinate vegetation with increasing tree cover. Both of these changes in vegetation are dynamically active on specific acres of ground. In contrast, the continuum gradient based upon existing vegetation simply states that different acres of ground are floristically related. These two concepts are different. The former describes active change: the latter static relationship. A continuum gradient based upon existing vegetation clearly does not imply that differences in vegetation on this curve can apply to a single acre of ground; rather it states that these conditions are found on different acres of ground.

Third, and most important, a continuum gradient based upon existing vegetation fails to provide the land manager with an understanding of vegetation dynamics. This understanding is essential for analysis and management of forest and range lands.

Abies grandis/Bromus vulgaris association

Tree volumes per acre average 48,000 board feet, 6,111 cubic feet, and 211 square feet basal area which are not significantly different from the Abies/Calamagrostis association (Table 5). However, Abies grandis site index is 75 which is significantly lower than its site index in Abies/Calamagrostis. Stocking in the 7 inch DBH and larger class seems to be somewhat higher in the Abies/Bromus association. This is due to the successional status of some stands which contained few mature and over mature trees.

Heartrot is present in Abies grandis in this association but is less serious than in Abies/Calamagrostis. Many sound trees may be found having diameters greater than 24 inches.

Stocking recommendations are similar to those in the Abies/Calamagrostis association for the high site, deep soil conditions.

Based on a three-cut, 120-year rotation, initial stocking should be around 300 trees per acre. About 200 trees per acre should remain after the first cut and 100 trees after the second cut. These would be primarily for dimension stock and saw logs if quality would permit.

The Abies/Bromus association is not generally well suited for livestock grazing but it is often an important summer range for elk and deer. Average herbage production is 208 pounds with a standard error of 287 pounds. This wide standard error is due to combining seral and climax data. In a number of cases no herbage production could be measured in climax stands. Production under 60 to 80 percent tree crown cover may be 400 to 500 pounds composed primarily of Bromus vulgaris, Calamagrostis rubescens, Lupinus latifolius, and Carex geyeri.

Pinus contorta/Vaccinium scoparium/Calamagrostis rubescens associes

Board foot volume was not computed for this associes because Pinus contorta seldom attains saw log size. Cubic volume averages 2,000 cubic feet which is quite low for such a productive site. Basal area is only about 98 square feet per acre. Site index for Pinus contorta averages 66 with a standard error of 7.3 (Table 5).

Forest management objectives must be defined for this associes. If maintenance of Pinus contorta is desired, pulpwood would probably be the major product. Assuming a two-cut, 60-year rotation, initial stocking should be about 300 trees per acre with 150 trees remaining after the first cut.

Herbage production averages 258 pounds and is composed primarily of Calamagrostis rubescens. Where topography is suitable, stands of this associes may be used for livestock grazing, but in the study area it is used mostly by elk. Calamagrostis rubescens has been classified as a decreaser. Palatable increasers may be Lupinus caudatus, Hieracium albiflorum, and Lupinus latifolius. The reaction of palatable increasers depends upon the kind of grazing animals. If elk and deer are prevalent, Hieracium albiflorum and possibly Lupinus caudatus would become decreasers. In poor condition, this associes is generally dominated by Vaccinium scoparium, Fragaria species, and Arnica cordifolia.

Mapping

Mapping of vegetation meets the initial criteria of land management, that of resource inventory. This inventory requires at least two kinds of maps. A vegetation type map depicts existing vegetation and a basic vegetation map shows the kind, amount, and location of various vegetation associations (Appendix G).

Basic Vegetation Map

Since vegetation classification is essential for development of the basic map, management criteria should be given some consideration in the classification system. For example, Abies/Calamagrostis exhibits the widest variation in environmental factors and has significant correlations between tree growth and soil. This association has been divided into three site classes: I. represents soil over 40 inches deep and site index of 81 or better; II. represents 25 to 40 inches of soil and site index of 74 to 80; III. represents 18 to 24 inches of residual soil and site index of 66 to 73. Recall from Table 6 that tree stocking recommendations are different for each site class. The basic vegetation map in Appendix G delineates these site classes for the Abies/Calamagrostis association.

The basic vegetation map, in conjunction with descriptions and characteristics of each vegetation association, presents a graphic illustration to the land manager of his vegetation resource and a general picture of soil types.

A standard procedure in land management is to assign color designations to similar vegetation as an aid in map interpretation. The basic vegetation map has a color system depicting different associations. For instance, Artemisia rigida/Poa secunda is white, Artemisia arbuscula/Agropyron spicatum is yellow, climax pine associations are light green, Abies/Calamagrostis is medium green, and Abies/Bromus is dark blue-green.

Vegetation Type Maps

In many cases existing vegetation is not in climax condition. The land manager must have a map of this existing vegetation for it will indicate to him what products he may harvest, and, to a certain extent, how he can harvest them. To aid this harvest, association type lines on the basic vegetation map are reproduced on vegetation type maps. Where existing vegetation is significantly different from the descriptions of an association, additional type lines should be drawn. Appendix G shows a range type map and a timber type map as illustrations.

Application in Forest Management

Timber management must consider future stand composition as well as harvestable trees. For instance, when the timber type map is compared to the basic vegetation map (Appendix G), the forester may quickly determine the trend of his forests and their potential tree cover. This is very similar to analysis of trend in range management. Notice the preponderance of the *Abies*/*Calamagrostis* association on the basic vegetation map and the preponderance of saw log size *Pinus ponderosa* on the timber type map. Where *Pinus ponderosa* is dominant, it has been colored light green on the timber type map. In comparing these maps, one can clearly see that most of the lower elevational *Abies*/*Calamagrostis* association is still in the *Pinus* ponderosa/Calamagrostis rubescens fire climax stage of succession.

Density and species of reproduction are also noted on the timber type map. This information is essential in planning timber sales and timber stand improvement. It is also a reason why all association type lines present on the basic vegetation map also occur on the timber type map even though, for harvest purposes alone, many of the type lines could be eliminated. Adequate stocking guides depend upon the ecological characteristics of each association and the three site classes within Abies/Calamagrostis. Stocking notations on the timber type map are based upon these recommended stocking guides.

For instance, in sections 7 and 8, T15S, R25E, Pinus ponderosa is dominant. In referring to the basic vegetation map, notice that part of section 7 contains Abies/Calamagrostis of site I and II quality. Pinus/Carex is adjacent in section 8. These require three different stocking appraisals. Site I in Abies/Calamagrostis is properly stocked at about 250 trees per acre, Site II is properly stocked at about 210 trees per acre, and Pinus/Carex is properly stocked at about 150 trees per acre. Thus, association type lines are essential for interpretation of stocking notations on the timber type map.

Application in Range Management

Range management also requires a map of existing vegetation conditions and an inventory of this vegetation. Here, too, additional type lines are often necessary within an association. For instance, the Artemisia arbuscula/Agropyron spicatum association east of the Ranger Station has been divided into three units on the range type map. One unit, blue in color, indicates primary cattle range that is in good condition. Another unit, orange in color, depicts primary cattle range in fair condition. A third unit, white in color, depicts secondary range in good condition.

In this case, map coloration has nothing to do with vegetation. It is used to emphasize primary range as an aid in depicting livestock distribution. Knowledge of animal distribution is an important criteria in devising improved management systems. Note also that grey has been used to indicate unsuitable range. In some cases the range is unsuitable due to dense reproduction. Comparison with the timber type will demonstrate that the unsuitable area north of the Ranger Station is overstocked with Pinus ponderosa reproduction. On the other hand, it may be unsuitable due to low herbage production. This is illustrated on Wolf Mountain where the Artemisia tridentata var. vaseyana/Carex species association is in very poor condition.

Once the land manager has surveyed existing vegetation and appraised its condition, he should determine the long term potential vegetation and carrying capacity on his management area. This is one of the primary reasons for a basic vegetation map depicting climax vegetation. For instance, the basic vegetation map in Appendix G shows that approximately one-third of the forest range is climax Pinus ponderosa. The rest is the Abies/Calamagrostis association which, according to the forest type map, is largely dominated by Pinus ponderosa. Much of the primary Abies/Calamagrostis range is well stocked with Pseudotsuga and Abies reproduction. Characteristics of the Abies/Calamagrostis association suggest that increasing tree cover due to fir reproduction decreases subordinate vegetation.

By comparing the three maps in Appendix G, the range manager can quickly see that almost half of his current primary range will gradually diminish in herbage production. This, of course, is an important consideration in formulating long-term management plans. Not only will a large portion of this primary range deteriorate for livestock use, but most of his secondary range, which at the present time could be used for increasing livestock numbers or improving distribution, will also diminish in herbage production. If current successional trends continue, future animal production will be greatly reduced.

The range manager, in this case, cannot be satisfied with management planning designed simply to manipulate animals for an upward trend of existing vegetation. In forested range, he must consider forest succession, logging methods and long term timber management objectives.

The importance and usefulness of maps illustrates an important consideration in ecological philosophy. Note on the maps in Appendix G that each and every acre had to be classified into an association or vegetation type. There are no intergrades delineated on these maps. This demonstrates that classification of vegetation, when used for land management, must be developed on the basis of plant community groups. Division into groups is accomplished by studying variability within the entire area of application (Ellenberg, 1956; p. 37, p. 102).

Application in Forest Management

Silviculture

Plant ecology is the basis for silvicultural methods (Lutz, 1959; Curtis, 1961). Consideration is given to climax, succession, and the influence of subordinate vegetation (Pearson, 1942). These silvicultural characteristics can be most expeditiously investigated, described and characterized if vegetation is classified into associations or groups of similar associations.

For instance, methods for maintenance of Pinus ponderosa on climax pine associations would be different from those for maintenance of pine on associations where it is successional. Pine could be maintained on the climax associations described in this study by a wide variety of silvicultural treatments. They could range from high risk cutting of one or two trees per acre to clearcuts of 30 acres. The entire gamut of harvest methods was observed on the study area and all these methods showed satisfactory regeneration of pine. The forester may select the method which best fills his harvest needs. However, more intensive investigation might show that different kinds of subordinate vegetation influence the frequency and rate of seedling establishment. One may then prescribe certain site preparation techniques according to each association.

Silvicultural methods for the Abies/Calamagrostis association could be quite different from those suitable in climax pine associations. First, one has a selection of three important trees. Second, each of these trees differ in their silvicultural characteristics (Haig, et al, 1941; Curtis and Lynch, 1957; Foiles, 1959). Third, these trees differ in their individual growth rates and in their optimum stocking density. The silvicultural treatment would have to be chosen after careful analysis of economics and selection of the species to encourage.

For example, one may wish to grow high quality Pinus ponderosa sawlogs. In the Abies/Calamagrostis association, Pinus is a successional species requiring abundant sunlight for reproduction and a rather wide spacing for satisfactory growth. In old growth pine stands harvest cutting would probably be limited to large group selection, shelterwood, or seed tree clearcutting followed by removal of fir reproduction. A rather open canopy of 40 to 60 percent should be maintained to discourage fir reproduction and encourage pine growth. Periodic removal of fir reproduction would probably be required at

20- to 30-year intervals. In addition, sawlog crop trees would require pruning for optimum quality.

Should one wish to encourage nearly pure stands of Abies grandis, silvicultural treatment would have to be quite different. Although methods would depend upon existing vegetation, the principle would be the same. To prevent Pinus and Pseudotsuga reproduction, a nearly closed crown canopy would have to be encouraged or maintained. In near climax stands individual tree selection or small group cuttings would probably be most desirable. While this does not preclude thinning of overly dense reproduction, large openings or open crown cover should be avoided since these conditions appear quite suitable for Pseudotsuga establishment.

A mixed stand of fir with occasional pine would probably offer the widest selection of silvicultural treatments. In general, one could probably encourage any of the three species by manipulation of crown cover and species selection in thinning.

In the Abies/Bromus association, the forester has four tree choices, all of which have different silvicultural characteristics. They are Abies grandis, Pseudotsuga menziesii, Larix occidentalis (Boe, 1958) and Pinus contorta (Tackle, 1959). He may also encourage Picea englemanni in some situations. Silvicultural treatments for fir would probably be similar to those suggested for the Abies/Calamagrostis association. In addition, small shelterwood or clearcut methods might be suitable if *Larix* and *Pinus* seed sources are remote.

For the *Pinus contorta*/*Vaccinium scoparium*/*Calamagrostis rubescens* associes, management objectives must be defined before a silvicultural system may be developed. *Pinus* may be maintained if the crown cover remains open and fir reproduction is periodically removed. Clearcutting and burning seem to be the best method of maintaining *Pinus* (Trappe and Harris, 1958). Should one wish to convert to fir, light cuts or clearcutting without burning appear desirable (Trappe and Harris, 1958).

In general, definite silvicultural suggestions are difficult to present since the methods will depend upon the existing overstory, age, and soundness of the trees, species composition of the reproduction, and land management objectives. The forester often has a rather wide choice of systems. He should use or modify these to meet his management objectives.

Forest Management

Ecological analysis of associations and inventory of existing versus potential vegetation materially aid the forester's difficult problem of defining management objectives. For the *Abies*/*Calamagrostis* association he must consider the present value of existing vegetation, such as *Pinus ponderosa*, the future values of other trees which he may grow such as *Abies grandis* and *Pseudotsuga menziesii*, and the cost of maintaining the most desirable products from the area. The cost of maintaining Pinus ponderosa on an Abies/Calamagrostis site would be considerably more than on a climax pine site. This must be balanced against superior growth and quality of pine on the Abies/Calamagrostis site, the greater animal capacity with pine instead of fir, and increased water production with pine.

Even though timber is the most important product of forested range in the study area, the forester must view his silvicultural and harvest methods in light of their influence on range management. Again, characteristics of associations and maps of current and potential vegetation materially aid his decisions. In making these decisions he must consult the range type map as well as his timber type map and the basic vegetation map. This is an important consideration on the Ochoco National Forest because roughly two-thirds of the forested range land is Abies/Calamagrostis which is now in a successional stage of Pinus ponderosa. This stage supports a majority of the grazing on this forest.

Reforestation

Characterization and mapping of associations are also important in reforestation. Selection of species and strains within a species should be based upon associations (Callaham and Liddicoet, 1961; Squillace & Silen, 1962). For instance, if one should clearcut and plant in the *Abies/Bromus* association, he would be well advised to use *Larix occidentalis* rather than *Pinus ponderosa* because sites that support this association are apparently not suitable for *Pinus ponderosa*.

On the other hand, he should select dry land strains of *Pinus ponderosa* for planting on climax pine sites, and more mesic strains for planting on *Abies/Calamagrostis* sites. The best procedure would be to collect seed from the specific vegetation to be planted.

Application in Range Management

Development of Condition and Trend Guides

Guides for evaluation of range condition and trend are a necessary tool for the wild land manager. They have two primary functions: First, they describe the vegetation which is climax under specified soil and climatic conditions, or the potential under existing tree cover on forested range. This offers the land manager a basis by which he may appraise the carrying capacity, the season of use, and the type of animal best suited for the vegetation. Second, they serve as a guide for evaluating existing vegetation and its successional status in relation to climax or the potential under existing tree cover. This information is essential for appraising current management practices and prescribing modifications leading to improvement of the vegetation and increase of capacity.

These condition and trend guides are most accurately developed when based upon vegetation associations.

The United States Forest Service has designated five range condition classes. These classes are arbitrarily divided into equal 20 percent increments based upon the proportion of decreaser and palatable increaser species in climax. In this way, excellent condition encompasses 80 to 100 percent of the composition and density of decreasers and palatable increasers in climax and represents little or no over grazing; good condition encompasses 60 to 79 percent and represents moderate over grazing; fair condition 40 to 59 percent and represents prolonged over grazing; poor condition 20 to 39 percent representing severe over use; and very poor condition 0 to 19 percent representing destruction of decreaser and many palatable increaser species.

The above system has certain disadvantages among which are the arbitrary division of condition classes and the omission of range trend from the condition class rating. However, it does have several distinct advantages for land management agencies with modestly trained and experienced personnel. Compared to many other systems, the concept of successional condition classes is easiest to understand, simplest to apply in the field, and most easily used in appraisal and development of management plans. It is understood by ranchers using the range and has been accepted by courts hearing grazing appeals.

These are some of the reasons why development of condition and trend guides have followed current Forest Service condition class nomenclature. Alteration of the arbitrary 20 percent condition classes is not possible at the present time because suitable data from over used range is not available.

Prior to discussion of condition and trend guide development, certain characteristics of the loop transect method should be clarified. Plants which fall inside the three-quarter inch loop are recorded as hits and are an index, but not an absolute measure, of plant basal area. These hits have generally been found to lack precision (Johnson, 1957; Hutchings and Holmgren, 1959; Smith, 1962). The method is greatly improved in accuracy and sensitivity when supplemented by recording the nearest perennial to a loop that does not hit a plant. Since 100 observations are made along a 100 foot line, the combination of hits and nearest perennial tallies will total 100. The sum for each species will be its percent composition.

The notation of nearest perennial is a plotless technique. Therefore, it is sensitive to numbers of plants per unit area and distribution of the plants. As a result, it lacks the descriptive character found in weight, volume, or crown cover methods. It does not measure the amount of ground occupied by plants, only their relative abundance. Hits offer an index to ground occupied by plants. These characteristics do not detract from the method's usefulness. It is still sensitive to changes in vegetation (Parker and Harris, 1959). One must understand that changes in percent composition represent changes in relative abundance of species and do not necessarily represent an increase in absolute numbers of one species and a decrease in another. For instance, *Agropyron* may be 40 percent composition and *Poa* 60 percent in excellent condition. With over grazing the composition may change to 10 percent *Agropyron* and 90 percent *Poa*. In many cases this represents a 75 percent reduction in the number of *Agropyron* plants and only a slight increase in the number of *Poa* plants. Hits are then evaluated for an indication of the change in basal area of *Agropyron* and *Poa*. Frequency methods using small plots tend to give similar results.

Accurate numerical data is essential for development of condition and trend guides. These data should be collected on excellent condition range encompassing as much environmental variability as possible. In this way, a measure of the diversity in field conditions is obtained. With this measure the land manager can determine the accuracy of data for each association and its reliability for development of condition and trend guides. He often has an opportunity to refine data by correlation with measurable environmental factors. The objective is to prepare a guide that will permit the land manager to accurately evaluate his range resource.

Condition and trend guides are developed around three criteria:

species composition, species hits, and plant vigor. These three criteria are given different weights based upon their accuracy in indicating range condition. Table 7 shows the variability in hits and composition for classes of species according to their reaction to grazing in seven associations. In most cases, composition is three to five times more accurate than hits. For this reason, composition accounts for 80 percent, hits 15 percent, and vigor 5 percent of the condition rating. Vigor is limited to about 5 percent because it is entirely subjective.

Minimum accuracy for a condition and trend guide should be a standard error of 10 percent of the mean for hits and composition of species or groups of species in the association. This 10 percent standard error encompasses one condition class of 20 percent. It means that in two cases out of three, any stand in the association has the potential of reaching some numerical position in excellent condition. Note in Appendix A that species composition is quite variable. Grouping species by reaction to grazing tends to reduce variability (Table 7). However, the standard errors shown in Table 7 are often greater than 10 percent. This variability represents the natural variation found in the associations and poses a distinct problem for development of condition and trend guides. For example, the Pinus ponderosa/ Carex geyeri association has an average decreaser composition of 70 percent with a standard error of 25 percent of the mean. If 37

Table 7. Numerical data for development of condition and trend guides based upon means and percent standard errors. Data presented represent top range condition.

Item	Arri/ Pose	1/ Arar/ Agsp	1/ Pipo/ Putr/ Sihy	Pipo/ Feid	Pipo/ Cage	1/ Abgr/ Caru	Pico/ Vasc/ Caru
Decreaser Species							
Number of hits	19±30%	14±36%	17±48%	11±63%	18±40%	10±35%	9±44%
Percent composition	86±9%	45±42%	50±38%	68±12%	70±25%	75±21%	63±44%
Palatable increasers							
Number of hits	2±100%	5±60%	2±86%	2±100%	2±110%	1±200%	5±66%
Percent composition	8±62%	35±9%	30±73%	18±49%	18±53%	8±80%	22±49%
Unpalatable increasers							
Number of hits	0	3±150%	0	2±85%	2±110%	1±200%	0
Percent composition	2±110%	19±99%	20±60%	15±24%	15±72%	18±67%	15±80%
Combination of decreasers and palatable increasers							
Number of hits	21±31%	18±38%	19±36%	13±31%	20±41%	10±36%	15±37%
Percent composition	93±11%	72±20%	81±12%	82±8%	86±11%	81±18%	86±12%
Shrub cover	10±55%	11±79%	11±56%		15±78%		3±88%
Total hits	21±24%	22±27%	20±38%	15±46%	23±35%	12±41%	13±28%

1/Correlation analysis increases numerical accuracy.

percent composition (70 x .25 = 17.5; 70 + 17 = 87 percent) is used as the 100 percent value in excellent condition, the natural variability within this association varies from a rating of 72 to 100. This represents a range from mid-good to top-excellent condition which is not accurate enough for condition and trend guides. It means that in only two instances out of three a stand in this association has the potential of reaching some numerical value between 72 and 100. Some stands may have a potential of only low-good condition.

Analysis of Table 7 shows that only two associations have percent composition standard errors which are low enough for accurate condition and trend guides. These are the Artemisia rigida/Poa secunda association for decreaser composition, and the Pinus ponderosa/Festuca idahoensis association for the combination of decreaser plus palatable increaser composition. Correlation analysis will permit reduction of variability to acceptable limits in the Artemisia/Agropyron, the Abies/Calamagrostis, and the Pinus/Purshia/Sitanion associations. The Pinus/Carex and the Pinus/Vaccinium/Calamagrostis associations have standard errors of decreaser plus palatable increaser composition that are only slightly larger than the established criteria. These could not be refined through correlation analysis. Note particularly that in no case were hits sufficiently accurate for sound condition and trend guide use.

A condition and trend guide is developed as follows. The three criteria of composition, hits, and vigor are handled separately. The average percent composition of decreasers and palatable increasers in the association is used as the basis for excellent condition. This percentage is then divided into five numerical groups corresponding to the five condition classes. Each group is given a rating value with a maximum of 80. This maximum rating of 80 corresponds to the 80 percent weighted value of composition. In summarizing composition, one may not count more than a certain percentage of palatable increasers and should not count composition of unpalatable increasers. The maximum permissible palatable increaser composition is the average percentage in the association. In this way, major emphasis is given to composition of decreasers.

Species hits are handled in the same way as composition. In this case, the maximum rating is 15 corresponding to the 15 percent weighted value of hits. The Pinus ponderosa/Festuca idahoensis association is given as an example in the following tables:

Composition of Vegetation. Count percent composition of decreasers and palatable increasers only. Disregard any percent above 18 percent for palatable increasers.

Decreaser plus palatable increaser composition	Rate	Condition
Over 82	64 - 80	Excellent
61-81	48 - 63	Good
40-60	32 - 47	Fair
20-39	16 - 31	Poor
0-19	0 - 15	Very poor

<u>Hits on Decreasers and Palatable Increasers</u>. Count hits on decreasers and palatable increasers only. Disregard any palatable increaser hits above 2.

Hits	Rate	Condition
Over 13	12-15	Excellent
9-11	9-11	Good
6-8	6-8	Fair
3-5	3-5	Poor
0-3	0-2	Very poor

No more than two hits and no more than 18 percent composition may be counted for palatable increasers. These values were obtained from Table 7 and represent the average number of hits and percent composition of palatable increasers in climax conditions. This limit is necessary because as decreasers are reduced in composition and density due to overgrazing, palatable increasers will increase in percent composition and possibly density. This change must be reflected in the rating scale. If decreasers have been completely eliminated, only 18 percent composition of palatable increasers may be counted even though their actual percent composition may greatly exceed this value. In this example, condition would rate 15 or very poor.

The final item used in determination of condition is plant vigor. This has been given an average rating value of five which represents vigor of decreaser plants in excellent condition. Ratings lower than five represent decreased plant vigor due to overgrazing. On the other hand, vigor may be rated higher than five, to a maximum of ten, when plants exhibit greater vigor than in climax situations. This higher vigor can only occur on deteriorated range where grazing use is light and plant competition is not so intense as in climax. These vigor ratings may be briefly summarized as follows:

Rate		
8-10	Maximum	Deteriorated range in maximum upward trend.
6-7	Good	Deteriorated range in moderate upward trend or range approaching excellent condition.
4-5	Average	Plant vigor on excellent condition range or on deteriorated range that does not exhibit a trend change.
1-3	Fair	Moderate down trend vigor which may exist in any condition.
-2-0	Poor	Maximum downward trend.

The main reason vigor has been given an average weight of five is due to the problem of correlating yearly fluctuations in growing conditions with a subjective estimation of vigor.

Condition is determined by adding together the rating values for composition, hits, and vigor as follows:

1. Rate composition (i.e. 65% rates 50)
2. Rate the number of hits (i.e. 10 hits rate 10)
3. Rate vigor (i.e. average vigor is 5)
4. Total the ratings
5. Read condition from the following scale:

   (i.e. 65 = good

   Excellent: 80-100; Good: 60-79; Fair: 40-59;

   Poor: 20-39; Very Poor: 0-19

This system may be used for decreasers in the Artemisia rigida/ Poa secunda association, and the combined values of decreasers plus palatable increasers in the Pinus ponderosa/Festuca idahoensis, Pinus ponderosa/Carex geyeri, and the Pinus contorta/Vaccinium scoparium/ Calamagrostis rubescens associations.

Modification is necessary when correlation analysis increases accuracy of numerical data. An excellent example is the Abies grandis/ Calamagrostis rubescens association.

In this case, the condition and trend guide cannot be based upon climax vegetation. Instead, the guide must reflect the maximum potential vegetation under existing tree cover. The correlation relating hits to tree cover will reduce the standard error in hits from 36 percent of the mean to 25 percent. The correlation of composition and tree cover will reduce the standard error of composition from 12 percent of the mean to 8 percent. While this does not reduce variability of hits to an acceptable minimum, it does refine composition data sufficiently to meet condition and trend guide criteria.

Tree cover is measured on three step transect lines by vertical intercept methods. Overstory and understory tree cover are measured separately, then added for total tree cover. In this way, one may obtain more than 100 percent cover. This does not mean that crown cover is totally closed. In many cases, overstory and reproduction are clumped permitting occasional light spots. This is why numerical criteria are valid in the category of 91 to 110 percent tree cover. Evaluation of percent composition and hits is presented in the following tables.

Composition of Decreasers and Palatable Increasers

Count percent composition of decreasers and palatable increasers only. Disregard any percent above 8 percent for palatable increasers.

Tree Cover				
Less 60%	61-90%	91-110%	Rate	Condition
over 90	over 80	over 70	64-80	Excellent
67-89	58-79	53-69	48-63	Good
44-66	38-57	35-52	32-47	Fair
21-43	18-37	17-34	16-31	Poor
0-20	0-17	0-16	0-15	Very Poor

Hits on Decreasers and Palatable Increasers

Count hits on decreasers and palatable increasers only. Disregard palatable increaser hits above 2.

Tree Cover

Less 60%	61-90%	91-110%	Rate	Condition
over 14	over 10	over 6	12-15	Excellent
10-13	8-9	4-5	9-11	Good
6-9	5-7	2-3	6-8	Fair
3-5	3-4	1	3-5	Poor
0-2	0-2	0	0-2	Very Poor

Similar treatment is possible in the *Artemisia arbuscula/Agropyron spicatum* and the *Pinus ponderosa/Purshia tridentata/Sitanion hystrix* associations.

Comments on Condition and Trend Guides. Ecological description, classification, and statistical analysis have shown that development of condition and trend guides requires consideration of both vegetation variability and measurable environmental factors. Natural variability in density and composition of vegetation, when evaluated on a numerical basis, introduces serious problems of accuracy in development of condition and trend guides. This variability is caused by the continuum nature of environmental influences on plant communities. It is a factor which must be recognized and dealt with intelligently.

It must be dealt with because the land manager must evaluate condition and trend of range areas that are being heavily used by livestock. These livestock care not whether they over graze communities typical of an association, communities representing intergrades between associations, or communities representing some variation in an association. A condition guide which is useful to the land manager must encompass all the variability possible to give him maximum opportunity to evaluate accurately whatever field condition he may encounter. Development of suitable condition and trend guides requires sampling variability and application of correlation analysis relating measurable environmental factors to the vegetation. The resulting guide often appears complex; but so is the interaction of vegetation and environment.

Range Trend. The first step in trend analysis is to appraise the successional status of the range area in question. If the condition guide rating is below excellent, one may be reasonably assured that some kind of range trend should be expected. It should be upward with proper management, remain static with slightly adverse management, and go down with improper livestock management. Excellent condition should not be expected to exhibit a trend caused by animals unless management is improper. Thus, correct appraisal of range condition is the cornerstone of trend interpretation, appraisal of current management practices, and evaluation of changes in management practices.

Direction of trend may be determined by evaluating the change in hits and composition of decreaser and increaser species over a five year or longer period. However, this evaluation is not simple. Range trend may be caused by: biotic influences, vegetation influences, erosion and growing conditions. Faulty site appraisal may influence interpretation of trend.

Faulty appraisal of the potential vegetation on an area can lead to discouraging interpretation of trend. For instance, one cannot expect an upward trend in a good condition stand of Artemisia rigida/ Poa secunda just because the Artemisia arbuscula/Agropyron spicatum condition guide was used which rates the area in poor condition. Misclassification of a stand means assigning an inappropriate condition rating to the existing vegetation. It may mean improper classification of species reaction to use and incorrect limits on hits and percent composition of palatable increasers. A sound appraisal of site potential is necessary for interpretation of trend.

Livestock are generally considered the primary biotic cause of range trend. However, one must also consider the influences of game animals, small animals such as rodents and rabbits, insects, and disease. The vegetation reacts to the total effects of use, not just to livestock use. The range manager must determine what animals are using the area, when they are grazing, and how much use they are making of each species. Answers to the last two questions require utilization measurements. These measurements tend to separate biotic causes of trend from the other causes. Utilization data should be compared with trend data to evaluate cause and effect relationships. For this evaluation, consideration should be given to plant physiology, season and degree of use by species, and the type of use. Adjustments in livestock will not eliminate influences by other biotic agents. Since one purpose of trend analysis is to appraise current livestock management practices, one must first determine if livestock are the animals causing a trend in the range. If they are not, the land manager may have to develop an entirely different program to maintain or improve the vegetation.

Some plant communities contain vegetation that can influence range trend. Increasing tree cover will cause a decrease in density and a change in composition of excellent condition range thus causing a downward trend. Increasing tree cover may prevent an upward trend in fair to good condition range even though livestock management is proper. On the other hand, a reduction in tree cover may cause an upward trend even though livestock management has not been altered. Shrub cover such as sagebrush may cause similar reactions. The influence of vegetation on range trend must be determined because it requires development of management programs quite different from those suitable for animals. In many cases, animal management will have little effect upon trend caused by vegetation.

Erosion may be an important influence on range trend. If erosion has occurred, soil has changed and therefore the site has changed. A changed site cannot be accurately judged by a condition guide suitable for its pristine condition (Ellison, 1951). Interpretation of trend is difficult on eroded areas because potential vegetation is unknown and the reaction of species to grazing is difficult to evaluate. Static trend or a downward trend under active erosion may occur without animal use.

Growing conditions may influence trend. Yearly changes in both density and composition have been related to temperature and precipitation (Craddock and Forsling, 1938; Blaisdell, 1958). In addition, prolonged moist or dry periods may cause significant changes in trend (Hurtt, 1951; Duncan and Reppert, 1960). Consideration should be given to utilization and climatic data. Where possible, exclosures should be sampled to evaluate the effects of climatic factors on ungrazed range. Climatic causes of trend must be separated from animal causes for sound evaluation of management practices.

In many cases, two or more factors influence range trend. While livestock management is the most versatile and most widely used method of altering trend, it is not necessarily the most common and reliable cause of range trend.

<u>Range Management</u>. Maintenance of sustained grazing capacity requires a sound working knowledge in two basic fields. One is an

understanding of the nature and characteristics of vegetation; another is an understanding of the nature and characteristics of animals. Each is interdependent upon the other. It is for this reason that basic soils-vegetation relationships are so important in range management.

Vegetation is the basic resource which is converted into profit by means of animals. Maximum animal production is generally attained on excellent condition range. Animal use must be reduced on areas not in excellent condition and distributed onto areas in better condition. Therefore, management success depends to a large degree upon accurate condition and trend guides and useful vegetation maps.

At times, revegetation is a desirable method of increasing forage production. Success depends upon selection of species and methods suitable for a given soil and environment.

For instance, the *Artemisia rigida*/*Poa secunda* association is completely unsuited to revegetation due to shallow soils and adverse soil moisture relationships. In addition, sagebrush control is undesirable because *Artemisia rigida* is quite palatable.

The *Artemisia arbuscula* associations are extremely questionable for plowing and seeding due to stony, rather shallow soil and adverse soil moisture characteristics. Under some conditions, chemical control of *Artemisia* might be desirable.

Thus a basic vegetation map may be used to quickly appraise and inventory the amount and location of areas suitable and not suitable for revegetation. Accurate description and characterization of associations offer a sound basis on which to develop range improvement methods.

Application in Watershed Management

Watershed management may be divided into two categories: watershed protection and water production.

Protection

Watershed protection is concerned mainly with maintaining a vegetative cover which will prevent soil erosion. This is directly related to range condition and trend whereby shrub and herbaceous vegetation is essential ot prevent soil movement. It is also related to revegetation and reforestation which requires sound analysis of soil-vegetation relationships for success.

Water Production

Water production is another problem. It is influenced by the combination of soil and vegetation. Ecology is a basic starting point for this evaluation. The *Abies*/*Calamagrostis* association may be used as an example. Satisfactory watershed protection may be obtained in any successional stage providing range condition is good. Greatest water production is probably obtained with a carpet of grass under an open stand of *Pinus ponderosa*. However, this will also create higher peak flows and tend to foster only moderate flood prevention. Climax conditions in *Abies/Calamagrostis* would have maximum tree cover which would create maximum interception of snow, and maximum transpiration of moisture, particularly from lower soil depths. This will result in lowest water production, reduced peak flows, and tend to create the best flood protection vegetation.

A decision must be made by the land manager as to what kind of water production and flood control vegetation is most desirable. This decision is facilitated by characterization of vegetation associations.

Application in Multiple Use

Vegetation-soil relationships and their ecological interpretations are the common ground of range management, forest management, and watershed management. This knowledge is essential for sound land use because no single practice can be divorced from any other. Overgrazing in forest areas reduces herbage competition and fosters overstocking of trees. Timber harvest methods influence not only herbage production for game and livestock but also watershed protection and water production characteristics. An ecological approach correlating vegetation with soils is essential for a wholistic understanding of land management.

This may be illustrated, again, by the *Abies/Calamagrostis* association. Pinus ponderosa may be maintained in a lush carpet of grass. This will produce a moderate quantity of high quality wood, a maximum quantity of herbage for livestock, and a maximum quantity of water. On the other hand, management for Abies would probably produce a maximum quantity of fair quality wood, a minimum amount of herbage for game and livestock, minimum water production, and maximum flood control. Short rotation logging for fir may be most desirable for pulp and fiber products, high game range productivity, a moderate balance between water production and flood control, and some livestock grazing. In general, maximum production for game animals in the Abies/Calamagrostis association is attained in fair to good range condition shortly after logging where numerous disturbed areas flourish with spring and summer forbs, groups of dense tree reproduction offer cover and concealment to the game animals, and a maximum variety of vegetation is available.

Thus all phases of land management are interrelated. The land manager may be greatly aided by clear and concise descriptions and characteristics of soil-vegetation relationships.

SUMMARY

Vegetation-soil relationships were studied on the Ochoco National Forest in central Oregon. The study was initiated to characterize and evaluate vegetation as a basis for improvement of land management. Objectives were to: 1. Characterize vegetation-soil relationships as a foundation for total land management. 2. Evaluate forest succession, stocking, and growth to improve timber management. 3. Develop accurate range condition and trend guides.

The ecological philosophy used acknowledges a continuum tendency of vegetation-environmental variability. However, this variability is not random but tends to result in clustering or grouping of plant communities. It implies that the entire spectrum of vegetation-environmental variability must be sampled to determine the nature of community groups or associations.

Elevation of the study area ranged from 4,000 to 7,300 feet. A pronounced drought period occurs during the summer.

Vegetation free from grazing or logging disturbance was selected for sampling. Sample plots were located in stands representing the general spectrum of variability as determined by the author's intensive reconnaissance in conjunction with range allotment analysis with the U. S. Forest Service.

Tree stocking was measured on a fifth-acre circular plot by noting the number and species of trees by one inch diameter classes.

Five mature dominant and codominant trees of each species were measured for height, diameter, and age for determination of site index. Three to five saplings were similarly measured to evaluate growth. Tree crown cover was measured by species for overstory and understory by vertical intercept methods along each of two 100 foot lines. Subordinate vegetation was sampled by the three-quarter inch loop transect method on two 100 foot transects in a 5 by 25 meter plot. All plants occurring in this macro-plot were recorded. Herbage production was estimated by species with ten 9.6 square foot plots.

A soil pit was dug at each sample location and the profile described by standard methods. Seven important series are proposed. In addition, other environmental factors were noted such as degree and direction of slope, topography, elevation, and geology.

Vegetation was classified into associations by use of vegetation association tables. After classification, statistical analysis was applied to determine association means, standard errors, and significant correlations. Correlation analysis suggested continuum tendencies within and between associations.

Vegetation associations were named for the dominant tree, shrub, and herb species present in climax conditions. Non-forest associations are: *Artemisia rigida*/*Poa secunda* on four to eight inches of soil, *Artemisia arbuscula*/*Agropyron spicatum* on ten to eighteen inches of clay-loam soil derived from basic igneous rock, and Artemisia arbuscula/Festuca idahoensis on ten to eighteen inches of clay-loam soil derived from acid igneous rock. These Artemisia associations occur as natural openings in the forest zone due to soil characteristics inimical to tree establishment.

Climax Pinus ponderosa associations occur on sandy loam to stony loamy sand soils twelve to thirty inches deep. They include: Pinus ponderosa/Purshia tridentata/Agropyron spicatum at lower elevations, Pinus ponderosa/Purshia tridentata/Sitanion hystrix on acid igneous derived soils, Pinus ponderosa/Carex geyeri on basic igneous derived soils, and Pinus ponderosa/Festuca idahoensis on a wide variety of soils. The Pinus/Festuca association tended to occur as islands and isolated stands. Tree cover in climax conditions seldom exceeded 50 percent. When it did, tree growth stagnated. Stocking recommendations were proposed.

The Abies grandis/Calamagrostis rubescens association occupies more land area than all the other forest associations combined. As a result, it contains the greatest variability in environmental factors. It was subdivided into three site classes based upon correlation analysis of tree site index and soil depth. Tree stocking recommendations were made for each site by species.

Few stands of the Abies/Calamagrostis association could be found in climax condition because recurrent natural ground fires tended to maintain a fire climax of moderately open Pinus ponderosa over a lush carpet of grass. Correlation analysis has shown that basal area of fir is negatively correlated with ground fires, crown cover of Pinus ponderosa is negatively correlated with fir cover, and herbage production is negatively correlated with total tree cover. These correlations demonstrate a "successional continuum" which must be separated from the continuum effect in climax vegetation.

This succession in the Abies/Calamagrostis association is of major importance in land management. First, since Pinus ponderosa is successional to Abies grandis, maintenance of pine will require silvicultural methods different from climax pine associations. Second, the forester has a choice of Pinus ponderosa, Pseudotsuga menziesii, and Abies grandis which range from high quality wood and moderate growth to low quality wood and fast growth respectively. Third, natural succession is causing a gradual reduction in herbage production resulting in diminishing carrying capacities for livestock and game animals. Fourth, this succession is apparently causing a reduction in water production and an increase in flood control.

Correlation analysis demonstrates both the continuum tendency of vegetation and the non-random grouping of communities. In the Abies/Calamagrostis association, Pinus ponderosa site index increases one foot for each 2.6 inch increase in soil depth. This is highly significantly different from the site index correlation in the Pinus/Festuca association. These correlations demonstrate continuum gradient within associations and differences between associations. However, when the Pinus ponderosa/Carex geyeri association, which is closely related to the Abies/Calamagrostis association, is included in the site index correlation for Abies/Calamagrostis, 1.7 inch increase in soil depth results in a one foot increase in site index. It accounts for 52 percent of site index variability whereas the correlation for Abies/ Calamagrostis accounts for 26 percent. This demonstrates a continuum effect between associations. It is highly significantly different from the Pinus/Festuca site index correlation.

The Abies grandis/Bromus vulgaris association occurs at upper elevations. Successional species are Pinus contorta, Larix occidentalis, and Pseudotsuga menziesii following conflagration fires rather than ground fires. High precipitation and northerly exposure fosters rather dense forests which are unsuited for livestock use.

One successional community group was designated as an aid in forest management. The Pinus contorta/Baccinium scoparium/ Calamagrostis rubescens associes is a pioneer community following fire in the Abies/Bromus association. It has some grazing potential due to a rather open forest canopy. Forest products are limited to pulpwood due to small tree size.

Four other associations were noted but not intensively sampled due to excessive grazing. These were a lower elevation shrub type dominated by Purshia tridentata, Abies lasiocarpa, Artemisia tridentata var. vaseyana/Carex species, and Festuca idahoensis.

Numerical variability within associations poses serious problems for development of condition and trend guides. Species were grouped into categories according to their reaction to grazing. Accurate guides require standard errors less than 10 percent of the mean for hits and composition. Few associations could meet this criteria. However, correlation analysis was successfully used in most cases to reduce variability.

This study has demonstrated that the continuum effect is a factor that must be recognized and dealt with intelligently in ecological studies. It has also demonstrated that plant communities can be successfully and usefully classified into groups or associations.

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APPENDIX A

(Average and range in tree cover and species composition, and constancy of species in ten associations as measured with the loop transect method.)

Appendix A. Average and range in tree cover and species composition, and constancy of species in ten associations as measured with the loop transect method. Only those species with 50 percent or more constancy are listed.

	Association									
	Arri/ Pose	Arar/ Feid	Arar/ Agsp	Pipo/ Putr/ Agsp	Pipo/ Putr/ Sihy	Pipo/ Feid	Pipo/ Cage	Abgr/ Caru	Abgr/ Brvu	Pico/ Vasc/ Caru
	1/ %C	%C	%C	%C	%C	%C	%C	%C	%C	%C
	2/x̄ Range	x̄ Range	x̄ Range	x̄ Range	x̄ Range	x̄ Range	x̄ Range	x̄ Range	x̄ Range	x̄ Range
Trees in percent cover	3/ 10	3	10	2	6	7	8	24	10	5
Juniperus occidentalis	20	33	50 1:0-5	50	33 1:0-4	56	50	29		
Pinus ponderosa				100 8:4-12	100 42:24-53	100 41:25-47	100 49:25-71	92 34:0-65	30	20
Pseudotsuga menziesii							12	96 18:0-82	60 6:0-25	60 5:0-21
Abies grandis								88 4:0-81	100 69:40-107	30 5:0-10
Larix occidentalis								8	80 3:0-10	80 2:0-6
Picea engelmanni									20 3:0-24	
Pinus contorta								4	20 1:0-10	100 51:31-65
Total Tree Cover			1:0-5	8:4-12	43:24-57	41:25-47	49:25-71	69:30-114	84:60-115	65:55-78
Shrubs and herbs in percent composition										

	Arri/ Pose	Arar/ Feid	Arar/ Agsp/	Pipo/ Putr/ Agsp	Pipo/ Putr/ Sihy	Pipo/ Feid	Pipo/ Cage	Abgr/ Caru	Abgr/ Brvu	Pico/ Vasc/ Caru
Poa secunda 4/	100 46:15-74	100 13:10-16	100 29:3-50	100 4:0-14	100 1:0-6	43	12			
Trifolium macrocephalum	90 20:0-34	66 8:0-18	60 1:0-4							
Artemisia rigida	90 9:0-18		10							
Sitanion hordeoides	100 3:T-4	33								
Allium acuminatum	50 1:0-10		80 2:0-18							
Artemisia arbuscula	30 1:0-6	100 25:10-34	100 17:T-34							
Festuca idahoensis		100 16:5-26	40 2:1-6	100 3:1-6	33	100 57:42-80	25			
Danthonia unispicata	20	100 4:2-10	50 1:0-8							
Phlox douglasii	20 1:0-6	100 13:6-22	40 1:0-10	50	16	12				
Balsamorhiza serrata	10	100 3:2-4	30							
Koeleria cristata		100 1:T-3	50	100 2:2-3	83 1:0-4	29	37	12		
Agoseris glauca	20	100 T	50		33	57	50	29		
Agropyron spicatum	20 1:0-12	66 2:0-8	100 31:12-38	100 25:17-34	33 1:0-6	29 2:0-12	12			

	Arri/ Pose	Arar/ Feid	Arar/ Agsp	Pipo/ Putr/ Agsp	Pipo/ Putr/ Sihy	Pipo/ Feid	Pipo/ Cage	Abgr/ Caru	Abgr/ Brvu	Pico/ Vasc/ Caru
Sitanion hystrix		33	80 1:0-6	50	100 10:4-32	100 3:T-10	100 3:T-8	17		
Purshia tridentata	10	33 1:0-2	70 1:0-6	100 13:8-18	100 19:10-34	72 1:0-2	75 8:0-25			
Achiliea milefolium	20		80 1:0-4	100 4:3-5	100 4:T-12	100 7:2-13	100 2:T-4	75 2:0-8	20	60
Antennaria stenophylla	20		80 2:0-4		66	57	75 1:0-3	4		
Artemisia tridentata				100 8:T-17			12			
Erigeron eatoni				100 9:4-14	16	29	50	8		
Antennaria rosea				100 2:T-4	16		25	8		
Carex rossii				50	100 25:14-44	100 5:T-20	38 1:0-6			
Stipa occidentalis					100 3:T-8	57 1:0-6	88 1:0-4	13		
Cercocarpus ledifolius				50	33 1:0-4	29 1:0-6	75 3:0-20	8		
Hieracium albertinum					12	57 1:0-4	75 2:0-5	37		
Poa nervosa				50	66 10:0-37	29 2:0-10	88 7:0-15	33		
Carex geyeri						14 1:0-12	100 55:28-87	92 29:0-68	60 7:0-24	20

	Arri/ Pose	Arar/ Feid	Arar/ Agsp	Pipo/ Putr/ Agsp	Pipo/ Putr/ Sihy	Pipo/ Feid	Pipo/ Cage	Abgr/ Caru	Abgr/ Brvu	Pico/ Vasc/ Caru
Berberis repens				50	66 6:0-16	29	62 3:0-12	50	10	
Symphoricarpos albus				50 1:0-2			62 1:0-4	46 1:0-6	40 1:0-8	
Fragaria vesca crinita				50		29	50	42 1:0-8	70 4:0-16	40 1:0-2
Arnica cordifolia						14	50 7:0-28	88 10:0-45	80 10:0-52	100 8:T-32
Calamagrostis rubescens						57 4:0-18	25 2:0-8	92 43:0-66	50 5:0-26	100 59:18-82
Lupinus caudatus						14	12	75 2:0-12		40 2:0-10
Hieracium albiflorum								67 2:0-9	100 6:2-12	60 1:0-4
Fragaria virginiana platypetala								46	40 2:0-22	80 3:0-8
Festuca occidentalis							25	50 1:0-8	70 1:0-4	40 2:0-6
Osmorhiza purpurea								50	90 6:0-18	80 4:0-20
Bromus vulgaris								12	100 18:3-36	
Lupinus latifolius								12	80 5:0-20	60 4:0-14
						14		17	80 4:0-16	40 1:0-4
Pyrola secunda								17	70 6:0-24	60

	Arri/ Pose	Arar/ Feid	Arar/ Agsp	Pipo/ Putr/ Agsp	Pipo/ Putr/ Sihy	Pipo/ Feid	Pipo/ Cage	Abgr/ Caru	Abgr/ Brvu	Pico/ Vasc/ Caru
Aquilegia formosa								12	60	20
Vaccinium scoparium									40	80 9:0-20
Smilacina sessilifolia									60	20

1/ %C is the percent constancy of occurence for the species in each association.
2/ $\bar{x}$ is the average percent composition; range is the range on percent composition for all stands in the association.
3/ Numerals indicate the number of sample plots per association.
4/ Underlined data denotes indicator significance.

APPENDIX B

Environmental factors on ten associations.

APPENDIX B

Environmental factors on ten associations

Environmental factor in percent occurrence	Arri/ Pose	Arar/ Feid	Arar/ Agsp	Pipo/ Putr/ Agsp	Pipo/ Putr Sihy	Pipo/ Feid	Pipo/ Cage	Abgr/ Caru	Abgr/ Brvu	Pico/ Vasc/ Caru
Location										
Snow Mountain Area		100	30	100	100	15	50	17		
Eastern Ochoco Area	100		40			70	30	41	60	60
Western Ochoco Area			30			15	20	42	40	40
Topography										
Undulating	100	100	100	50	100	57	90	56	20	40
Rolling						43	10	21	40	
Rough				50				23	40	
Elevation										
4000 to 4700 feet	40		40	50		14	12	25	10	20
4800 to 5500 feet	30	100	60	50	100	86	63	54	10	20
5600 to 6400 feet	30						25	21	80	60
Percent slope										
0 to 10%	100	100	80	50	83	86	100	54	40	10
11 to 25%			20		17	14		29	50	90
26 to 40%				50				9	10	
over 40%								8		
Direction of slope										
S.E. to S. W.	60		20		50	57	75	17		
S.W. to N.W.	20		70	50	30	14		29	10	
N.W. to N.E.	20	34					25	25	60	80
N.E. to S.E.		66	10	50	20	29		29	30	20

Environmental factor in percent occurrence	Arri/ Pose	Arar/ Feid	Arar/ Agsp	Pipo Putr/ Agsp	Pipo/ Putr/ Sihy	Pipo/ Feid	Pipo/ Cage	Abgr/ Caru	Abgr/ Brvu	Pico/ Vasc/ Caru
Position on the slope										
Top	60	66	40	50	50	14	37	17		
Upper Third	20	34	20	50	16		13	8	50	20
Mid slope	20		30		34	29	50	46	30	20
Lower and bottom slope			10			57		29	20	60
Geology										
Pumicite over rock						43	13			
Pumicite over buried soil								88	100	100
Basic igneous rock	90		100			43	50	8		
Acid igneous rock	10	100		100	100	14	37	4		
Surface stones										
None					100	72	25	84	100	100
2 to 9% cover			20	100		28	50	16		
Over 10% cover	100	100	80				25			
Soil depth										
Less than 8 inches	100									
9 to 18 inches		100	100	50	100	57	62	12		
19 to 27 inches				50		29	25	17		
28 to 36 inches						14	13	21		
Greater than 36 inches								50	100	100
Soil stoniness										
0 to 15% stone						57	26	84	100	100
16 to 30% stone	40	66	70	100	33	43	74	16		
More than 30% stone	60	34	30		67					

Environmental factor in percent occurrence	Arri/ Pose	Arar/ Feid	Arar/ Agsp	Pipo/ Putr/ Agsp	Pipo/ Putr/ Sihy	Pipo/ Feid	Pipo/ Cage	Abgr/ Caru	Abgr/ Brvu	Pico/ Vasc/ Caru
Soil Texture										
Gravelly sand to sandy loam				100	100	43	87	8		
Fine sand to loam						43	13	92	100	100
Silt loam to clay loam	100	100	100			14				
Soil pH										
6.9 to 7.4	10	34	30		17					
6.4 to 6.8	70	67	60	100	83	100	87	50	40	20
5.7 to 6.3	20						13	50	60	80

*Underlined factors characterize the type

APPENDIX C

Summary of tested correlations.

APPENDIX C

Summary of tested regressions

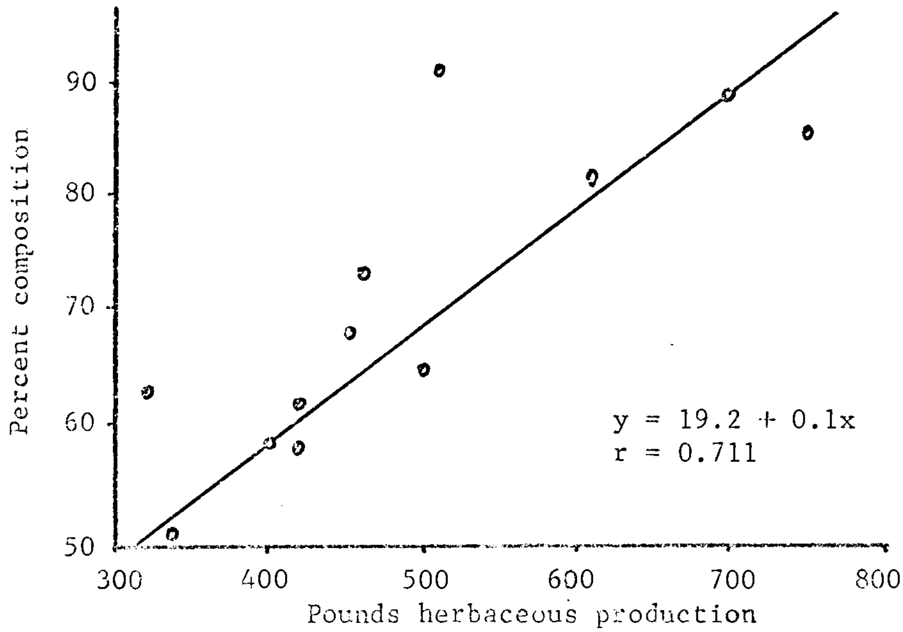
Regression possibilities were evaluated for all vegetation types. In many cases, simple inspection of data revealed no possibilities for significant associations. Other regressions were eliminated by plotting data on graph paper. This summary lists only those correlations which were mathematically computed. Black spaces indicate no correlation.

Regression	Arri/ Pose	Arar/ Agsp	Pipo/ Putr/ Sihy	Pipo/ Feid	Pipo/ Cage	Abgr/ Caru	Abgr/ Brvu	Pico/ Vasc/ Caru
Decreaser composition/soil depth		*r=.85						
" " /elevation		ns						
" " /production		ns						
Decreaser plus palatable increaser composition /soil depth		ns	ns	ns	ns			
" " /elevation		ns			ns			
" " /production		*r=.85						
" " /tree cover			ns	ns	ns	**r=-.56	ns	
" " /tree volume				ns				
" " /basal area				ns				
Decreaser plus palatable increaser hits /soil depth		ns	ns	ns	ns	ns		
" " /elevation		ns						
" " /production				*r=.93	ns	*r=.76		
" " /tree cover			ns			**r=-.56	ns	
" " /tree volume			ns	**r=-.93				
Forage production /soil depth		*r=.72			ns			
" " /elevation		**r=-.91						
" " /tree cover				ns		**r=-.56		
" " /tree volume				**r=-.93				

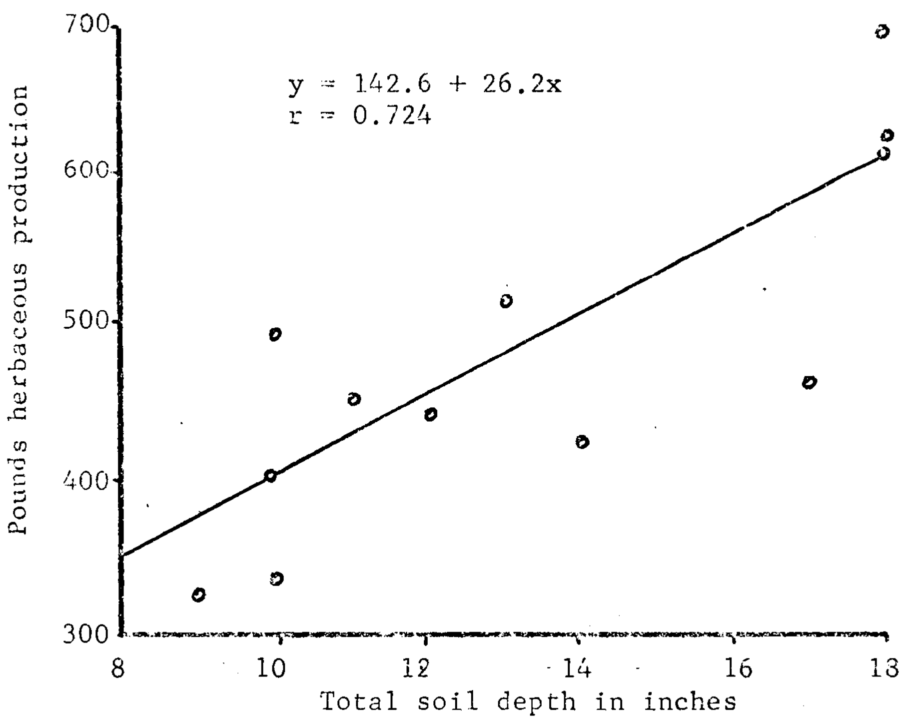
Regression	Arri/ Pose	Arar/ Agsp	Pipo/ Putr/ Sihy	Pipo/ Feid	Pipo/ Cage	Abgr/ Caru	Abgr/ Brvu	Pipo/ Vasc/ Caru
Shrub hits /elevation		**r=.87	ns					
" " /soil depth		ns						
" " /township			**r=.92					
Cubic volume /soil depth				ns				
" " /site index				ns				
" " /tree cover			ns	ns	ns	ns	ns	
"			**r=.96	*r=.88	**r=.88	**r=.99	** r=.95	
Basal area /tree cover			ns	ns	ns	ns	ns	
" " /soil depth						ns	ns	
Fir basal area/number of fires						*r=-.62		
" " " /years since fire						*r=-.46		
<u>Pinus ponderosa</u> site/soil depth				*r=.83		**r=.51		
Combining Pipo/Cage with Abgr/Caru:								
Pipo site index/soil depth					**r=.72			
Pipo basal area-volume/site index					**r=.73			
<u>Pinus ponderosa</u> cover/fir cover						**r=.62		
Tree cover/ soil depth							ns	
" " / elevation							ns	

*Significant at the 95 percent level
**Significant at the 99 percent level
ns = not significant

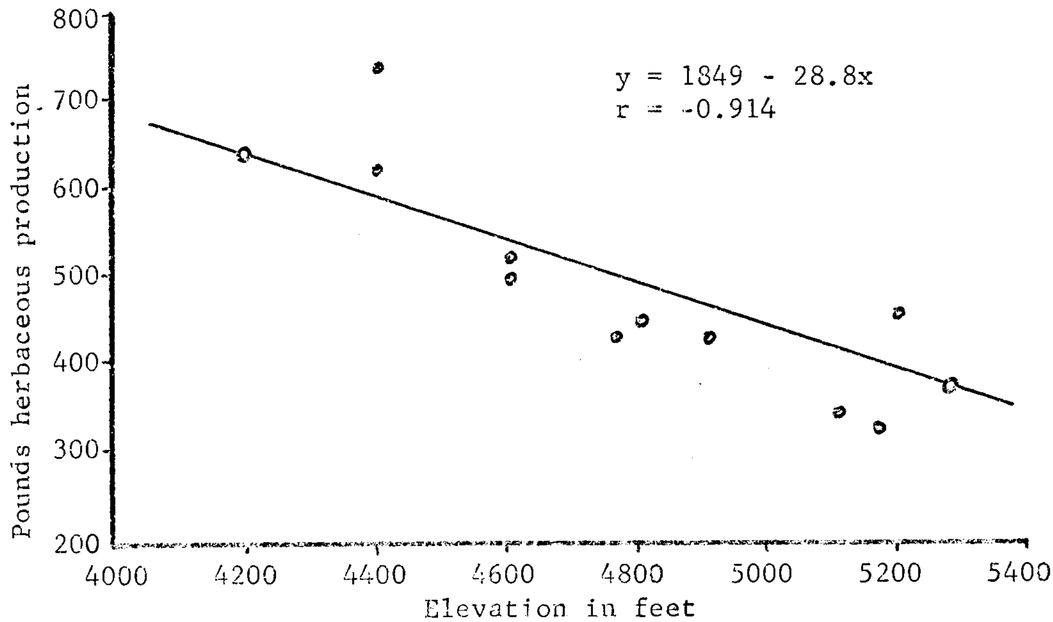
Artemisia arbuscula/Agropyron spicatum: Correlation of decreaser plus palatable increaser composition with herbaceous production.



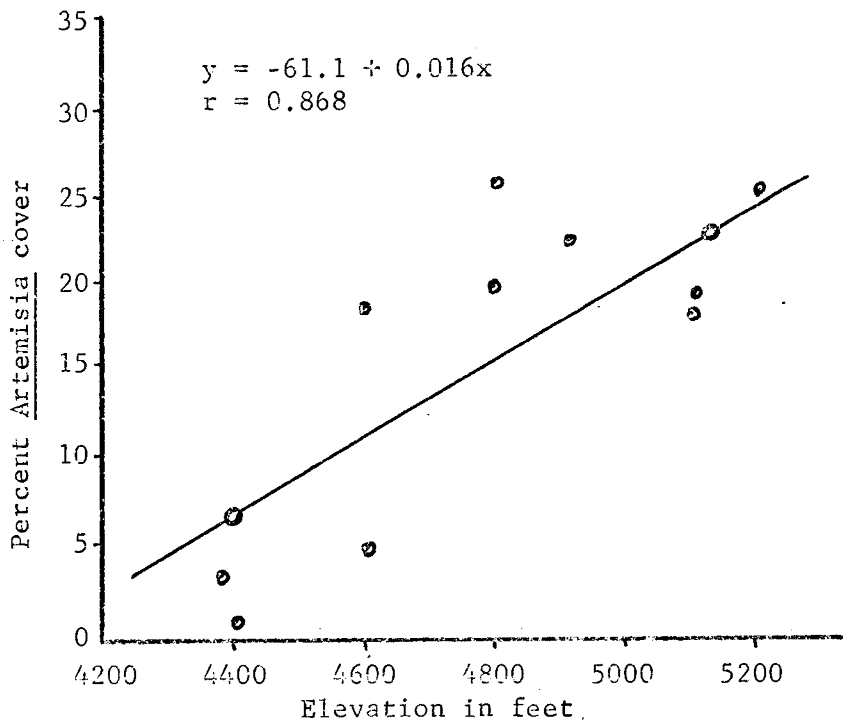
Artemisia arbuscula/Agropyron spicatum: Correlation of herbaceous production with total soil depth.



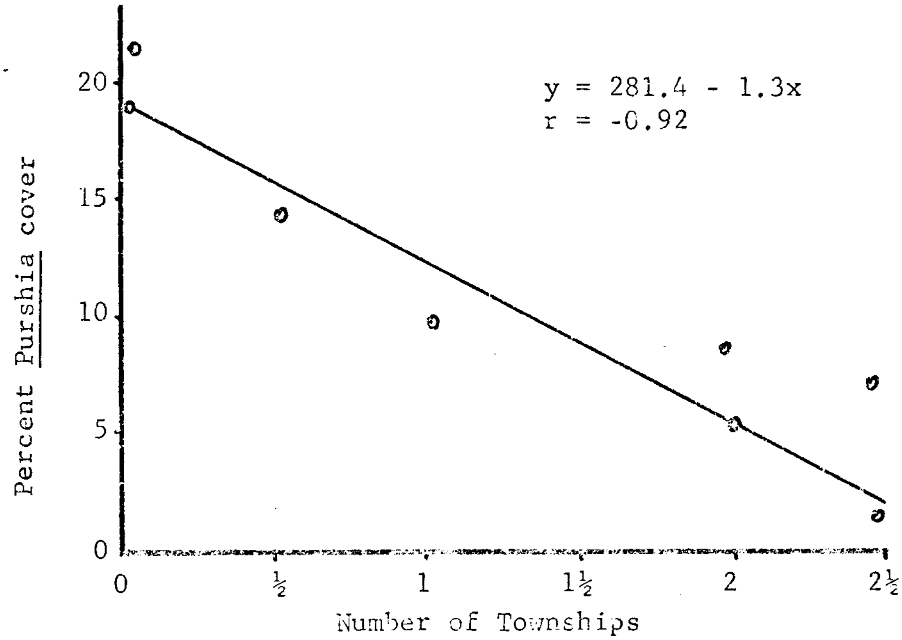
Artemisia arbuscula/Agropyron spicatum: Correlation of herbaceous production with elevation.



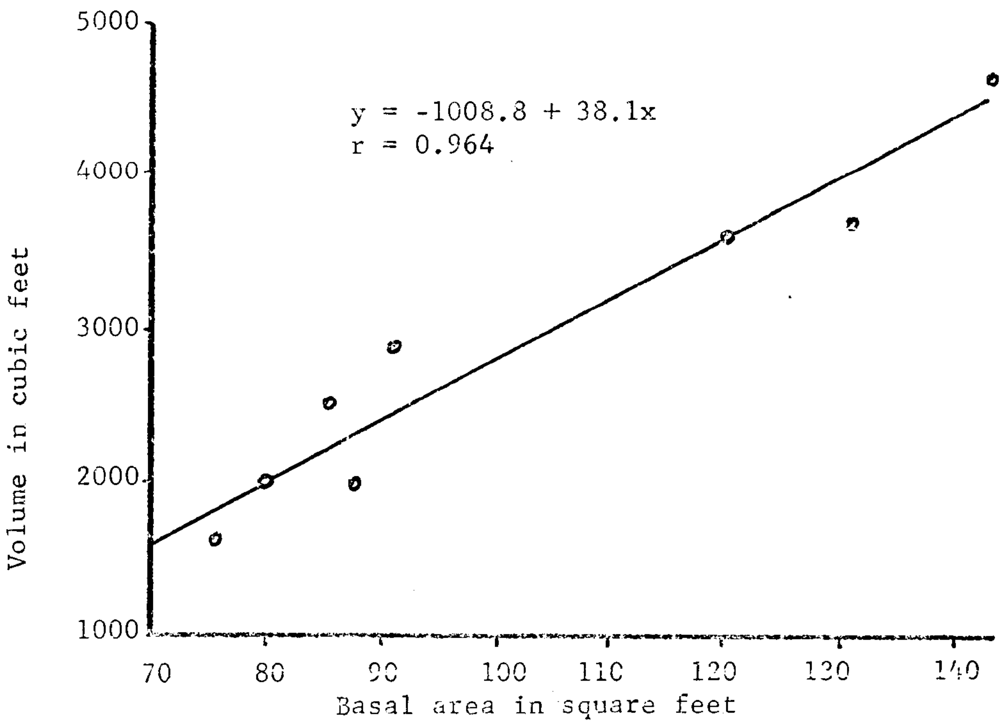
Artemisia arbuscula/Agropyron spicatum: Correlation of Artemisia cover with elevation.



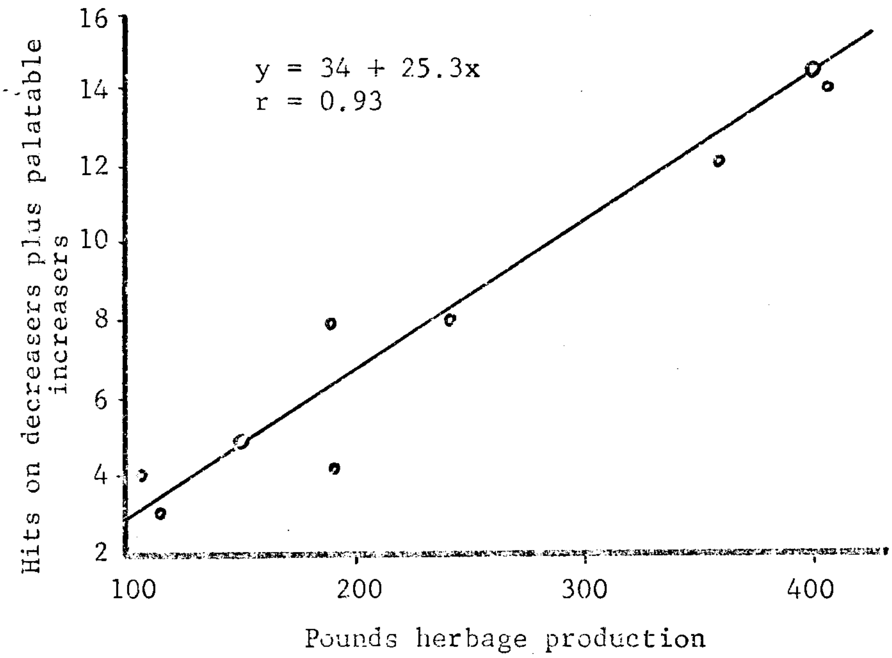
Pinus ponderosa/Purshia tridentata/Sitanion hystrix: Purshia cover correlated with Townships east of the western forest edge.



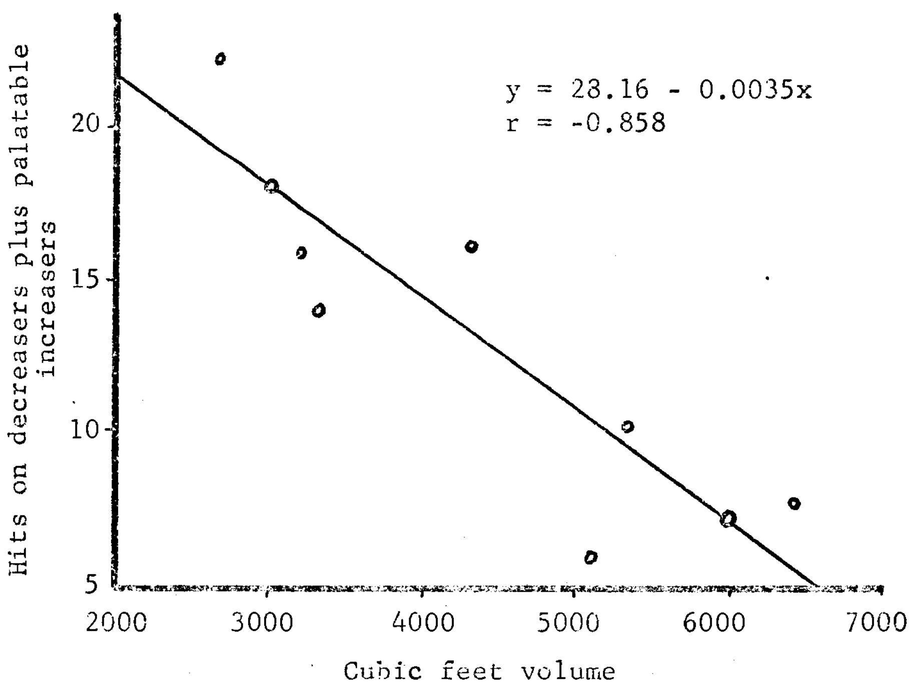
Pinus ponderosa/Purshia tridentata/Sitanion hystrix: Cubic volume-basal area ratio.



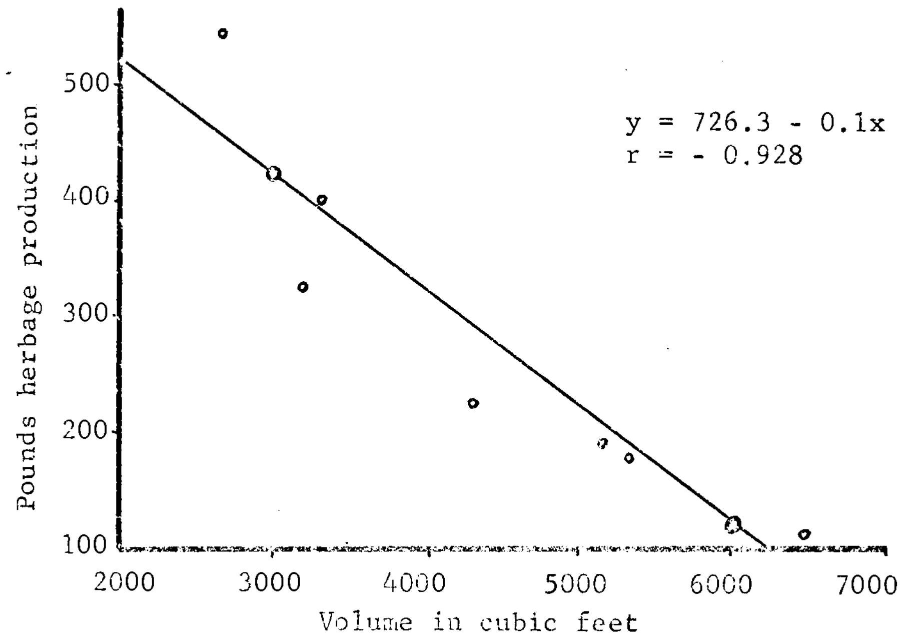
Pinus ponderosa/Festuca idahoensis: Decreaser plus palatable increaser hits correlated with herbage production.



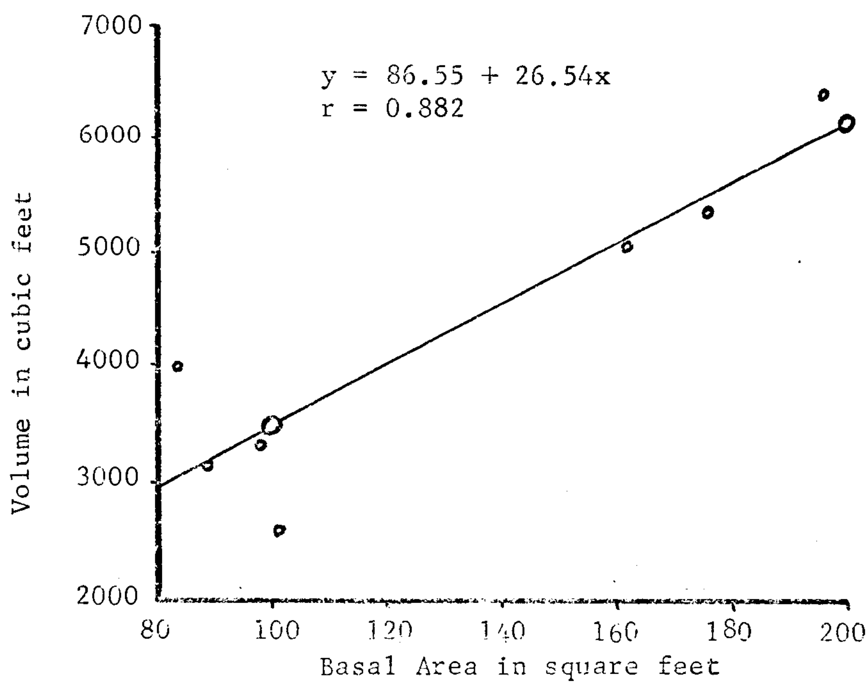
Pinus ponderosa/Festuca idahoensis: Decreaser plus palatable increaser hits correlated with cubic feet tree volume.



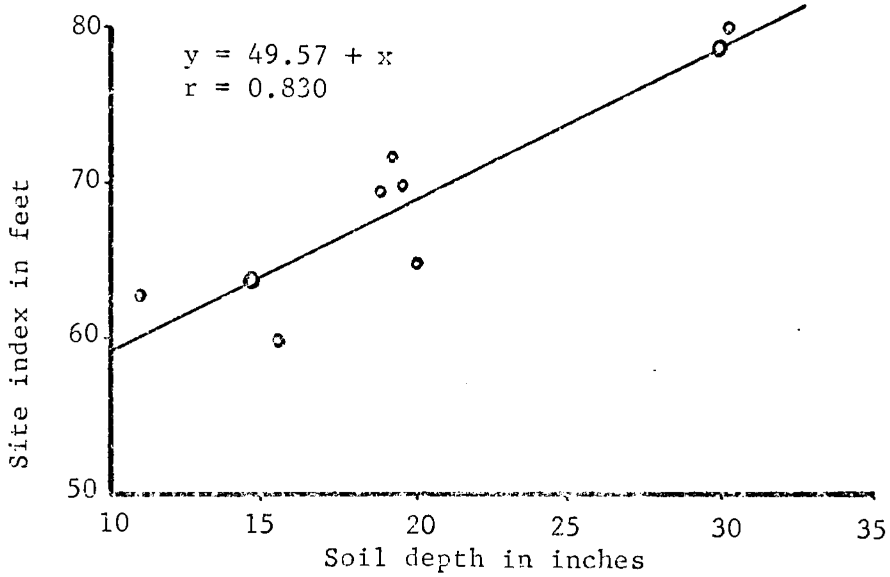
<u>*Pinus ponderosa*/*Festuca idahoensis*</u>: Herbage production correlated with cubic feet tree volume.



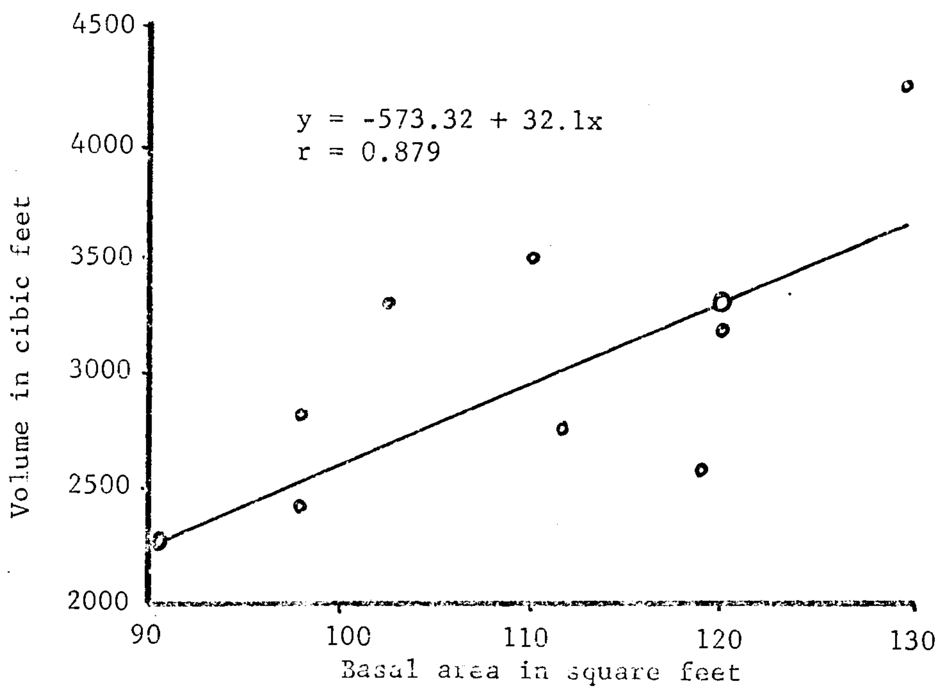
<u>*Pinus ponderosa*/*Festuca idahoensis*</u>: Cubic volume - basal area ratio.



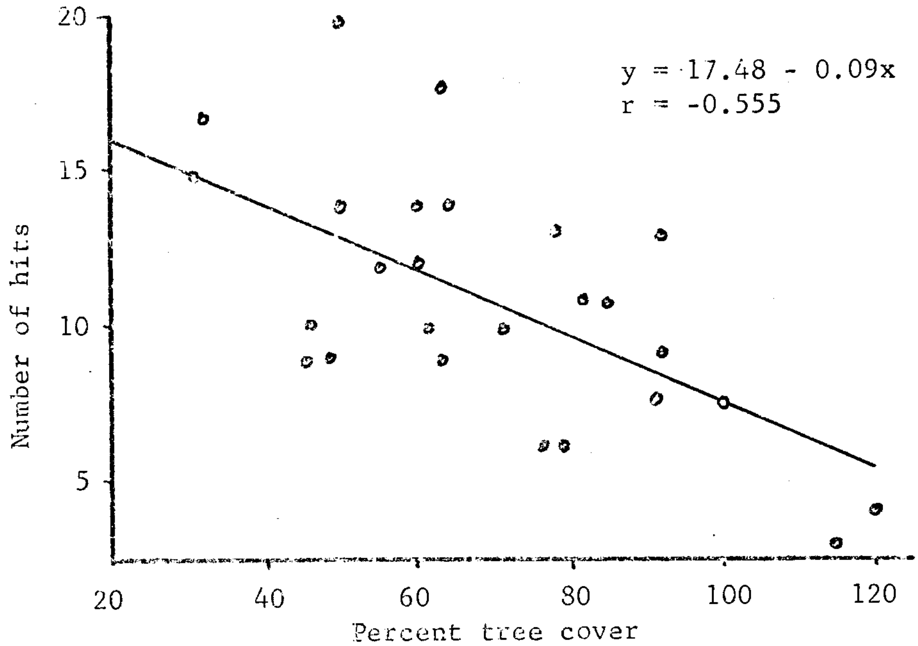
Pinus ponderosa/Festuca idahoensis: Site index of Pinus ponderosa correlated with total soil depth.



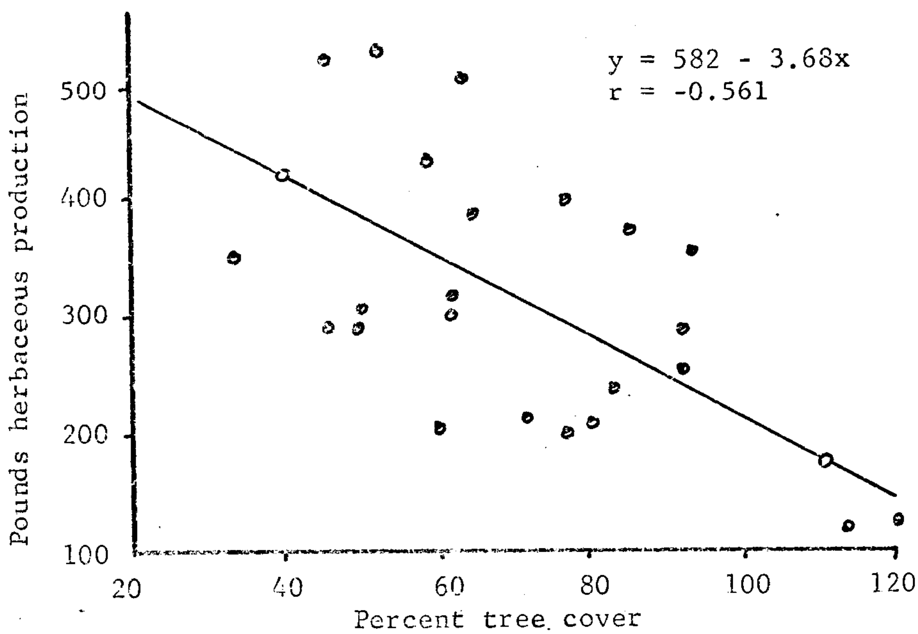
Pinus ponderosa/Carex geyeri: Cubic volume - basal area ratio.



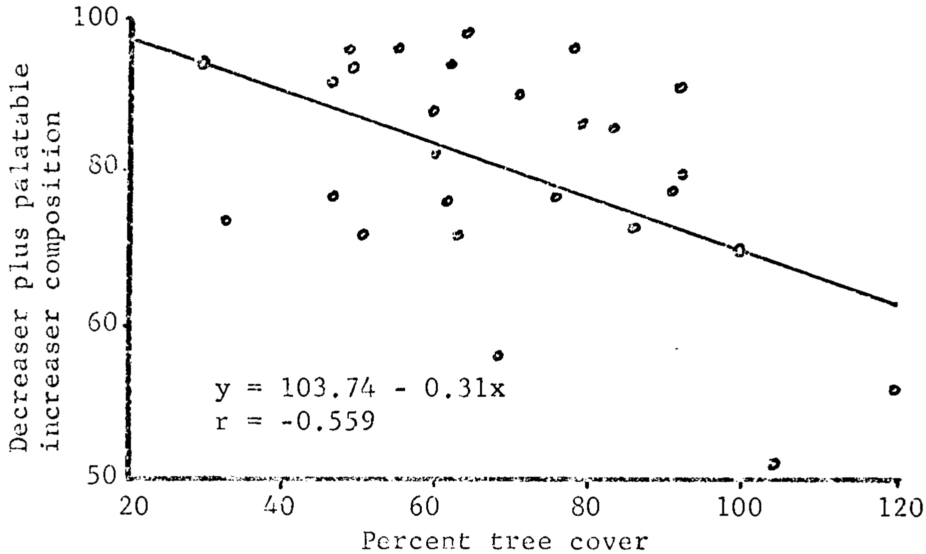
Abies grandis/Calamagrostis rubescens: Correlation of decreaser plus palatable increaser hits with tree cover.



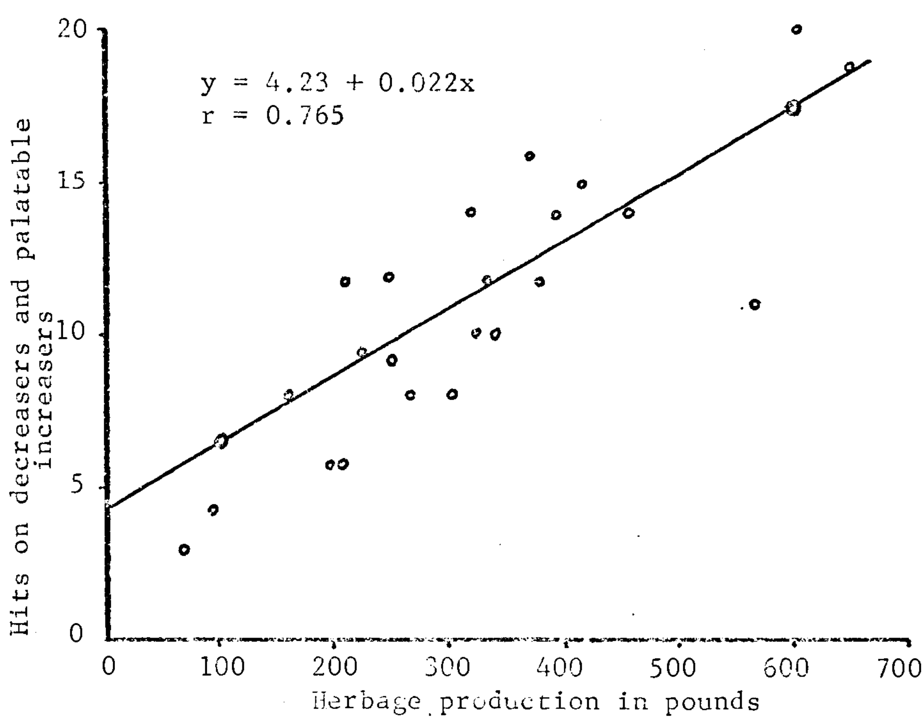
Abies grandis/Calamagrostis rubescens: Correlation of herbaceous production with tree cover.



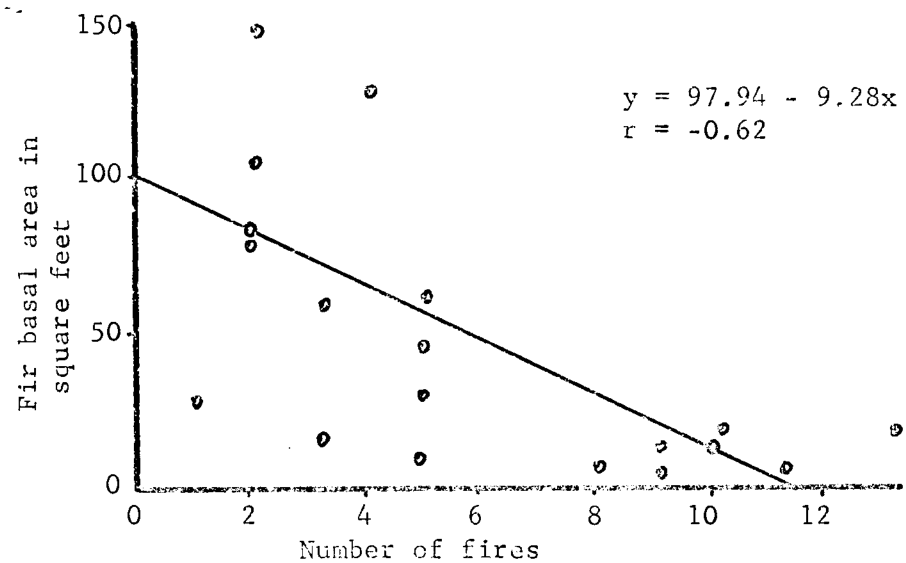
Abies grandis/Calamagrostis rubescens: Decreaser plus palatable increaser composition correlated with tree cover.



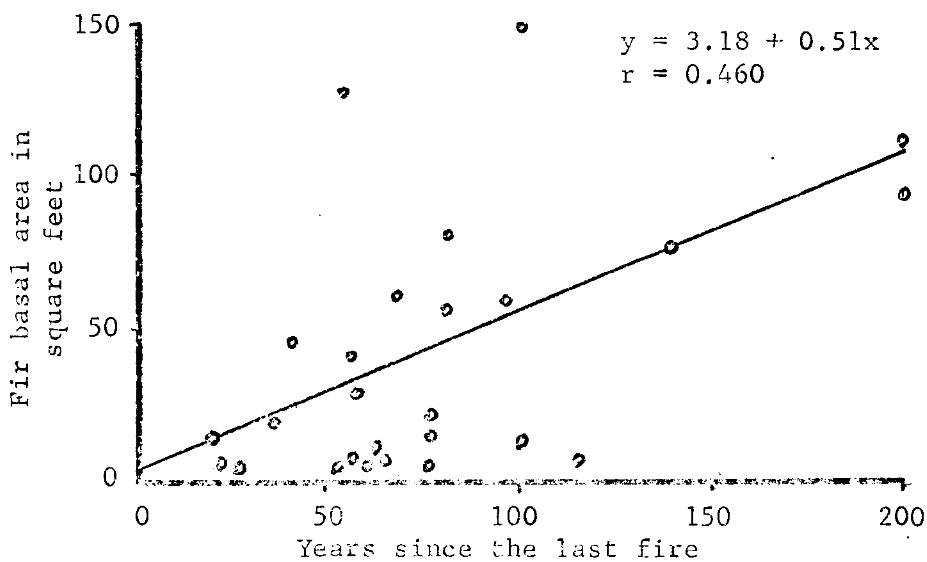
Abies grandis/Calamagrostis rubescens: Decreaser plus palatable increaser hits correlated with herbage production.



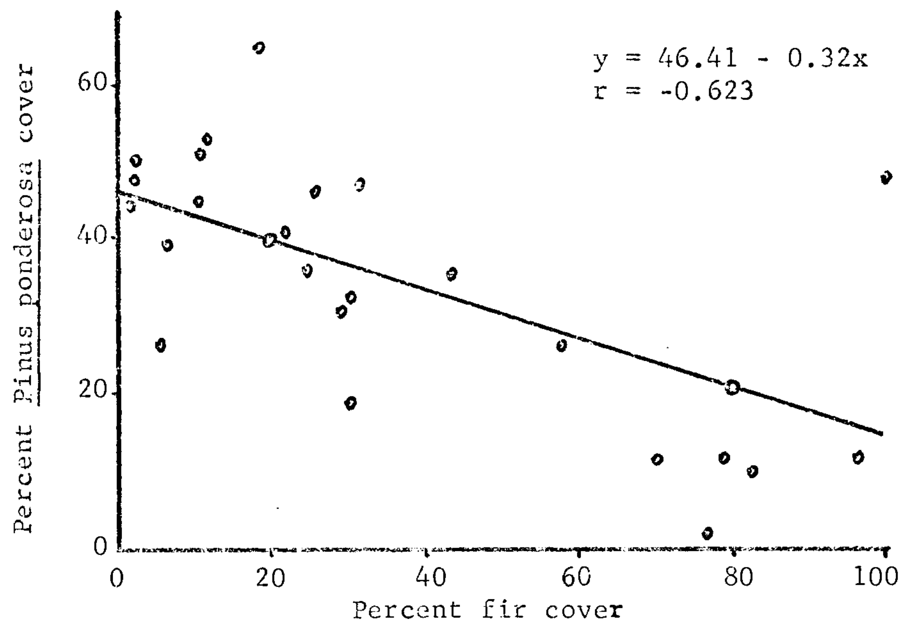
Abies grandis/Calamagrostis rubescens: Basal area of firs correlated with the number of recorded ground fires.



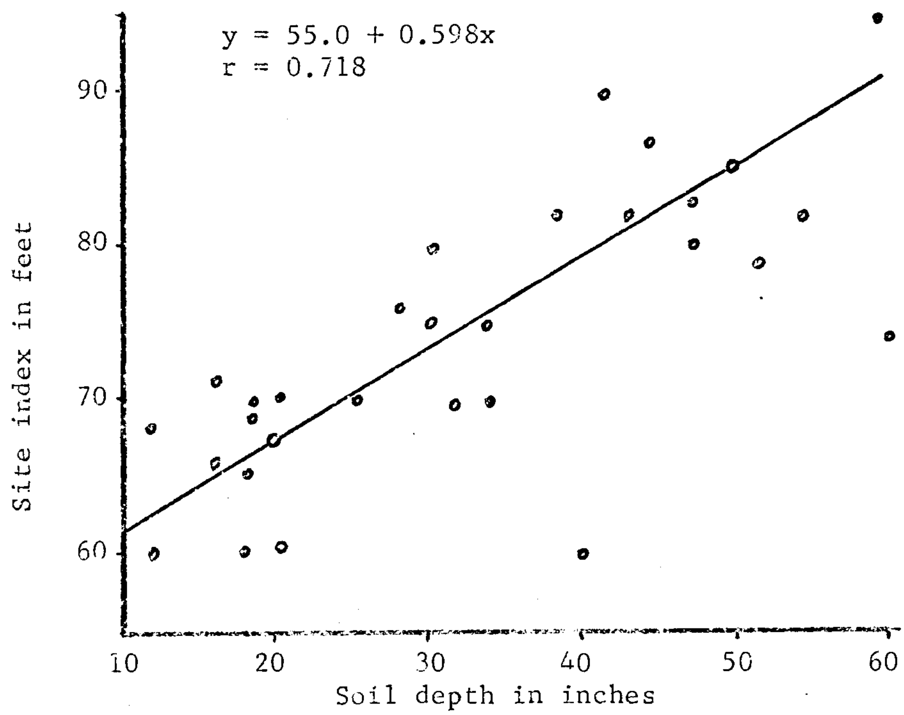
Abies grandis/Calamagrostis rubescens: Basal area of firs correlated with the number of years since the last recorded ground fire.



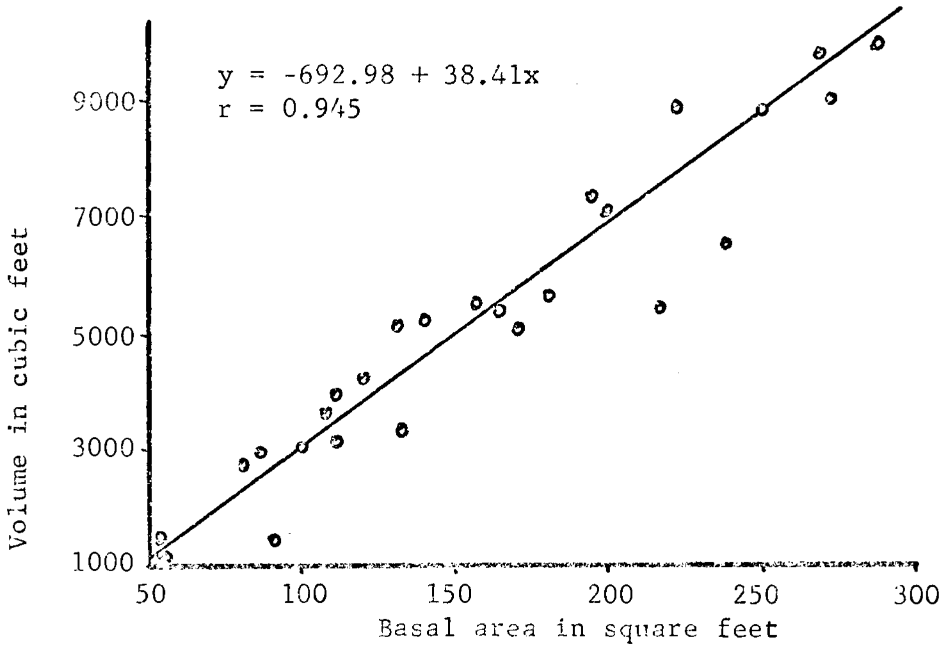
Abies grandis/Calamagrostis rubescens: Pinus ponderosa cover correlated with fir cover.



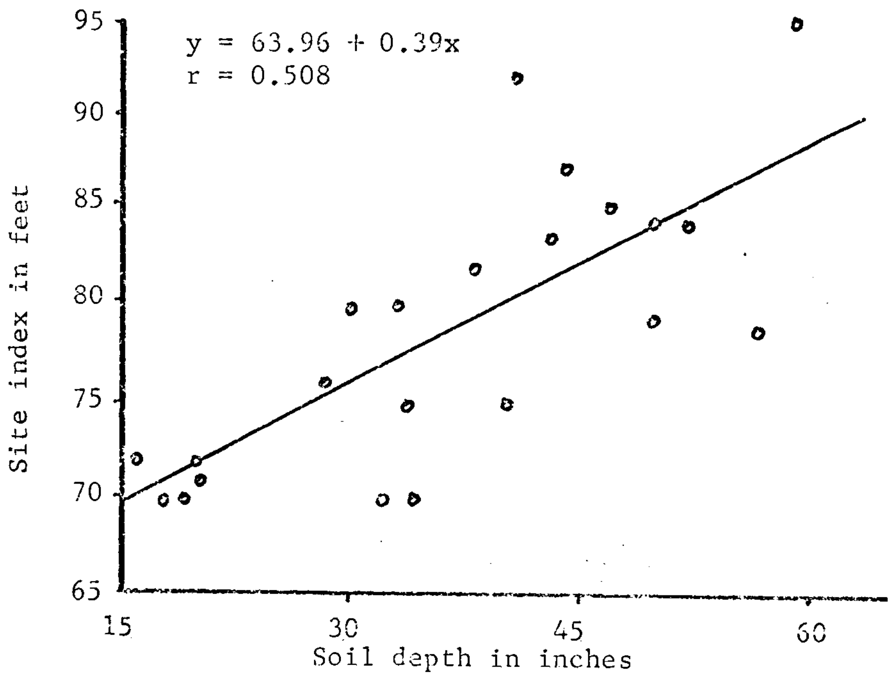
Pinus ponderosa/Carex geyeri combined with Abies grandis/ Calamagrostis rubescens: Pinus ponderosa site index correlated with total soil depth.



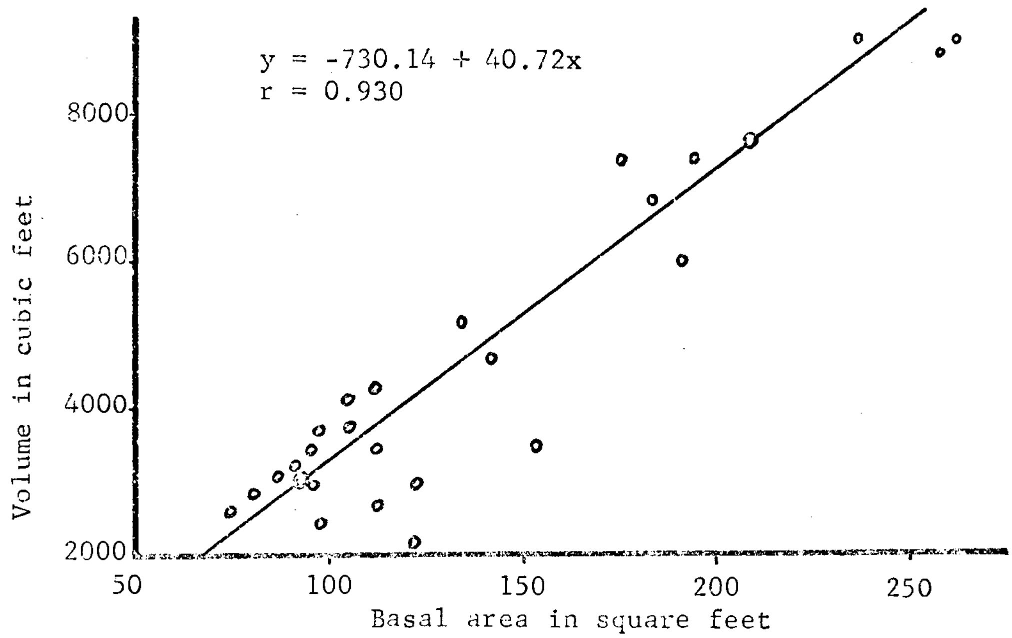
Abies grandis/Calamagrostis rubescens: Correlation of *Pinus ponderosa* cubic volume with basal area.



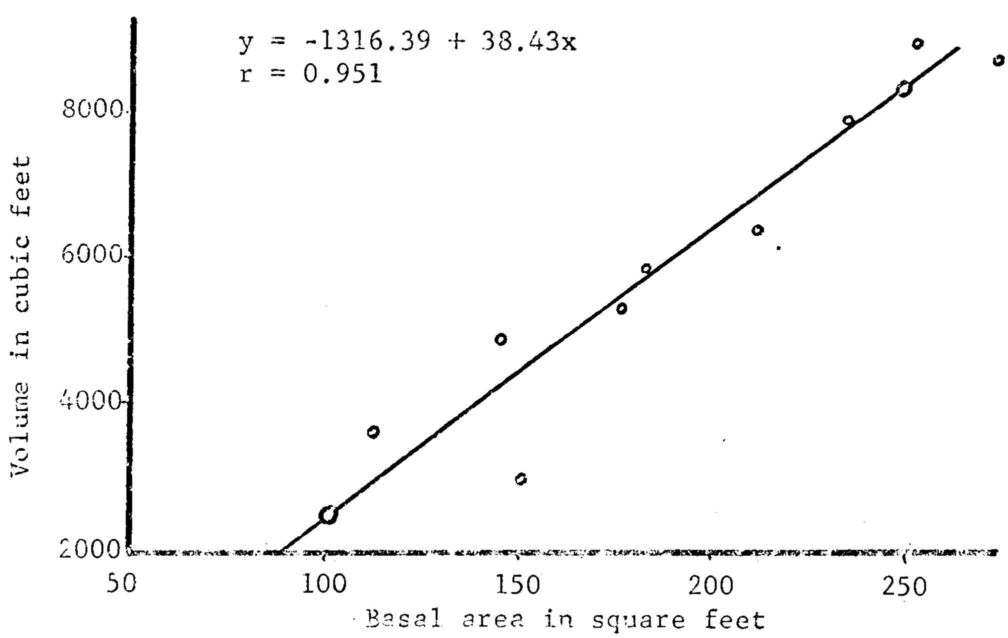
Abies grandis/Calamagrostis rubescens: Correlation of *Pinus ponderosa* site index with total soil depth.



Pinus ponderosa/Carex geyeri combined with Abies grandis/ Calamagrostis rubescens: Cubic volume - basal area ratios for Pinus ponderosa.



Abies grandis/Bromus vulgaris: Cubic volume - basal area ratio.



APPENDIX D

Tentative soil series of major importance on the Ochoco National Forest.

APPENDIX D

Tentative soil series of major importance on the Ochoco National Forest.

Tentative Series R

A shallow lithosol (lithic cryoboroll) soil developed from Ochoco Lavas. It tends to be saturated with moisture during the winter and early spring months. During the summer, severe moisture desiccation occurs to bedrock. Frost heaving is very active. It is characteristic of the Artemisia rigida/Poa secunda type. Elevations range from 4000 to 6000 feet, slopes seldom exceed 20% and topography is largely undulating. Surface rock occupies 10 to 30% of the surface.

Horizon	Depth	Description
G	1/2 - 1"	Gravel pavement composed of rock material from 1/4 to 2 inches in diameter well distributed over the soil surface.
A	1-3"	Reddish brown (5 YR 5/3) dry, dark reddish brown (5 YR 3/3) moist, loam, weak, fine subangular blocky structure breaking to weak, fine granular structure, friable, slightly sticky and nonplastic, few stones, abundant roots, many fine to medium vesicles, pH 6.5, lower boundary clear and wavy.
B	3-6"	Reddish brown (5 YR 5/4) dry, dark reddish brown (5 YR 3/4) moist, silt loam to clay loam, moderate, fine subangular blocky structure breaking to very fine subangular blocky structure, friable, sticky, slightly plastic, stone content often over 60%, many roots, pH 6.4, lower boundary abrupt and smooth to irregular.
R	Bedrock	Bedrock is characteristically poorly cracked, slightly weathered, and generally impermeable to moisture.

VARIATION: Depth to rock varies from 4 to 8 inches. Color ranges from reddish brown to brown (5 YR to 10 YR). Surface horizon pH varies from 6.4 to 6.8.

Tentative Series H

A moderately shallow, azonal (Lithic cryoboroll) soil developed from igneous flow rock. It tends to be saturated with moisture during the winter and early spring. During the summer, moisture is severely depleted to bedrock. Frost heaving is quite active, particularly at upper elevations. It is characteristic of the *Artemisia arbuscula* types. Elevations range from 4000 to 5500 feet, slopes seldom exceed 25%, and topography is generally undulating to slightly rolling. Rock occupies 10 to 30% of the soil surface.

Horizon	Depth	Description
A2	0-4"	Dark brown (10 YR 3/3) dry, dark brown (7.5 YR 3/2) to very dark brown (7.5 YR 2/2) moist, silt loam, moderate, fine subangular blocky structure breaking to moderate, fine granular structure, firm, friable, sticky, plastic, some stone, abundant roots, pH 6.5 to 6.8, lower boundary clear and wavy.
A3	4-8"	Brown (10 YR 5/3) dry, dark brown (7.5 YR 3/3) to dark yellowish brown (7.5 YR 3/4) moist, silty clay loam to silty clay, moderate, medium subangular blocky structure breaking to strong, fine subangular blocky structure, firm, friable, sticky, plastic, abundant to very abundant stones, abundant roots, pH 6.2 to 6.5, lower boundary clear to gradual, wavy to broken.
B2	8-16"	Brown (10 YR 5/3) dry, brown to dark brown (7.5 YR 4/3) moist, gravelly clay to clay, strong, medium subangular blocky structure breaking to strong, fine subangular blocky structure, hard, firm, sticky, plastic, over 80% stone, some roots, pH 6.4 to 6.6 lower boundary abrupt, irregular to broken.
R	Bedrock	Moderately to finely cracked bedrock which inhibits moisture perculation.

VARIATION: Depth to bedrock varies from 8 to 20 inches. Color varies from very dark brown at lower elevations to dark brown at upper elevations. Two phases are proposed:

<u>Basic igneous phase</u>: Developed from basalt and andesite rock. Associated exclusively with the <u>Artemisia arbuscula</u>/<u>Agropyron spicatum</u> type.

<u>Acid igneous phase</u>: Developed from rhyolite and tuff material. Associated exclusively with the <u>Artemisia arbuscula</u>/<u>Festuca idahoensis</u> type.

<u>Tentative Series B</u>

A moderately shallow, azonal (Lithic cryoboroll) soil developed from basic igneous flow rock, mainly basalt and andesite. Infiltration is rapid and drainage is usually rather good due to well cracked bedrock. It is characteristic of climax <u>Pinus ponderosa</u> sites and some <u>Abies</u>/<u>Calamagrostis</u> stands at upper elevations. Elevations range from 4000 to 6000 feet, slopes may be up to 60%, and topography is undulating to rough.

Horizon	Depth	<u>Description</u>
L	1/2-0"	Litter and some humus composed of pine needles and sedge leaves.
A2	0-6"	Brown (10 YR 5/3) to dark brown (10 YR 4/3) dry, dark brown (7.5 YR 3/2) moist, sandy loam, weak, medium granular structure breaking to very fine granular structure, soft, friable, nonsticky, nonplastic, some stone, very abundant roots, pH 6.4 to 6.5, lower boundary clear to gradual and wavy.
B1	6-18"	Pale brown (10 YR 6/3) to brown (7.5 YR 5/4) dry, dark brown (7.5 YR 4/4 to 7.5 YR 3/4) moist, loam to silt loam, weak, medium subangular blocky structure breaking to weak, very fine subangular blocky structure, firm, friable, slightly sticky, nonplastic, 20 to 60% rock, abundant roots, pH 6.3 to 6.5, lower boundary abrupt to clear and irregular to broken.
R	Bedrock	Bedrock is well fractured to broken and generally does not inhibit moisture perculation.

VARIATION: Depth to bedrock varies from 12 to 24 inches with little more than broadening of the horizons. Color variations seem to be related to the bedrock: 10 YR colors from basalt and 7.5 YR colors from andesite. One phase is proposed:

Steep phase: Slopes from 30 to 60%, same profile development.

Tentative Series E

A moderately shallow to shallow, azonal to lithosol (Lithic cryorthent) soil developed from rhyolite or tuff. While profile development is similar to the B series, fertility seems to be much lower. It is listed as a separate series on this basis. Infiltration is rapid and drainage is good due to well cracked bedrock. It is characteristic of the *Pinus ponderosa*/*Purshia tridentata*/*Sitanion hystrix* type. Elevations range from 4800 to 5300 feet, slopes are generally less than 20%, and topography is undulating to rolling.

Horizon	Depth	Description
L	1/4-0"	Sparce density of pine needles and occasional grass litter. Little humus.
A2	0-5"	Brown (10 YR 5/3) dry, dark brown (10 YR 4/3) moist, sandy loam, no structure to weak, very fine granular structure, nonsticky, nonplastic, some stone, moderate to abundant roots, pH 6.5 to 6.8, lower boundary clear to gradual and wavy.
A3	5-15"	Brown (10 YR 5/3) to pale brown (10 YR 6/3) dry, dark brown (10 YR 4/3) moist, sandy loam to gravelly loam, no structure to weak, fine granular structure, nonsticky, nonplastic, 30 to 70% stone, moderate to abundant roots, pH 6.4 to 6.6, lower boundary abrupt to clear and irregular to broken.
R	Bedrock	Bedrock is well fractured to broken and generally does not inhibit moisture perculation.

VARIATION: Depth of bedrock varies from 10 to 20 inches with little more than broadening of the horizons. One phase is proposed:

Steep phase: Slopes from 20 to 40%. Limited to occasional canyon slopes.

Tentative Series S

A moderately developed soil (Typic cryochrept) derived from alluvial material. Infiltration is moderate and drainage is restricted due to an impervious claypan. It is very limited in extent and seems to be restricted to the Pinus ponderosa/Festuca idahoensis type. Elevations range from 4500 to 5000 feet, slopes are under 15% and topography is undulating.

Horizon	Depth	Description
L	1/2-0"	Litter and some humus of pine needles and grass litter.
A2	0-10"	Pinkish grey (5 YR 7/2) dry, very dark grey brown (10 YR 3/2) moist, silt loam, weak fine granular structure breaking to weak, very fine granular structure, slightly sticky, slightly plastic, firm, friable, no stones, abundant roots, pH 6.8, lower boundary clear to gradual and smooth.
B2	10-20"	Light brown (7.5 YR 6/4) dry, dark brown (10 YR 3/3) moist, silty clay, moderate, medium subangular blocky structure breaking to moderate, fine subangular blocky structure, firm, friable, sticky, plastic, no stones, moderate roots, pH 7.1, lower boundary abrupt and wavy.
C1	20+-36+	Pale yellow (2.5 YR 7/3) dry, pale yellow (2.5 Y 7/3) moist with some mottles of reddish brown (2.5 YR 5/4), clay, weak, medium subangular blocky to massive structure breaking to weak, fine subangular blocky structure, firm, friable, very sticky, plastic, no stones, very few roots, pH 6.7, lower boundary unknown.

VARIATIONS: Depth to restrictive clay layer varies from 15 to 22 inches.

Tentative Series P

A moderately shallow, wind deposited pumice ash soil resting directly upon bedrock (Andic cryoboroll). Profile development is minimal and resembles that in the "O" series. Infiltration is rapid and drainage is generally fair to good depending upon bedrock fracturing. It is characteristic of the mid-elevation range of Pinus ponderosa/ Festuca idahoensis type which often contains Purshia tridentata. Elevations range from 4800 to 5300 feet, slopes are generally less than 20%, and topography is undulating.

Horizon	Depth	Description
L	1/2-0"	Litter and some humus of pine needles and grass.
A21	0-4"	Brown (7.5 YR 5/2) dry, dark brown (7.5 YR 3/2) moist, fine sandy loam, no structure, nonsticky, nonplastic, abundant roots, pH 6.6, lower boundary gradual and smooth.
A22	4-10"	Brown (7.5 YR 4/2) dry, dark brown (7.5 YR 3/2) to very dark brown (7.5 YR 2/2) moist, fine sandy loam, weak, fine granular structure, soft, friable, slightly sticky, nonplastic, abundant roots, pH 6.4, lower boundary gradual and wavy.
A3	10-20"	Brown (10 YR 5/3) dry, dark brown (10 YR 3/3) moist, fine sandy loam, no structure, nonsticky, nonplastic, moderate roots, pH 6.4, lower boundary abrupt and wavy to irregular.
R	Bedrock	Bedrock is moderately to well fractured andesite or basalt, often with some chert and stone on the surface.

VARIATIONS: Depth to bedrock varies from 16 to 24 inches.

Tentative Series C

This series is a wind deposited pumice ash resting upon buried soil (Thapto cumulic cryandept). Profile development is quite poor in the pumicite layer but may be reasonably developed in the buried soil. The buried soil may be derived from basic or acid igneous rock or from sedimentary material. Infiltration is rapid and drainage is good. It is characteristic of the Abies grandis/Calamagrostis, Abies grandis/Bromus, and the Pinus contorta/Vaccinium/Calamagrostis types. Elevations range from 4000 to 7000 feet, slopes are variable but are often less than 30%, topography varies from undulating to rough.

Horizon	Depth	Description
L	1/2-0"	Litter and humus of tree needles and grass. Depth and composition of litter and humus varies depending upon fire history.
A21	0-2"	Grey brown (10 YR 5/2) dry, very dark brown (10 YR 2/2) moist, fine sandy loam, weak, very fine granular structure, soft, nonsticky, nonplastic, abundant roots, pH 6.0 to 6.2, lower boundary clear and smooth.
A22	2-8"	Grey brown (10 YR 5/2) dry, dark brown (10 YR 3/2) moist, fine sandy loam, weak, very fine granular structure, soft, nonsticky, nonplastic, abundant roots, pH 6.0 to 6.2, lower boundary gradual and smooth.
A3	8-25"	Brown (7.5 YR 5/2) dry, dark brown (7.5 YR 3/3) moist, fine sandy loam, moderate, very fine granular structure, soft, friable, nonsticky, nonplastic, abundant roots, pH 6.2 to 6.4, lower boundary abrupt and smooth.
Ab2	25-27"	Dark brown (10 YR 4/3) dry, dark brown (7.5 YR 3/4) moist, sandy clay loam, weak, fine subangular blocky structure, firm, friable, slightly sticky, slightly plastic, some stones, moderate roots, pH 6.4, lower boundary clear and smooth.

Horizon	Depth	Description
Bb2	27-33+	Yellowish brown (10 YR 5/4) dry, dark yellowish brown (10 YR 4/4) moist, gravelly clay loam, moderate, fine subangular blocky structure breaking to moderate, very fine subangular blocky structure, firm, friable, sticky, plastic, few to some stones, few roots, pH 6.4 to 6.6, lower horizon gradual to parent material on sedimentary rock, abrupt to bedrock on igneous flow rock.

VARIATIONS: Pumicite layer varies from 8 to 36 inches in depth. Buried soil varies from 4 to 24 inches in depth. Total soil depth varies from 24 to 70 inches in depth. Two phases have been proposed:

Yellow phase: Very similar profile description except that the pumicite colors are stronger in chroma ranging from 7.5 YR 7/6 to 7.5 YR 5/8.

This phase characteristically occurs at upper elevations in the *Abies grandis*/*Bromus vulgaris* and the *Pinus contorta*/*Vaccinium*/*Calamagrostis* types.

Colluvial phase: Slopes are generally greater than 25%. Stones and some gravel are mixed in the pumicite layer as the result of colluvial action, tree blowdown, or both. Generally, a layer of stone is present on top of the buried soil. Pumicite stone content varies from 10 to 30%.

APPENDIX E

Percent of plots burned by decades in seven forest associations as indicated by fire scars and charred logs and stumps.

Appendix E. Percent of plots burned by decades in seven forest associations as indicated by fire scars and charred logs and stumps.

Percent of plots burned by decade	Association						
	Pipo/ Putr/ Agsp	Pipo/ Putr/ Sihy	Pipo/ Feid	Pipo/ Cage	Abgr/ Caru	Abgr/ Brvu	Pico/ Vasc/ Caru
	2[1]	6	7	8	24	10	5
1960							
1950							
1940							
1930				12	8	10	
1920			29		8		
1910	50	33	14	37	8		
1900		33	29	50	36	10	
1890		17	14	25	17	10	20
1880	50	50		12	47		
1870		33	57	25	42	10	20
1860			43	37	42	10	
1850	50	33	29	50	33		
1840		66	43	63	47	10	
1830	50	50	29	12	47	10	
1820			57	25	29	10	
1810		50	29	25	33		
1800		17		25	25	10	
1790		17	29	25	17		
1780			14	12	29		
1770		17	14	12	21		
1760					8		
1750				12	21		
1740			14	12	17		
1730					4		
1720			29		4		
1710							
1700			14		4		
1690							
1680					8		
1670							
1660							
1650							
1640							
1630					4		
Unknown date of fire					8	50	60
Percent of plots with a record of fire	50	83	86	88	100	50	100
Average number of fires per burned plot	4.0	5.0	5.7	4.8	5.9	2.6[1]	1

1/Number of plots per association

2/Only one plot contained fire scar history. Eight fires were recorded.

APPENDIX F

Plant species reaction to grazing on ten vegetation associations as suggested by loop transect data.

Appendix F. Plant species reaction to grazing on ten vegetation associations as suggested by loop transect data.

Percent composition by plant species 1/	Arri/ Pose G/P	Arar/ Feid G/P	Arar/ Agsp G/P	Pipo/ Putr/ Agsp G/P	Pipo/ Putr/ Sihy G/P	Pipo/ Feid G/P	Pipo/ Cage G/P	Abgr/ Caru G/P	Abgr/ Brvu G/P	Pico/ Vasc/ Caru G/P
					Associations					
Decreasers										
Artemisia rigida	6/4									
Sitanion hordeoides	4/0									
Agropyron spicatum		8/0	36/6		2/0	4/0				
Purshia tridentata		2/0	4/0		18/12		4/0			
Carex geyeri						6/0	77/11	22/7		
Calamagrostis rubescens						7/2		58/5	2/0	36/11
Bromus vulgaris									21/4	
Decreaser or Palatable Increaser										
Poa secunda	68/30	10/24	44/56		8/14	0/4				
Trifolium macrocephalum	12/T	12/22								
Festuca idahoensis		26/2	0/4		0/5	62/42	0/4			
Sitanion hystrix		0/4	1/7		22/17	2/6	0/5			
Carex rossii					18/11			0/24		
Stipa occidentalis					5/2	0/6				
Palatable Increasers										
Poa nervosa					2/18	0/4	0/9	2/11		
Lupinus caudatus								3/5		
Hieracium albiflorum								2/4	3/5	2/6
Lupinus latifolius									3/7	5/17
Unpalatable Increasers										
Artemisia arbuscula		20/34	7/17							
Phlox douglasii	1/4	6/12	0/4							
Balsamorhiza serrata		2/18	0/3							
Achillea milefolium			2/6		3/7	4/12	1/6	2/13		
Fragaria vesca crinita								1/6		
Arnica cordifolia								8/14		

(continued)

Percent composition by plant species 1/	Associations									
	Arri/ Pose G/P	Arar/ Feid G/P	Arar/ Agsp G/P	Pipo/ Putr Agsp G/P	Pipo/ Putr/ Sihy G/P	Pipo/ Feid G/P	Pipo/ Cage G/P	Abgr/ Caru G/P	Abgr/ Brvu G/P	Pico/ Vasc/ Caru G/P
Fragaria virginiana platypetala								1/5	3/5	4/7
Mitella stauropetala									4/8	
Vaccinium scoparium										8/28

1/ G: data gathered from good or excellent condition ranges.
P: data gathered from poor condition ranges.

APPENDIX G

Vegetation Maps

APPENDIX G

Vegetation Maps

BASIC VEGETATION MAP

Vegetation is mapped according to the ecological classification shown in the text. This map is reproduced from U. S. Forest Service records on the Paulina District, and is part of the former Badger Creek Allotment.

Topography is undulating (Figure 3) with macrorelief facing a southerly direction. Elevation ranges from 4000 feet at the ranger station to 6372 feet at the summit of Wolf Mountain.

The ranger station, at the bottom of the map, is on the edge of the forest-Artemisia steppe transition.

Map Legend.

Artemisia rigida/Poa secunda association (Arri/Pose)

Artemisia arbuscula/Agropyron spicatum association (Arar/Agsp)

Pinus ponderosa/Festuca idahoensis association (Pipo/Feid)

Pinus ponderosa/Carex geyeri association (Pipo/Cage)

Abies grandis/Calamagrostis rubescens association (Abgr/Caru)

I = soil deeper than 40 inches, site 81 to 90 phase. I

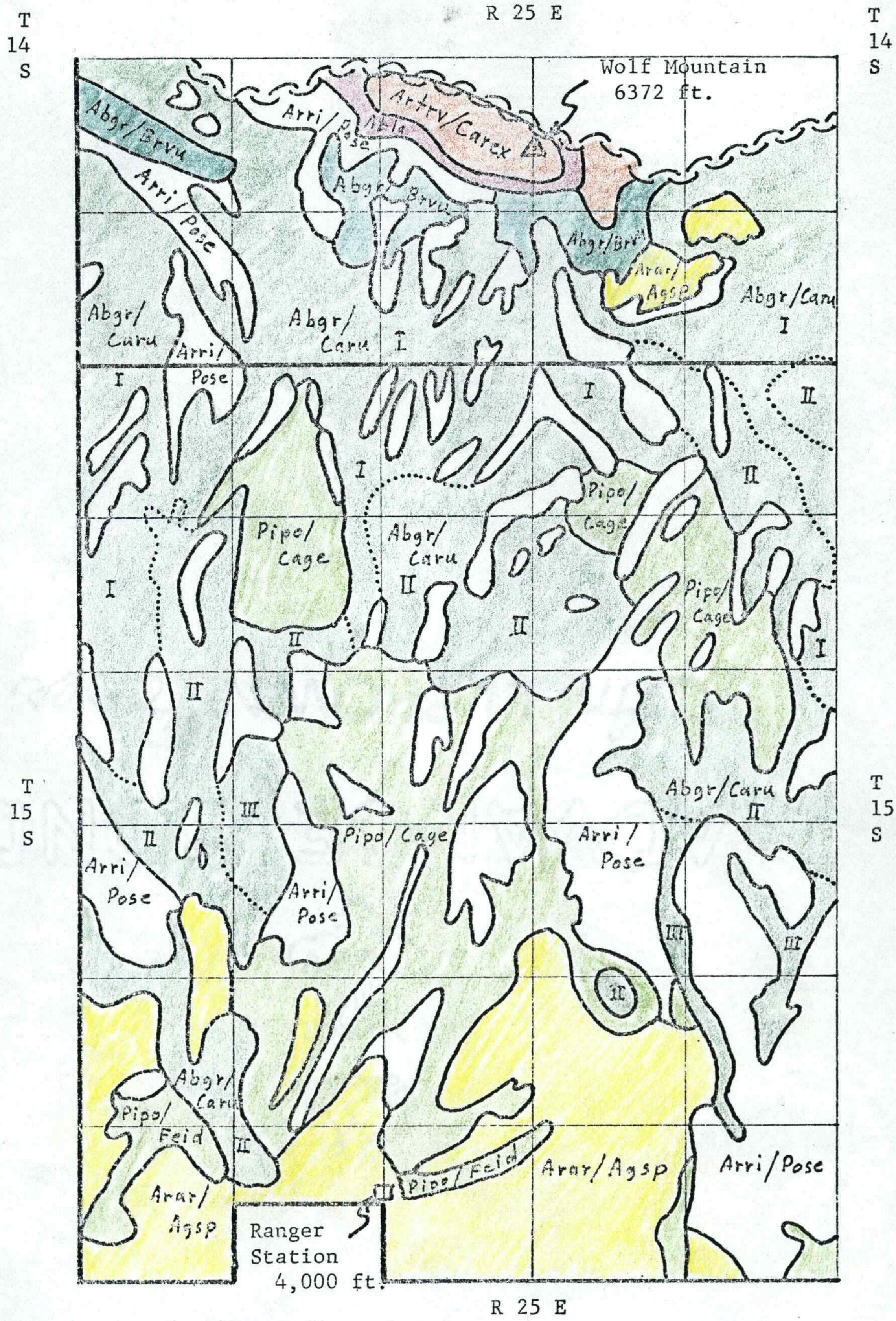
II = 25 to 40 inches of soil, site 74 to 80 phase. II

III = 18 to 24 inches residual soil, site 66 to 73 phase. III

Abies grandis/Bromus vulgaris association (Abgr/Brvu)

Abies lasiocarpa/Pinus contorta association (Abla/Pico)

Artemisia tridentata var. vaseyana/Carex association (Artrv/Carex)



BASIC VEGETATION MAP

TIMBER TYPE MAP

The timber type map is based upon existing tree cover. This vegetation is delineated on a map containing association lines from the Basic Vegetation Map. Where existing vegetation is different within a vegetation association, an additional vegetation type line is drawn. Examples are Sections 31 and 35, T14S, R25E. In these cases, *Pinus ponderosa* dominance was replaced by fir. This delineation is essential for timber management.

Notice that existing vegetation is quite different from potential vegetation in relation to dominance of *Pinus ponderosa*.

Map Legend

P = sawlog size *Pinus ponderosa* (dominant species are listed first).

D = sawlog size *Pseudotsuga menziesii*. 

W = sawlog size *Abies grandis*. 

L = sawlog size *Larix occidentallis*. 

A = sawlog size (or mature) *Abies lasiocarpa*. 

Stocking:

Small case letters indicate the dominant species of reproduction. They correspond to the above designations. If reproduction is the same as the dominant species, no letter is given.

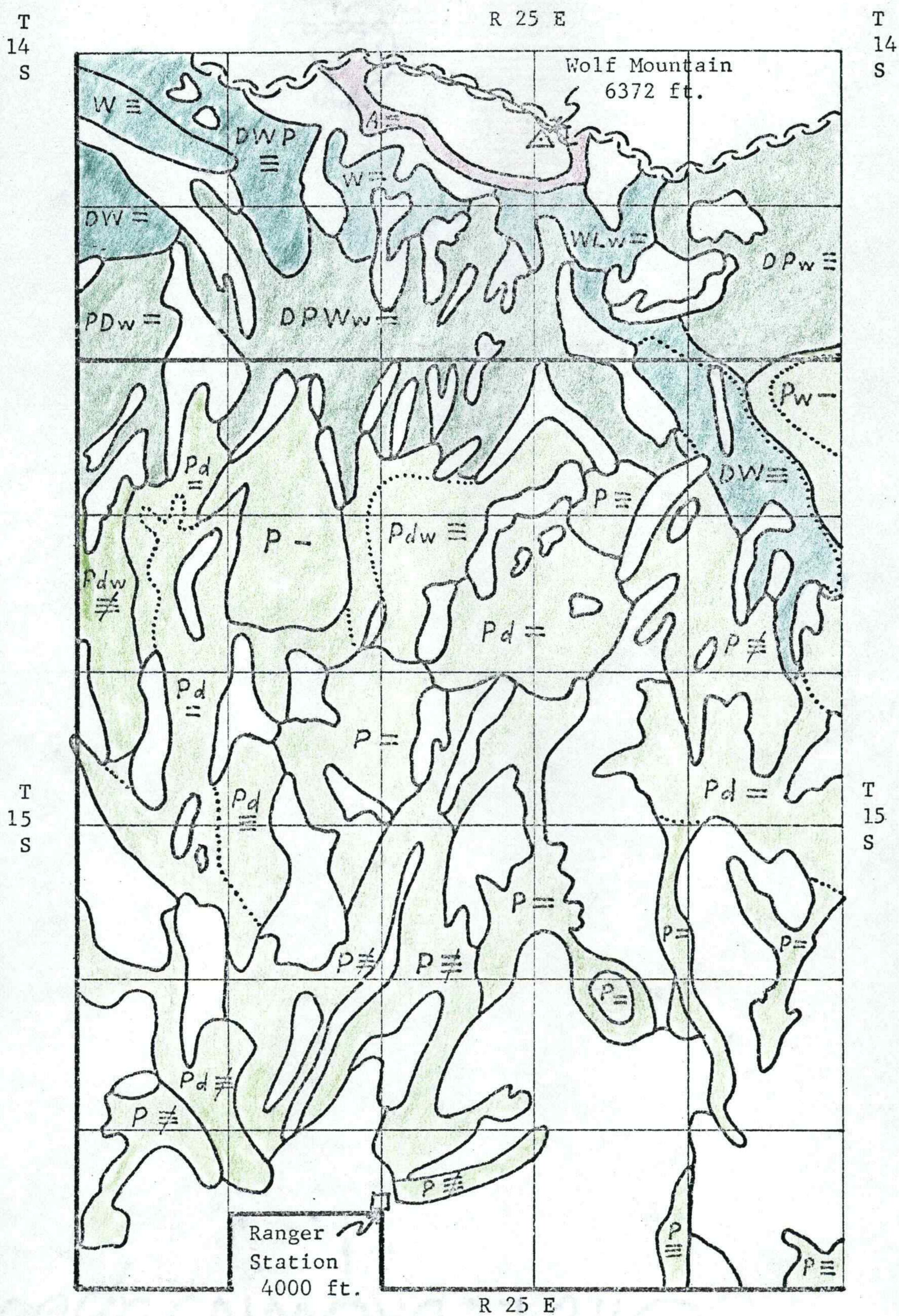
Degree of stocking is based on recommendations for each vegetation type.

= understocked, need for corrective measures.

= marginal stocking, low priority for corrective measures.

= adequately stocked.

= over-stocked, requires thinning.



TIMBER TYPE MAP

RANGE TYPE MAP

The range type map is based upon existing vegetation. This vegetation is delineated on a map containing lines from the Basic Vegetation Map. Where existing vegetation is different within a vegetation association, an additional type line is drawn. This is particularly common for range types where both range condition and intensity of animal use are mapped. A good example is the *Artemisia arbuscula*/ *Agropyron spicatum* association east of the ranger station. In this case, it had to be divided into three categories: primary range in good condition, primary range in fair condition, and secondary range in good condition. This delineation is desirable for range management purposes.

Colors are used for primary range and unsuitable range. These colors draw one's attention to directly opposite categories of animal distribution. Uncolored types are lightly used areas that have the potential for increased grazing. This is one method of quickly appraising livestock distribution and selecting possible areas for improving distribution.

Map Legend

Range types are named as follows: P-6d-Cage-Caru-F
(1)(2) (3) (4)

(1) Intensity of animal use:

P = primary range: that range which is most heavily used.

S = secondary range: areas which receive light use.

U = range unsuitable for grazing, the cause is given:

Dense = dense timber prohibiting livestock or causing low forage production.

VP = very poor condition range that does not produce enough forage for livestock.

Unsuitable range is colored grey 

(2) Abbreviated notation of the ecological types.

4a = *Artemisia rigida*/*Poa secunda* association and condition guide.

1b = *Artemisia arbuscula*/*Agropyron spicatum* association and condition guide.

6c = *Pinus ponderosa*/*Festuca idahoensis* association and condition guide.

6d = *Pinus ponderosa*/*Carex geyeri* association and condition guide.

6e = *Abies grandis*/*Calamagrostis rubescens* association condition guide.

6f = *Abies grandis*/*Bromus vulgaris* association (no guide).

6g = *Abies lasiocarpa* association (no guide).

4h = *Artemisia tridentata* var. *vaseyana*/*Carex* association (should have a guide).

(3) The two dominant subordinate vegetation species regardless of their palatability for livestock.

(4) Condition of the range type based on the condition and trend guide for the particular type.

Primary Range Color

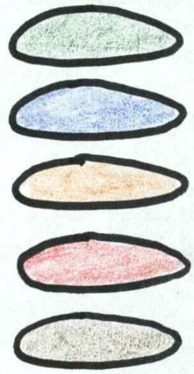
E = Excellent condition

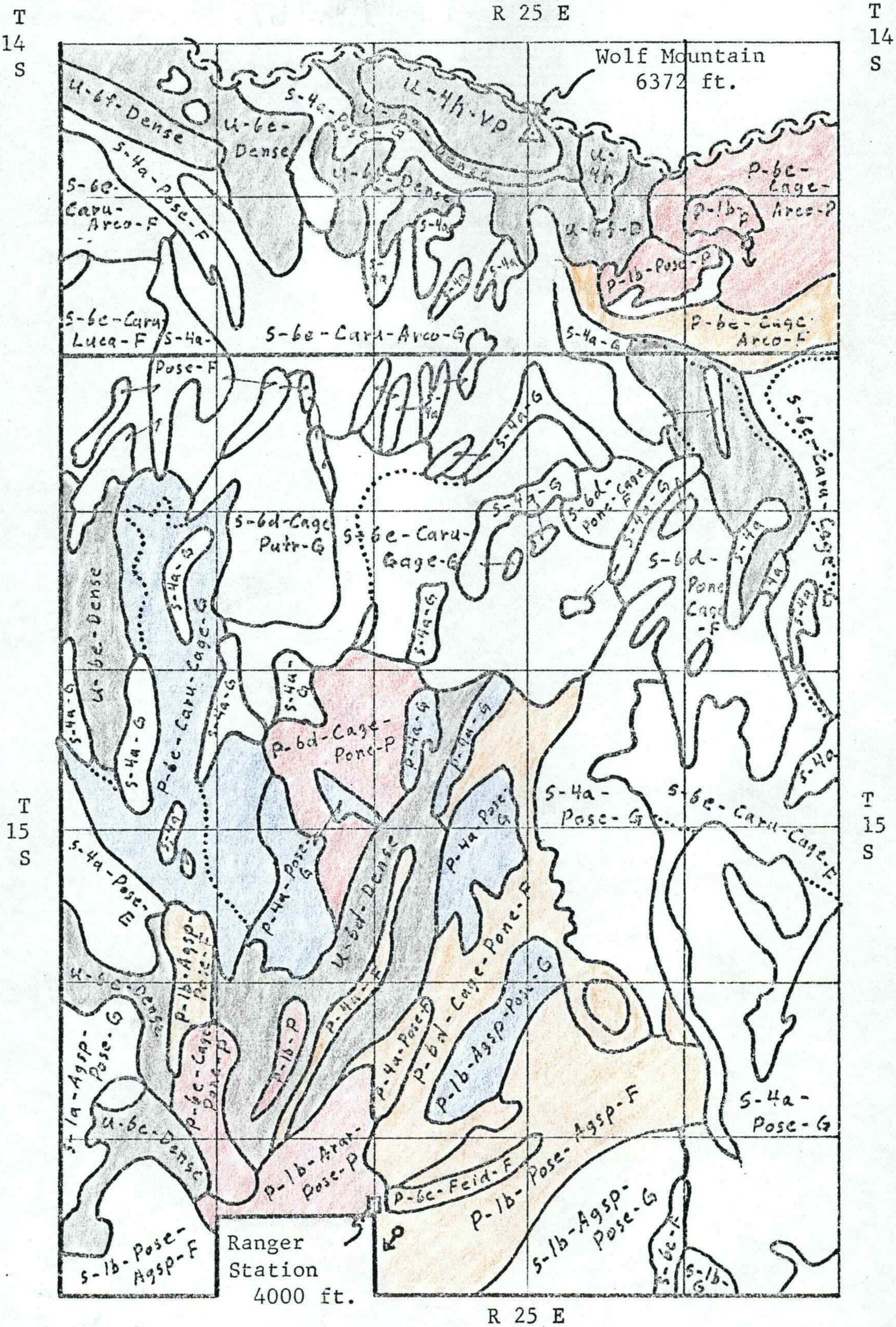
G = Good condition

F = Fair condition

P = Poor condition

VP = Very poor condition





RANGE TYPE MAP