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Abstract approved
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The study was conducted over approximately 191, 000 acres in central Klamath County, Oregon. The research had three objectives: first, to describe and classify the seral and near-climax vegetation by using polyclimax principles; secondly, to determine the southern extension of five plant associations and one plant associes as previously described by C. T. Dyrness within the Weyerhaeuser Antelope Unit; and thirdly, to determine the inherent variability of these and other plant communities on young pumice soils over various elevation and relief patterns.

The sampling was limited to those soils derived from aerially deposited pumice of Mt. Mazama origin. These included the widely distributed Lapine soil series and the less prevalent Longbell and Shanahan soil series. Their profiles are characterized by an A00, A1, AC, C, and D horizon sequence. A qualitative reconnaissance method permitted the gathering of vegetation, soil and physiographic data from a large number of variable-sized sample locations. These locations were statified to obtain a homogeneous vegetation-soil sampling unit. The association table was used to synthesize the analytical stand data into units of similar ecology. The mechanics of association table construction are described.

The *Pinus ponderosa*/*Purshia tridentata*, the *Pinus ponderosa*/*Purshia tridentata*/*Festuca idahoensis*, the *Pinus ponderosa*/*Purshia tridentata*-*Arctostaphylos parryana* var. *pinetorum*, the *Pinus ponderosa*/*Ceanothus velutinus*-*Purshia tridentata*, the *Pinus ponderosa*/*Arctostaphylos parryana* var. *pinetorum*-*Ceanothus velutinus* and the *Abies concolor*/*Ceanothus velutinus* association plus the *Pinus ponderosa*/*Ceanothus velutinus* associes are defined and characterized as they occur in the study area. Factor compensation plays a significant role in determining the location of these classification units since any single plant community may occur over several different soil and physiographic situations.

The appearance of these associations over the landscape is presently determined by the young soils and the local physiographic features. Therefore, their representative stands are designated as edaphic or topo-edaphic climaxes depending upon the location of these stands in relation to the typical elevational range of the association. The Pinus ponderosa/Ceanothus velutinus associes is considered to be an early successional stage of the Abies concolor/Ceanothus velutinus association as evidenced by the rapid encroachment in the Pinus ponderosa/Ceanothus velutinus understory of mesic-tending tree and herbaceous species. In addition, the characteristic species which are common to both communities express similar presence and dominance values, and their physical environments are similar. Heavy seed pressure from mesic species on locally favorable micro-environments permit fragmentary expressions of the Abies concolor/Ceanothus velutinus association to appear in the adjacent ecosystems representative of more xeric-tending effective environments.

The variability in the species' presence and relative dominance as they occur among and within ecological units can be partially explained by the species' autecological requirements in relation to the physical environments typical of each ecological unit. The influence of an effective environment upon some species is reflected in the growth form, vigor and phenology of these species and their competitive relationships to other species in the stand.

The utilization of this ecological knowledge is related to the timber, range and wildlife resources of the Upper Williamson River Basin. As emphasized, however, effective resource management is achieved only by an understanding of the plant and animal environment, a realization of the biological principles related to these environments, and the economical regulation of resource use within the framework of these biological limitations.

PHYTOSOCIOLOGY OF THE PONDEROSA PINE TYPE ON PUMICE SOILS IN THE UPPER WILLIAMSON RIVER BASIN, KLAMATH COUNTY, OREGON

by

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS, (Continued)

LIST OF FIGURES

PHYTOSOCIOLOGY OF THE PONDEROSA PINE TYPE ON PUMICE SOILS IN THE UPPER WILLIAMSON RIVER BASIN, KLAMATH COUNTY, OREGON

INTRODUCTION

The study of plants and plant environments may be pursued from three closely related, but distinctly different viewpoints. One alternative is to study the environment and surmise its influence upon the plants from what is known about the plant's requirements and tolerances. Another approach, often used by plant physiologists, is to determine the response of the plant to individual factors of its environmental complex. The third method investigates both the plant and its environment in their natural settings. This latter viewpoint is frequently employed in plant ecology and is the method used in the present study.

This work was conducted in the pumice soil area of central Klamath County which resulted from the eruption of Mt. Mazama and the subsequent formation of Crater Lake. The sampling was limited to immature pumice soils of aerial deposition and intentionally excluded the pumice flow soils to the west of the Klamath Marsh.

The synecology of the ponderosa pine type on pumice soils in south central Oregon has been investigated by C. T. Dyrness

(22) on the Weyerhaeuser Antelope Unit. The present study has three primary objectives: first, to define and characterize the seral and near-climax vegetation in relation to habitats of the Upper Williamson River Basin; secondly, to determine the extent to which the five vegetation associations and one seral plant community characterized by Dyrness are expressed southward from his research area; and thirdly, to determine the inherent variability of these and other associations as they occur on Lapine, Longbell, and Shanahan soils in varying elevational and relief positions.

In this study, a qualitative reconnaissance method was used to facilitate the gathering of vegetation and site data from a large number of sample locations. By employing the reconnaissance method, reliable ocular estimates of several qualitative vegetation and site characteristics, as well as accepted soil descriptions were obtained on 130 sample locations over approximately 191,000 acres in a total of 55 working days.

The extensive coverage permitted by this method far outweigh any present value of more quantitative, yet more restrictive data--especially since the synecology of pumice soils and their related vegetation is not fully understood at the present time. Such an understanding is achieved when the description and classification of vegetation-soil units precedes an interpretation of the dynamic phenomenon within this vegetation-environment complex. At this point, hypotheses concerning the phytosociology may be developed. The subsequent confirmation or rejection and modification of these hypotheses will require more intensive study than is feasible by reconnaissance interpretation. Through this sequence of reconnaissance to quantitative study, an understanding of the synecology of the upper Klamath Basin may become fully effective.

The utilization of synecological studies in the resource management of the upper Klamath Basin is fundamental to the economic development of this region. A phytosociological approach to the description, classification and interpretation of plant communities permits the use of the vegetation as an index for ascertaining similar effective environments. Therefore, the landscape is visualized as being a mosaic of several ecological units, each ecological unit having its own vegetation and site factor complex, management problems and production potential. However, the managing of natural resources upon ecological principles is dictated neither by ecological thinking that is oblivious of economic considerations, nor by the unrestricted expenditure of monies that are available. But any resource is managed by using the ecological knowledge of the resource as a device to wisely control the disbursement of funds, labor skills and energy so that an optimum return results for each dollar spent towards its utilization and integration into the land management program.

DESCRIPTION OF AREA

General

The Upper Williamson River Basin is located in Klamath County about 40 miles northeast of Klamath Falls, Oregon. These investigations were conducted in an area of approximately 191,000 acres of Winema National Forest, Klamath Indian Forest,[1] and private land. The study area is bordered on the west by Klamath Marsh and the lower portion of the Williamson River; on the south by the line separating Townships 33S. and 34S., Williamette Meridian; on the east by the western boundary of the Weyerhaeuser Longbell Tract and the line separating Ranges 11E. and 12E., Williamette Meridian; and on the north by Townships 28S. and 29S., Williamette Meridian (Figure 1). The Antelope Unit of Weyerhaeuser Timber Company where C. T. Dyrness conducted his synecological study is located adjacent to the northeastern corner.

The Williamson River and its tributary creeks drain most of the work area; however, a small portion of the southern

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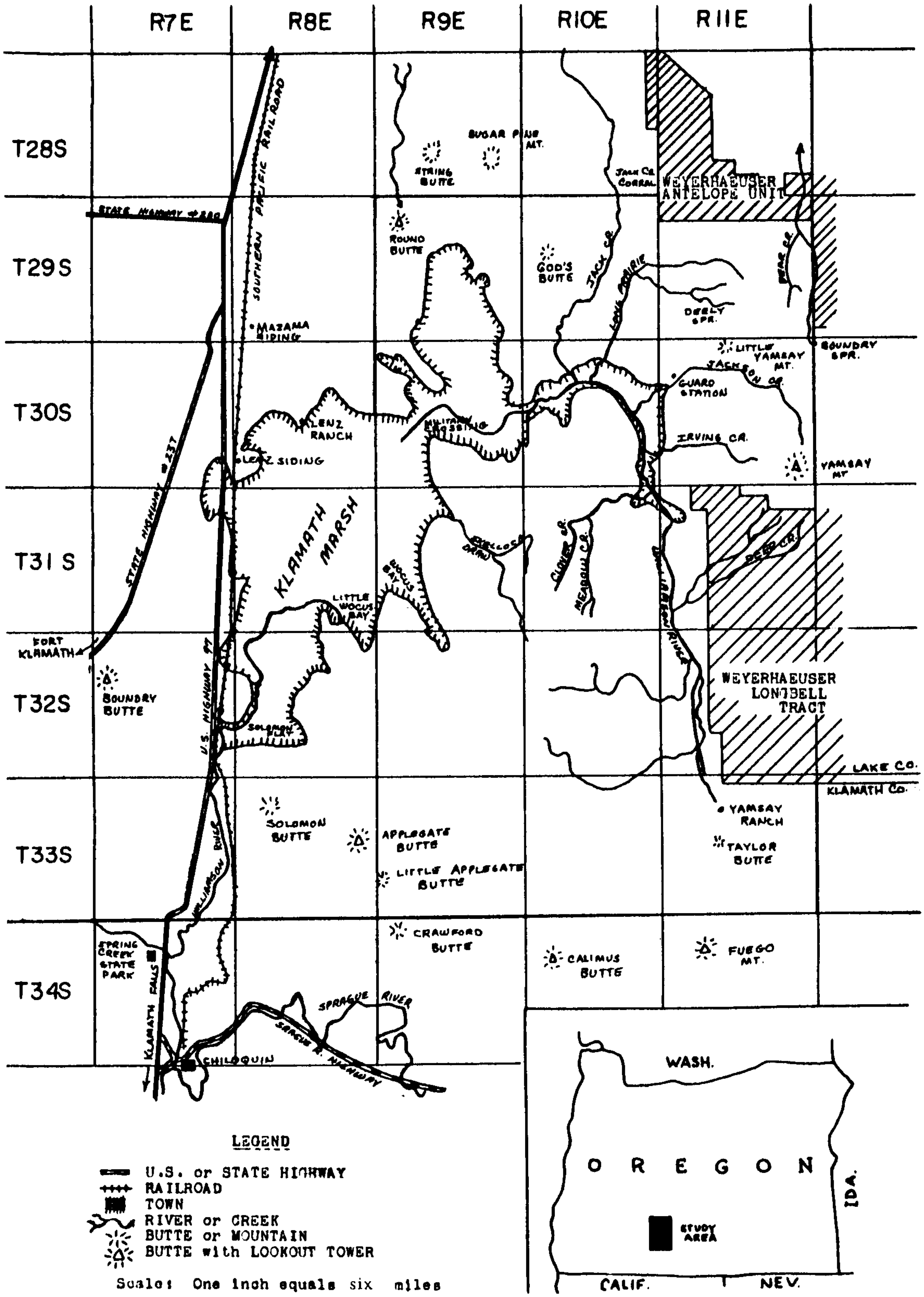
[1] The Klamath Indian Forest includes the land that remains after the termination of the Klamath Indian Reservation by the Proclamation of April 13, 1961. The Klamath Indian Forest is owned by the Klamath Indian Tribe and is managed in trust by the U. S. National Bank.

Figure 1. Map of Williamson River Basin, Klamath County, Oregon.



section is either internally drained or drained by the Sprague River. The Sprague River flows into the Williamson River at Chiloquin, Oregon, and the latter river flows into Klamath Lake.

Geology

The local geological formations indicate much volcanic activity was present within and adjacent to the study area since early Pliocene time. The presence of basalt outcrops, old volcanoes, cinder cones, large fault scarps, and deposits of volcanic tuff and pumice are evidence to the variability of the volcanic activity that has occurred in the past.

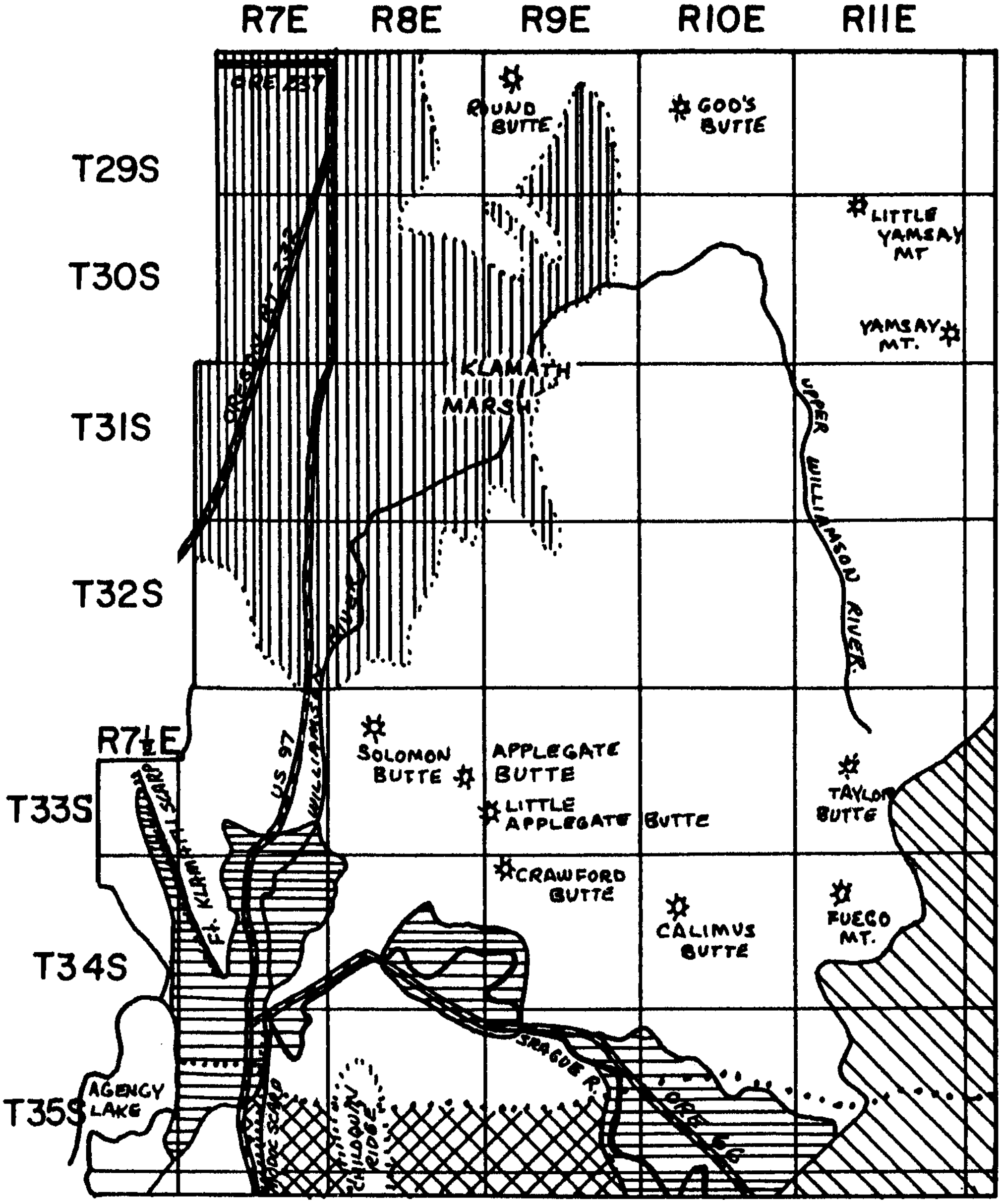
In early Pliocene, andesites and basalts extruded from fissures in the ground and dammed the Klamath River to form a series of fresh water lakes (51). During the Pliocene epoch, diatomaceous material was deposited as lake formations together with local extrusions of basaltic, pyroclastic material. These diatomaceous beds can be seen in the road cut north of Spring Creek State Park on U. S. 97 located southwest of the study area. The volcanic tuff and weakly-cemented, fine-grained sand underlying much of the area adjacent to the east shore of the north Klamath Marsh is attributed to this epoch.

In late Pliocene time, fluid basalt again began to extrude from fissures and shield volcanoes. These flows deposited igneous beds from 300 to 1000 feet thick, and created a landscape with very little relief (4; 51). The beds consist of semi-consolidated olivine basalt and hypersthene andesite cooled in the form of massive, platy or columnar jointing, pillow lavas or flow breccia. All these lava forms can be observed within the study area.

The basalt deposition continued into the Pleistocene epoch but was interrupted by periods of faulting. The faulting has been estimated to occur during the upper Pliocene, Pleistocene, and Recent epochs (51, p. 44). The faulting appeared in a northwest-southeast direction along zones of weakness and has contributed to the present relief pattern in the study area. Chiloquin Ridge, south of the area, is an example of a Pliocene fault block mountain. The Modoc and Fort Klamath fault scarps (Figure 2) were uplifted during the Recent epoch. The Klamath and Agency Lake Basins has resulted from the down dropping between the Modoc and Fort Klamath scarps and the Cascade Range scarp (76, p. 33).

During the Pleistocene period, volcanoes and composite cinder cones developed along the fault lines (51). Little Yamsay Mountain (5955 feet), Applegate Butte (6015 feet), and Crawford Butte (5200 feet) are examples of cinder cones. Yamsay Mountain (8085 feet), Fuego Mountain (6810 feet), and Sugarpine Mountain (6338 feet) are volcanoes in the study area (Figure 2). Mt. Mazama was a

Figure 2. Geology Map of Williamson River Basin, Klamath County, Oregon.[1]



LEGEND

STATE OR U.S. HIGHWAY — RIVER

EXTINCT CONE OR VOLCANO — FAULT BLOCK MOUNTAIN

PUMICE MANTLE BOUNDARY (PUMICE OVER PLIOCENE BASALT)

PLIOCENE BASALT BROKEN INTO FAULT BLOCKS — PLIOCENE DIATOMITE TUFF FORMATION

QUATERNARY BASALT FLOW — PUMICE FLOW AREA

[1] U.S. Bureau of Indian Affairs, Soil Conservation Service, and Oregon State College cooperating. Soils of the Klamath Indian Reservation (Interim Report). 1958. p. 52.

Scale: 3 0 3 6 9

Pleistocene volcano located along the Cascade Range scarp to the west of the study area.

Between the last of the Pleistocene basalt flows and the eruption sequence of Mt. Mazama about 7,600 years ago (89), a relatively inactive period occurred. During this intervening period, a solum was developed from aeolian volcanic ash that was deposited upon the Pleistocene basalt flows by active volcanoes of that epoch (22, p.126). This solum is represented by the buried soil which underlies much of the pumice deposits in the area.

The eruption of Mt. Mazama, now Crater Lake, deposited the pumice mantle which covers most of the study area. This aerial transportation and deposition has greatly influenced the physiognomy of the pumice soils. Stratification of the coarser pumice gravels is apparent throughout all but the southern-most portion of the study area. The pumice particle size and deposition depth also decreases as one proceeds eastward toward Yamsay Mountain from the source. The pumice particle size and depth differentiation is related to the direction of movement of the pumice cloud from the source, the particle mass per unit of surface area, and the distance of the site from the source (76, p. 40-43). The thickest beds, five to 20 feet thick, are located to the south and east of Klamath Marsh (80, p. 2). The pumice deposits which are located on the west slope of Yamsay Mountain are usually less than two feet deep.

The pumice is composed mainly of dacite. The major constituents are silica, alumina, and soda. An individual particle may contain phenocrysts of feldspar, hornblende, hypersthene, augite, and magnetite. A few soil profiles exhibit small fragments of foreign rock material theorized to have been blown from the volcano walls during the most violent activity (80). The pumice particles are neither cemented nor compacted and retain their angular or subrounded, equidimensional shape remarkably well when subjected to soil weathering processes.

Topography

The topography of the Upper Williamson River Basin has retained features indicative of its recent volcanic origin. From Yamsay Mountain, the majority of the gentle slopes face a westerly direction. The combination of basalt flows and stream erosion has created narrow canyons that disect the west-facing slopes at high elevations. As a result, many east-west ridges predominate in this section of the study area.

At lower elevations, major changes in relief are created by fault scarps, raised plateaus, and cinder cones. Numerous northwest-southeast ridges and scarps (4800-5500 feet) are located in the central and southern portion of the study area. These parallel-arranged ridges are interspersed by low, nearly flat, basins.

The raised plateaus (4600-5000 feet) are characteristic of the north and central portion of the study area. These tablelands may be elevated 100 to 300 feet above the surrounding basins and drainages. The plateaus have undulating to rolling relief; whereas, the adjacent basins and drainages are flat or concave.

The composite cinder cones (4800-6500 feet) are widely scattered throughout the upper Klamath Basin. The smaller cones are moderately symmetrical from all aspects; but they may have a ridge-swale microrelief. The larger cones are more complex in their arrangement of ridges and draws.

The major tributary streams of the Williamson River rise and drain either the west slopes of Yamsay Mountain or the high plateau sections of the study area. The stream canyons of Yamsay Mountain are characterized by v-shaped bottoms, steep slopes, and numerous basalt outcrops. The creeks that drain the plateau areas generally form broad bottoms with adjacent steep slopes ascending to the surrounding tablelands. Many of the basins and draws located within the plateau and fault scarp areas are internally drained and support small, narrow meadows and/or dense stands of Pinus contorta. The Klamath Marsh

(4500 feet), a lowered plateau, lies to the south and west of the plateau area and to the northwest of the fault scarp area. The presence of this large body of water may influence the micro-climate of the adjacent forest stands.

Climate

The climate of the study area is characterized by having cool, dry summers and cold, wet winters. The closest weather stations to the Upper Williamson River Basin are at Chemult, located 14 miles northwest; and Chiloquin, located ten miles to the southwest. Chemult has a 20-year mean annual precipitation of 25.77 inches and Chiloquin received 18.08 inches mean annual precipitation over the same period.

Both stations are climatologically atypical as compared to the research area. Chemult (4760 feet) lies in a basin to the west of Walker Rim. Chiloquin (4198 feet) lies in a river basin between two *Pinus ponderosa*-covered hills[2] at the confluence of the Williamson and Sprague Rivers. Since both stations lie at lower elevations, their weather data are only suggestive of conditions that may occur

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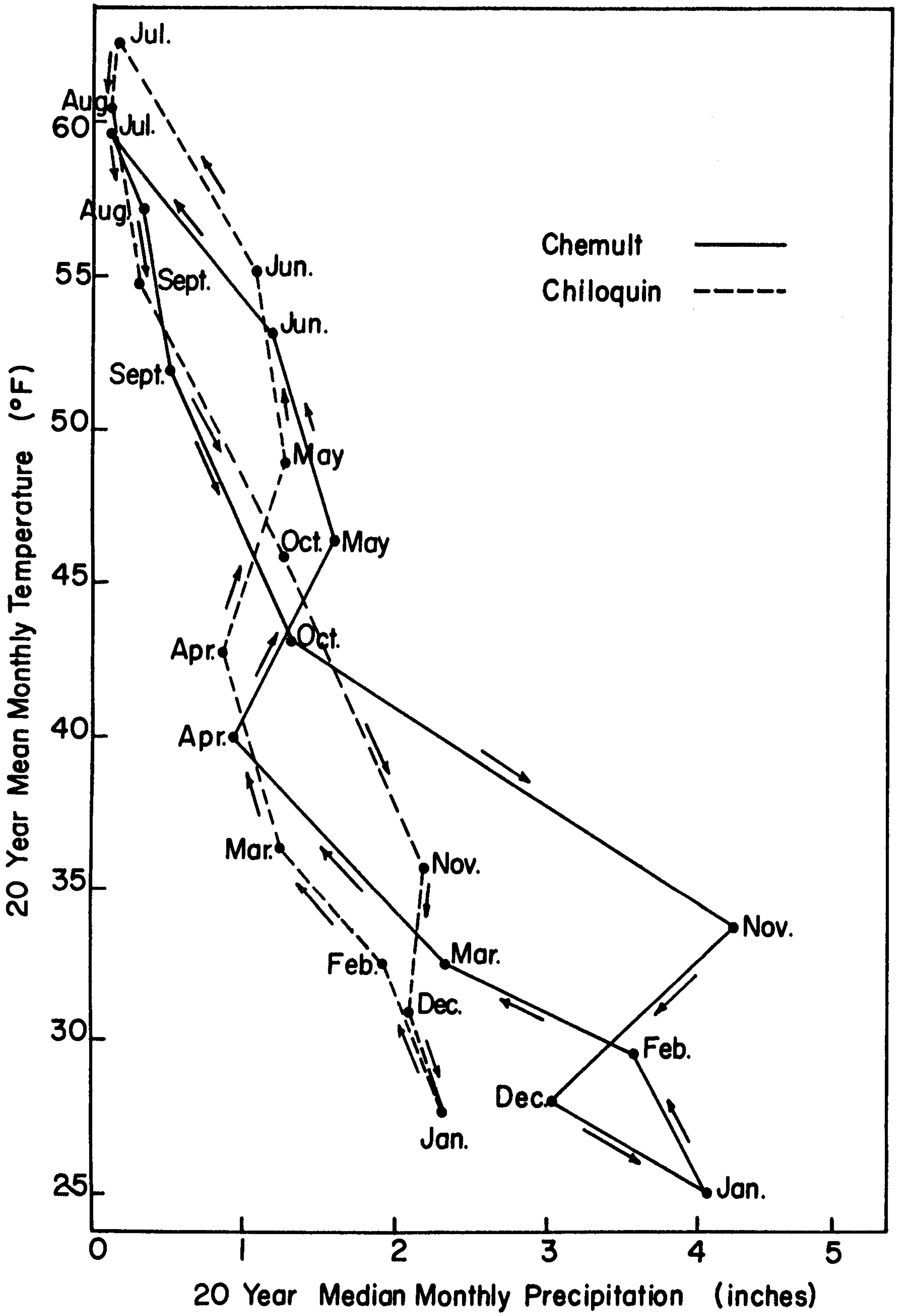
[2]The common names of all species that are mentioned in the text are listed in Appendix C, Table 4.

within the complex patterns of relief and high elevations typical of the study area.

Daubenmire (16) showed that hythergraphs of mean monthly temperature over median monthly precipitation correlated more closely with vegetation distribution than any of the more popular climatological indexing methods. He favored median precipitation because these figures are influenced less by extreme values. Since well-established plants and perennial vegetation are infrequently damaged by weather extremes, Daubenmire (16, p. 136) also concludes that the mean maximum or minimum temperature figures are not superior to the mean monthly values. For these reasons, the climate of the study area is presented as a hythergraph for the Chemult and the Chiloquin stations using median monthly precipitation and mean monthly temperature data over a 20-year period. These hythergraphs are developed from the data listed in Appendix C, Table 1 and are shown in Figure 3.

Chemult receives more precipitation during the winter months and less precipitation during the summer than Chiloquin. At the same time, Chemult has slightly lower temperatures throughout the year. This climatological difference may be explained by the change in elevation between the two stations and the location of the Chemult station within a cold-air drainage basin.

Figure 3. Hythergraphs for the Chemult and Chiloquin, Oregon weather stations (1942-1961 inclusive).



When these graphs are compared to those constructed by Daubenmire for the *Pinus ponderosa* type of the northern Rocky Mountains, many similarities are evident. The Chiloquin climograph shows a similar precipitation pattern; but the summer and autumn months are cooler, and the winter months warmer than the eastern Washington and northern Idaho *Pinus ponderosa* stations. The Chemult station is wetter in winter and drier in spring, and cooler in winter and spring than the eastern Washington and northern Idaho stations. This difference between the Chemult hythergraph and the northern Rocky Mountain family of hythergraphs is further suggestive of a cold-air drainage at the Chemult station. As may be expected (90), *Pinus contorta* and *Purshia tridentata* inhabit the Chemult area.

No direct comparison can be made between the climate of the Antelope Unit of the Weyerhaeuser Timber Company and the climate of the Upper Williamson River Basin since weather stations in both areas are lacking and microclimatic differences may prevail between the two areas due to changes in relief and aspect. However, a very short frost-free period is typical of the entire upper Klamath Basin--especially at higher elevations, in creek and valley bottoms, and on north-facing slopes. The Chemult station records one to four frost-free days quite regularly over the years.

Soils

The soils of the Upper Williamson River Basin that have pumice as their parent material are described in Soils of the Klamath Indian Reservation (76). The Dilman-Wickiup-Lapine catena is found extensively; while the Shanahan series and tentative Longbell series are found less common throughout the study area.

The Dilman series is a poorly-drained Humic Gley or Regosol of low, narrow drainage ways, depressional areas, and basins. The series is associated with much of the meadow vegetation of the study area.

The Wickiup series is an imperfect to poorly-drained Regosol of the narrow transitional zone between the meadow or basin areas downslope and the slightly steeper topography upslope. In some instances, these soils are found in low basins with high water tables. The series is important in the production of *Pinus contorta*.

The Lapine series (Figure 4) is the well to excessively drained member of the Dilman-Wickiup-Lapine catena and is the most widely distributed of the pumice-derived soils (4600-6500 feet). The series is associated with the production of *Pinus ponderosa* on undulating to mountainous topography, and *Pinus contorta* in some depressional, cold-air accumulation areas. The soils have

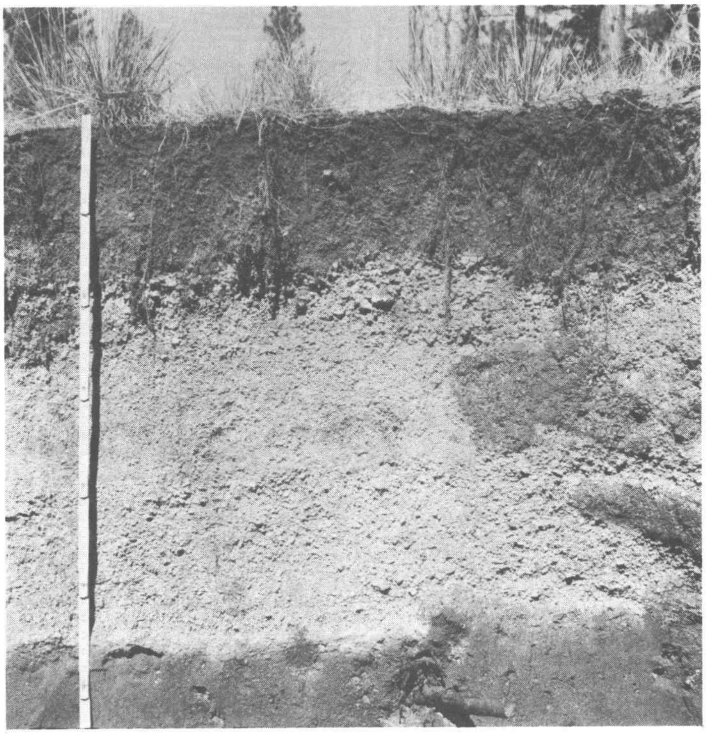


Figure 4. Lapine soil profile, moderately deep phase. A pocket of mixing occurs in the C horizon. Pinus ponderosa root protrudes from the D horizon.

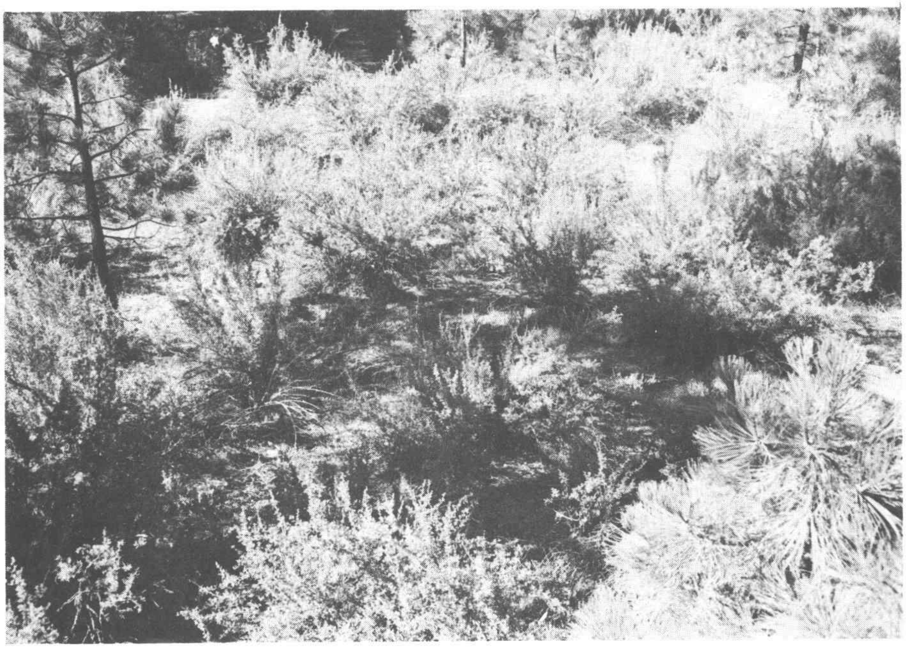


Figure 5. Close-up view of Pinus ponderosa/Purshia tridentata stand in excellent range condition.

a A00 and A0, A1, AC, C, and D horizon sequence.[3]

Many Lapine soil profiles in the northern and eastern section of the area have a C1 horizon of coarse pumice gravels and a C2 horizon of fine pumice gravels. The C2 horizon is light gray (10YR 7/2 moist), 12-64 inches thick and overlays a layer of light gray, silty material. The silty layer may be 1/4 inch to one inch thick, white (2.5YR 8/0 moist) or light gray (10YR 6.5/1 moist) in color. The physical composition of this layer closely resembles that of the D horizon and is considered to be derived from volcanic ash (22, p. 123-124). The D horizon is a buried soil unrelated to the pumice solum. This horizon is reddish brown, dark reddish brown or dark brown (5YR 4/4, 3/4, 7.5YR 4/4 moist) in color, clay loam, silty clay loam or sandy loam texture, and derived from volcanic ash of aeolian origin. Basalt or andesite stones and rock fragments or cinder gravels may be found mixed with the D horizon material. The presence of mottling in the D horizon may indicate impeded drainage within those Lapine soils that occupy level areas or gentle slopes into basins.

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[3]Complete profile descriptions for the Lapine, Longbell and Shanahan series are listed in Appendix C, Table 3.

The tentative Longbell series (Figure 6) is an excessively to well-drained Regosol associated with Pinus ponderosa, Pinus lambertiana, Abies concolor and Pinus monticola. The series appears in the eastern section of the study area, on nearly level to moderately steep topography between 5100 and 6500 feet elevation; and consequently, develops in areas of thin pumice mantle. The soils have a A00, A1, AC, C, and D horizon sequence, similar to that sequence encountered in Lapine profiles.

Like the Lapine series, Longbell soils may have both coarse and fine pumice gravel layers in the C horizon. However, the C1 horizon is usually thin or present as occasional pockets. In addition, the light gray, silty layer may also be present between the C and D horizons. The D horizon, located 20-48 inches below the soil surface, may vary from a sandy loam to clay loam texture, and may be derived from volcanic ash of aeolian origin. Basalt rock fragments or red cinder gravels are usually mixed with the D horizon soil.

Both the Lapine and Longbell series may exhibit areas of AC and D material mixed with the pumice gravels of the C horizon. The Lapine series is differentiated from the Longbell series by having less than 50 percent mixing of the AC and/or D horizon material in the C horizon. Therefore, when viewed in a

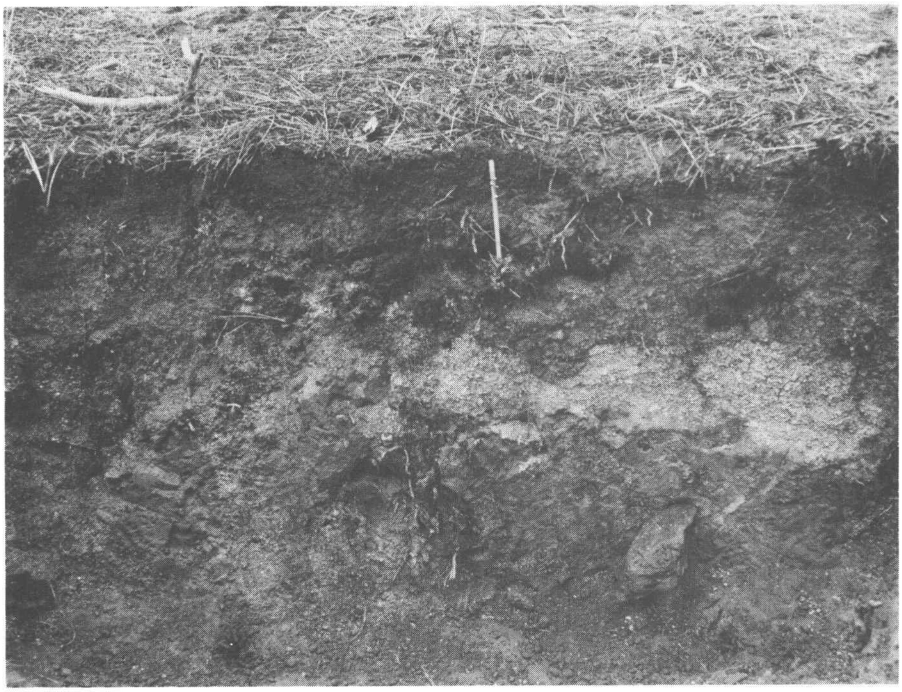

Figure 6. Longbell soil profile, shallow phase. Note pocket of raw pumice gravels in C horizon. C-D horizon boundary is diffuse and irregular. Pencil represents six inches.

Figure 7. Shanahan soil profile, shallow phase. Notice uniform mixing throughout C horizon.

physiognomic sense, the mixing is exhibited as pockets in a matrix of pumice gravels (Figure 4); while in the Longbell profile, the pumice gravels physiognomically appear as pockets within the C horizon (Figure 6). Lapine profiles rarely contain enough mixing to be designated as Lapine-Longbell intergrades.

The Shanahan series (Figure 7) is found on nearly level topography in the eastern section of the study area (5000-5600 feet). The series is associated with Pinus ponderosa, Purshia tridentata and Festuca idahoensis located adjacent to small, narrow meadows. In this situation, the profile depth[4] is commonly less than 24 inches. However, a variation of the series is located adjacent to Klamath Marsh (4550-4650 feet) where colluvium collects at the base of the steep slopes which lie above the edge of the marsh. In the latter areas, the profile is moderate to very stony, very deep, and is associated with Pinus ponderosa, Haplopappus bloomeri, Purshia tridentata, and Festuca idahoensis.

The horizon sequence of the Shanahan series is A00, A1, AC, C, and D horizons. The Shanahan C horizon exhibits a yellowish brown color (10YR 5/4 to 5/6 moist) and is generally mixed with fine soil material from either the AC or D horizons. The D

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[4]The solum depth phases may be referred to in Appendix C, Table 2.

horizon is a thin layer of buried soil derived from volcanic ash. Basalt rock fragments are found in both the C and D horizons.

The Shanahan series is differentiated from the Lapine series by having aerially deposited pumice that has been subsequently reworked by water and considerably mixed with the buried soil material, so that pockets of raw pumice in the C horizon are the exception rather than the rule. Usually the Shanahan profiles do not contain enough pockets of raw pumice to be considered Longbell-Shanahan intergrades.

Vegetation

The general physiognomy of the vegetation in the Upper Williamson River Basin is coniferous forest with *Pinus ponderosa* and *Pinus contorta* being the two most important species. However, meadows are dispersed throughout the area wherever imperfect or poorly drained sites occur.

The small, narrow meadows and treeless flats located in drainages and low basins on the Dilman series support meadows of grass, sedge, and rush vegetation. The wet meadows consist of *Alopecurus pratensis*, *Deschampsia caespitosa*, *Elymus glaucus*, *Hordeum nodosum*, *Carex nebraskensis*, *Carex praegracilis*, and *Juncus nevadensis*. The dry meadows lie adjacent to the wetter meadows or occupy drainages with lowered water tables. These meadows are represented by Muhlenbergia squarrosa, Koeleria cristata, Agrostis alba, Danthonia californica, Elymus cinereus, Deschampsia caespitosa, Poa cusickii, Carex douglasii, Potentilla glandulosa, Achillea lanulosa, and Erigeron sp.

The nearly level slopes that surround meadows or drainages are characterized by Wickiup or seasonally-wet Lapine soils, cold-air drainage, and stands of Pinus contorta (90, p. 115). Under the dense stands of Pinus contorta are Arctostaphylos uva-ursi, Spiraea douglasii, Vaccinium sp., Danthonia intermedia, Stipa occidentalis, Agropyron pauciflorum, Carex sp., Trifolium longipes, Galium sp., Smilacina stellata, and Fragaria cuneifolia.

Pinus contorta dominates in basins located below plateaus and between fault scarp ridges where well-drained Lapine soils occur, cold-air settles, and frost is prevalent (90, p. 117). These basins appear throughout the study area at lower elevations. Where some protection is afforded by the overstory Pinus contorta, Pinus ponderosa is present as scattered individuals along with Purshia tridentata, Ribes cereum, Stipa occidentalis, Sitanion hystrix, Carex rossii, Horkelia fusca, Lupinus minimus, Fragaria cuneifolia, Antennaria corymbosa, and Eriophyllum lanatum.

Pinus contorta is also a codominant species associated with Abies concolor, Pinus monticola, Pinus lambertiana, and Pinus ponderosa above 5800 feet on north slopes of cinder cones, and deep creek bottoms at lower elevations. Between the lower basins and meadow slopes at lower elevations and the Abies concolor-dominated forests of high elevations appear stands of Pinus ponderosa on east, south, and west slopes, cinder cones, plateaus, and ridgetops. These stands contain Pinus ponderosa and an occasional Pinus contorta except where they approximate north slopes, Pinus contorta flats, and basins and high elevation mesic forest stands. The understory shrubs of the Pinus ponderosa stands consist of Purshia tridentata, Arctostaphylos parryana var. pinetorum, Ceanothus velutinus, and occasionally Castanopsis sempervirens.

History of Use and Disturbance

Ancient Indian tribes lived in the Klamath Lake region between 10,000 years ago and the eruption of Mt. Mazama (8). These early people, like the Klamath Indians of recent times, lived off the river and marsh resources. Their centers of inhabitation were the Klamath Marsh, and the Williamson River at its confluence with the Sprague River and downstream. The Klamath and Modoc Indians numbered about 2000 when white men first explored the Klamath Region in the 1840's (32).

With white man, came the introduction of livestock grazing, logging, and eventually fire control. Livestock were introduced in the Bly, Bonanza, and Dairy, Oregon area in the 1870's, shortly after the formation of the Klamath Indian Reservation in 1864. At that time, open range was available and the livestock strayed over most of the reservation. For 60 years no attempt was made to control the overgrazing and misuse. In 1930, the Indian Service assigned all grazing administration to their forestry branch and also applied the permit system to both allotted and unallotted grazing lands. The U. S. Forest Service purchased many of the Klamath Indian Reservation lands in 1961 and presently administers the grazing on a permit and range allotment basis.

Logging began in the Klamath Basin in 1863 at Fort Klamath. From Fort Klamath, the logging of *Pinus ponderosa* and mixed species proceeded first toward the east, and then northward. Logging commenced in the southern section of the study area about 1913. The Solomon Butte (100, 000, 000 bd feet) and Calimus-Marsh units (400, 000, 000 bd feet) were sold in 1920 and the North Marsh unit (300, 000, 000 bd feet) in 1924. Seventy to ninety percent of the merchantable volume was selectively logged from large tracts of timber sold in lots of township size. This practice was followed because "Indians and such allottees desired that timber be cut as to yield them the largest possible income." (44, p. 204).

About 1911-1914, pine bark beetle (Dendroctonus brevicomis) activity slowly increased as a result of forest fires and the slash created from logging activities. By 1923-28, 450,000,000 bd feet of timber had been killed (44, p. 213). In 1927 the eastern section of the reservation had an insect attack. This beetle activity continued until 1936.

Additional timber sales were made to salvage the timber and to control the beetle epidemics. By the 1940's, logging had proceeded northward to the northern Klamath Marsh vicinity and the west slopes of Yamsay Mountain. The God's Butte Unit in 1939, Sellock Draw Unit in 1945, and Little Yamsay Unit in 1947 were some of the sales. Presently, sales in virgin Pinus ponderosa timber are being sold and logged in the eastern sections of the study area, and isolated sales are located in old logging areas to salvage windthrown trees.

Fire has played an important part in the ecology of the Pinus ponderosa type of the Klamath Basin. From personal observations of fire scars on stumps and living trees of the area, the author estimates that fires occurred in approximately 30-50 years intervals over the last 300 years. Not one sample location throughout the area was without some evidence of frequent fire occurrence.

Fire protection in the county began in 1908 with the formation of the "Weyerhaeuser Patrol" by the large timber owners. In 1910, the patrol included small owners and was changed to Klamath-Lake Counties Forest Fire Association. By 1922, the Association was incorporated and renamed Klamath Forest Protective Association. The last major fire occurred in 1918 on 200,000 acres in the central portion of the Klamath Indian Reservation (83, p. 569). In 1939 and 1940, high altitude Abies concolor and Pinus ponderosa were destroyed by fires amounting to 20,000 acres (83, p. 570). Then in 1959 a 15,000 acre blaze destroyed immature Pinus ponderosa and Abies concolor stands north of Chiloquin, Oregon. However, the majority of the fires since 1920 have been less than 20 acres in size.

LITERATURE REVIEW

Ecological Concepts

The purpose of the following discussion is to define the terms and concepts that are encountered in later sections so that the individual unfamiliar with plant ecology may better understand the terminology used. The phytosociology of the *Pinus ponderosa* type in the Upper Williamson River basin is analyzed and described by using polyclimax principles. The polyclimax viewpoint upholds the contention that every environment has its own biotic potential; and therefore, a mosaic of plant communities are developed over the landscape that may correspond to similar patterns in the environment (57, p. 261). These similar environmental patterns are called habitat-types and are defined as the collective area which one plant community occupies or will come to occupy as succession advances (18, p. 303). The stands which comprise the habitat-type are characterized by having the same climax plant community, relatively uniform successional sequences, and equivalent inherent land-use potentialities (15). The terms plant association or plant associes are used to designate whether a habitat-type presently supports either climax or successional communities, respectively. In this sense, Tansley (70, p. 127) defines the plant association as the classification unit composed of climax vegetation that combines all unions[5] superimposed upon the same habitat-type. However, if successional vegetation occupies the habitat-type, then the term associes replaces plant association as the name of the seral classification unit.

The polyclimax viewpoint acknowledges that several plant assemblages may concurrently occupy different portions of the landscape, and that these communities reach equilibrium with the local effective environment in a relatively short period of time i. e., not comprising a geological time period as asserted by the monoclimax theory. The climatic climax is a relatively permanent plant association, the development of which is determined by the local, zonal climate, undulating relief, and well-developed soils (17, p. 60; 18, p. 303). The edaphic climax denotes permanent vegetation which is strongly influenced by substratal peculiarities of its environment in addition to those imposed by climate and the vegetation (17, p. 60). The topographic climax applies to those permanent types of vegetation which develop on environments that have special local climates determined by land relief (72). However, the climatic, edaphic or topographic climaxes may be

[5]The union is the smallest structural unit in vegetation organization. It consists of one or several species that are of similar ecology as indicated by their similarity of local environmental amplitude, phenology, and in some cases life form (18, p. 302).

further modified and subsequently attain equilibrium either by a particular frequency and intensity of burning or by a particular degree of human and/or animal influence. These new associations are referred to as pyric and biotic climaxes, respectively (18, p. 303).

A recent disturbance to the plant environment by logging, grazing or fire may place the vegetation in a state of change. In this case, the resulting associes may ultimately develop toward the previous climax expression or may achieve a new climax state which is synecologically different from the former association. The floristic nature of the resultant association is governed by the degree to which the habitat-type is physically modified.

Vegetation

Any study that indicates successional relationships within its vegetational matrix would be incomplete if the paleobotanical background of this vegetation were not considered. The author is quite fortunate in having the research area located in a region in which the bogs have been intensively studied for their post-glacial pollen profiles (33, 34, 35). Since climatic barriers are the most influential in prohibiting plant migration (3), Hansen (34, p. 729) has classified the epoch following Pleistocene glaciation into four climatic periods:

Period I: 15, 000$^+$ years ago; climate cooler and more moist than today.

Period II: 15, 000 - 8, 000 years ago; warming and drying trend, temperature similar to what it is today.

Period III: 8, 000 - 4, 000 years ago; maximum warmth and dryness.

Period IV: 4, 000 to present; climate cooling and becoming moist.

He dated the eruption of Mt. Mazama as occurring after the last Pleistocene mountain glaciation maximum.

From pollen profiles located in bogs of the Klamath Marsh and lower Klamath Lake (35, p. 104-108), evidence indicates that Pinus ponderosa reached an advanced stage of expansion, with a notable decline in Pinus contorta by the time of the eruption, and continued its expansion as the postglacial climate became warmer. Pinus ponderosa reached its maximum about 4, 000 - 6, 000 years ago in the Klamath Basin as the postglacial climatic cycle was in its third period and the continued increase in temperature became unfavorable for this tree species. The climatic maximum in the region was marked by a limited influx of grasses, chenopods, and composites; however, these species have declined slightly due to the more moist conditions in the last 4, 000 years (35, p. 105). As the fourth postglacial period began, Pinus ponderosa slightly increased with the cooling trend, but was rapidly displaced by Pinus contorta at the Klamath Marsh site. This latter species has maintained itself in the local bogs of the area ever since the displacement. At higher elevations, Pinus ponderosa has remained relatively static over the last 2,000 years with a marked increase in the mesic species, Pinus monticola and Abies concolor (35, p. 114-115). Unless the influence of human activity reverts the microclimatic temperature trend at high elevations, it seems reasonable to predict a continued expansion of these mesic species into favorable environments at lower elevations.

Numerous references illustrate the importance of frequent fires in maintaining Pinus ponderosa on marginal sites. Effective fire protection has converted many once pure stands of this species into mixed stands of Abies concolor, Pinus monticola, Libocedrus decurrens, or other local mesic species (46; 52; 67; 81; 82).

The delineation of the environment into habitat-types is an important step toward understanding the synecology of an area. However, to competently manage each habitat-type, a realization of its effective environment is necessary. There are three avenues of approach by which the environment of a habitat-type may be surmised. The individual environmental factors that directly influence the production of plants--available soil moisture, soil texture and structure, nutrient regime, soil and air temperatures, light intensity, etc.--may be measured; and the response of the plants to these factors may be hypothesized. The second alternative involves the use of the plants as indicators of the environments. The plant indicator principle is directly related to condition and trend studies in range management. The ecologist must be familiar with the autecology of each indicator species and be observant of differences in the occurrence and dominance of each species within and among habitat-types. The third method, and the one used in this study, combines the use of indicator plants with environmental research.

The use of plants as indicators of the effective environment has been accepted by several authors. Sampson (66) suggested using communities of shrub and herbaceous vegetation that show a strong reaction to the direct environmental factors--aeration, moisture, temperature, and light. Muller (53, p. 987) illustrated that a plant's occurrence may indicate one given condition in one geological area and an entirely different condition in another geological area. For this reason, he favors growth form as a better environmental indicator than occurrence. Generally, the use of trees as indicators has not been accepted as a delicate enough measure of the environment. Westveld (86, 87) uses the indicator value of the minor vegetation in the forest to classify the environment into climax associations. He believes that the ground vegetation quickly comes back into equilibrium after disturbance to the site. Heiberg and White (38) utilize the lesser vegetation as an indicator of site quality for it may reflect temporary site changes that are not recognizable in the tree layer.

Some value may be attached to the role of herbaceous plants as indicators of the effective environment if the influence of the shrub species upon the microenvironment is considered. Furthermore, these microenvironmental differences may locally affect the development of the commercially valuable species. Wahlenberg (79) attributed the survival of Pinus ponderosa in the northern Rocky Mountains to the planting of the year-old seedlings within the microclimate of the Ceanothus velutinus canopy. He found that the atmospheric evaporation was less, relative humidity greater, soil temperature lower, and soil moisture greater under the shrub overstory than in the open between shrubs. Dahms (12), investigating a south-slope brush field on deep pumice soil, determined that the establishment of Pinus ponderosa seedlings was improved by Ceanothus and Arctostaphylos brush; but the brush reduced the growth of the established seedlings. The detrimental effect of brush upon the growth of seedlings is illustrated by Tarrant (74) who found that by chemically killing Arctostaphylos brush, moisture was available for plant growth throughout the growing season; whereas, the permanent wilting percentage was reached by early September under the remaining live brush canopy. Dyrness (22, p. 156), working in south central Oregon, determined that the soil moisture levels of the surface horizons of pumice soils were slightly higher under shrubs than in the openings between the shrubs. He concluded that this additional moisture was of importance in encouraging the survival of coniferous seedlings under the shrubs.

Zinke (91) showed that the deposition of bark and needle litter in Pinus ponderosa stands formed a circular pattern around each tree. The cation exchange capacity, exchangeable bases, pH, and percentage of nitrogen were more favorable within each pattern than in the openings between tree crowns. Plant litter was found to influence the chemical properties of the pumice soils, though not much difference in the nutrient regime occurred between habitat-types due to litter source (22, p. 173). However, the microenvironmental effect may be appreciable since Ceanothus velutinus and Arctostaphylos parryana var. pinetorum litter contained large amounts of exchangeable potassium, calcium, magnesium, and total nitrogen as compared to the _Pinus ponderosa_ litter and that litter found in the openings between the shrubs. In addition, Dyrness discovered that the incorporated organic matter content of the surface layer of pumice soils was related to the elevational gradient of the plant communities with the mesic, high-elevational communities containing the greatest amounts of organic matter.

Soils

Literature pertaining to the chemical and physical characteristics of pumice soils is not in abundance since these soils occur on a small fraction of the earth's crust and generally support vegetation of minor agricultural importance. However, work has been done on pumice soils both in New Zealand and the United States. Dyrness (22, p. 38-49) has reveiwed the information available on the Taupo pumice soils of New Zealand, and has, himself, contributed greatly to the understanding of the pumice mantle soils of central and south central Oregon (22, p. 110-113, 162-193).

Lutz (48) suggested that young soils owe their characteristics mainly to their parent material. This is especially true of young pumice soils since their morphology is determined by the pumice parent material and its mode of deposition.

Vegetation plays an important role in pumice soil genesis in that it determines the depth of profile development; while topography contributes to the productivity of these soils by influencing the soil depth to the D horizon. Dyrness (22, p. 114) determined that the AC-C horizon boundary of the Lapine soils corresponded to the depth of plant root growth, and considered this series as developing from the surface, downward (Figure 4). He noted that the degree of alteration of the pumice mantle increases with increasing effective moisture and plant density. Likewise, Eggler (24, p. 295) concluded that the presence of vegetation greatly accelerates the weathering of cinder material in southern Idaho.

Within his report, Dyrness mentions that great variation occurred in the amount of soil-pumice mixing within the C horizon of Lapine soils; the largest mixing percentage occurred most often in the shallower soils. These shallower soils have recently been designated as members of the Longbell series. But since the complete classification of the Longbell series was not available during the field investigations, Dyrness (22, p. 123) included these soils with the Lapine series.

The soil moisture relationships of the Lapine series are peculiar in that large amounts of available water can be retained by the pumice particles at low soil moisture tensions in spite of the sandy texture of the soil. This is attributed to the micropores which are interdispersed throughout an individual pumice particle. Therefore, the Lapine soils closely resemble a loam in moisture retention properties; but approach the characteristics of a sandy soil in their moisture release properties (22, p. 165). When the soil moisture is held at greater tensions, the Lapine soils tend to be droughty since unsaturated water movement within this soil is quite slow and the plant roots may absorb the available moisture from the soil adjacent to the root hairs faster than the moisture can be replaced (22, p. 167).

Dyrness (22, p. 153-156) illustrated the great influence which root distribution may have on soil moisture depletion and the important role soil moisture plays in the distribution of plant communities. He found that soil drought was less severe in mesic plant communities at high elevations than in xeric plant communities at low elevations. Daubenmire (16, p. 147) has also suggested that soil moisture data may show differences among plant communities.

The nutritional capacity of the Lapine series is largely ascertained by the organic matter content and degree of pumice weathering within the A1 and AC horizons. These horizons contained slightly more available phosphorus and total nitrogen than the unmixed C horizon. The C horizon was found to be deficient in boron and molybdenum, and Pinus ponderosa seedlings grown in C horizon material responded to additions of phosphorus, nitrogen, and sulfur (22, p. 181, 184). Dyrness attributes the low concentration of plant roots in the unmixed C horizon of the Lapine series to the poor nutrient regime of the raw pumice material. Conversely, the abundance of roots in the AC horizon and D horizon of the Lapine series and throughout the Shanahan soil horizons may be occasioned by the improved nutrient and moisture regime associated with the increase in the amount of organic matter and finer particles within these horizons. Such great variability occurs in the A1 and AC horizon nutrient regime within stands and, consequently, habitat-types that resolving a relationship between the distribution of plant communities and soil chemical properties is difficult (22, p. 173); however, this variability within stands may influence the distribution of the herbaceous species.

Vegetation-Soil Relationships

The consideration of both vegetation and soil implies a kinship in which both are members of equal importance. In this sense, the ecosystem concept is important in the study of vegetation for it implies that vegetation studies cannot be effectively utilized without regarding the total environment, and that attention to soils or vegetation, alone, leaves much to be desired. Daubenmire (18, p. 303) defined ecosystem as a unit which encompasses plants, animals, climatic, and edaphic factors as inseparable. Understandably, the ecosystem is so complex that one often finds difficulty in conceiving all of its many facets. Since vegetation is the most obvious component of the ecosystem, it is studied together with those factors which are the most stable, yet encompassing components--soil, macroclimate, topography. By considering these measurable constituents of the ecosystem, the investigator attempts to define the effective environment in question. Anderson (1), Daubenmire (15, 17), Eggler (24), Hanson and Whitman (37), Hills (39), and Poulton (64) have reported vegetation-soil studies which illustrate the use of the ecosystem concept in defining effective environment.

Youngberg and Dyrness (90) have described the occurrence of Pinus contorta as it is influenced by the topography and seasonal fluctuation of the local water table in central Oregon. They found Pinus contorta is the topographic climax species on the broad flats and depressions that have less than two percent slopes, well-drained Lapine soils, and cold-air accumulation. Furthermore, in depressional areas having less than two percent slopes and permanent or seasonally high water tables in conjunction with the Wickiup or Lapine soil series, Pinus contorta is a topo-edaphic climax dominant. At high elevations, this species was found to occur as a seral component in mixed or pure stands due to logging or fire disturbance. Pinus ponderosa was considered as a seral member of the plant community in areas with cold-air drainage and seasonally wet Lapine soils. Youngberg and Dyrness essentially substantiated the hypothesis expressed by Tarrant (75) that Pinus ponderosa will not tolerate conditions of excessive moisture in the root zone and the distribution of both Pinus contorta and Pinus ponderosa is determined, in part, by the degree of soil drainage.

Dyrness (22) interpreted the plant associations which occur within the Pinus ponderosa and Abies concolor zones on pumice soils of central Oregon. The four associations--Pinus ponderosa/Purshia tridentata, Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana var. pinetorum, Pinus ponderosa/Ceanothus velutinus-Purshia tridentata, and Abies concolor/

Ceanothus velutinus--and one seral community, Pinus ponderosa/Ceanothus velutinus, occurred on the Lapine soil series. One association, the Pinus ponderosa/Purshia tridentata/Festuca idahoensis, was restricted to Shanahan loamy coarse sand. He concluded that the Lapine soils were so immature that correlations between soil properties and the associated plant communities were difficult to define and, therefore, all the plant associations were edaphic climaxes (22, p. 195, 199).

This ambiguous relationship that may occur between soils and vegetation is emphasized by Daubenmire (19, p. 35), who states that one soil type may have significantly different vegetation potentialities. Gardner and Retzer (28, p. 152) consider this lack of definite relationship as being either due to two or more soils having the same biological equivalence or to the climatic factors compensating for certain soil differences. In addition, soils are often defined too broadly, as may be the case when soil series are established without making adequate reference to the ecology of the vegetation which they support.[6]

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[6]Personal communication with C. E. Poulton, Ph.D., Professor of Range Ecology. Oregon State University, Corvallis. March 1963.

METHOD OF STUDY

Reconnaissance Method

A reconnaissance technique resembling that described by Anderson and Poulton (2) was used to obtain the vegetation and soils data from plots located during the 1961 and 1962 field seasons. This particular reconnaissance method entails the subjective stratification of the environment into uniform units so that only a highly homogeneous soil and vegetation is described at each sample location (14, p. 47; 64, p. 31). A variable-plot is used, the size of which depends upon the area of the uniform unit and the richness of its flora. Since the purpose of the study is to characterize the habitat-types which appear to be in near-climax condition, stands that contain any logging, overgrazing, recent fire, or strong ecotonal influence are omitted as study sites. Ocular estimates are made of several vegetation, soil, and site characteristics at each plot. Therefore, each selected sample location is considered to be an adequate example of the habitat-type which it represents.

Admittedly, there are several innate disadvantages in using the reconnaissance method. The observer is required to treat each sample as a separate entity so that any particular sample will not be influenced by previous ocular estimates. A bias error may develop from mentally averaging visual observations. Furthermore, certain qualitative determinations may not be subject to statistical analysis; therefore, no measure of reliability or analysis of sampling error can be obtained.

Since stratification of the population into homogeneous units is a prerequisite for either subjective or objective methods; one advantage of this reconnaissance method is that more samples are obtained in the additional time required to establish and measure small quantitative plots. The ability to acquire a large number of samples may compensate for most of the inadequacies of this subjective method (63, p. 253; 55, p. 35). The reconnaissance method, as used in this study, has the additonal advantage of permitting the investigator to sample a larger geographic area than is possible by using a quantitative technique within an equivalent time period.

The reliability of the reconnaissance method is further enhanced by using a multiple-factor approach in the analysis of the data. The final synecological interpretation depends upon a combination of factors that accurately indicate relationships and determinative classification criteria. Thus by relying upon a multiple-factor approach, the highly accurate measurement of individual factor intensities is completely unnecessary.

Synecological research is normally performed in two separate stages; namely, reconnaissance followed by intensive, quantitative plot study. Since it is not the intention of the author to complete the phytosociological study of the Upper Williamson River Basin, the reconnaissance method has been used with the supposition that quantitative plot studies may later be advisable or necessary.

Vegetation Data

The most important factor used in describing a stand of vegetation is the complete species list. Such a species list provides valid presence[7] values and gives some measure of fidelity[8] as used in the phytosociological interpretation. In addition, some indication of disturbance is provided by those species for which the decreaser-increaser-invader response is known.

After making a complete species list, age or size classes, dominance ratings, and canopy coverage percentages are determined to provide a working basis for the analysis, description and classification of the plant community. The age or size class symbols (Appendix C Table 2) express the extent to which

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[7] Presence refers to how uniformly a species occurs over a number of stands in the same plant association unit. Presence is used in place of constancy when the sampling unit size varies from stand to stand (36, p. 124).

[8] Fidelity refers to the degree to which a species is restricted in its occurrence, or is faithful or limited to a particular association (36, p. 126).

each individual tree or shrub species is maintaining itself in the community. These classes are used to infer the dynamic relationships among species, stands, and associes.

The dominance ratings (Appendix C Table 2), as assigned to all species within the stand, were developed by Anderson and Poulton (2) as a quick reproducible index of dominance. Although a statistic cannot be calculated from these dominance values, a mode and range of values have considerable analytical importance.

The canopy coverage percentage of a species is estimated by summing the ground area covered by all the vertical downward projections of the crown peripheries of that species (14, p. 46). Each tree, shrub, and grass species is considered separately; a percentage for the tree layer is assigned individually to reproduction and oldgrowth. The use of canopy coverage percentage rather than merely species composition provides an arithmetical picture of the stand physiognomy and indicates the relative ecological importance of certain species in the community (2, p. 12).

The description of the vegetation for any particular sample is completed by noting the predominant life forms and ecological stage of succession of the stand, plant vigor and phenotypic changes in the species, and incidence of disease, insects, and fire.

Soils Data

Since the profile characteristics of the Lapine, Longbell, and Shanahan series have been defined either by Dyrness (22) or by the survey report, Soils of the Klamath Indian Reservation (76); a complete soil profile description, as outlined in the Soil Survey Manual (77), was not made at every sample location. Instead, the following profile characteristics were noted at each soil pit: soil series, series depth phases (Appendix C Table 2), soil horizon thicknesses, type of underlying material and/or parent material of the buried soil, abundance of roots and subsurface stones, percentage of C horizons mixed with AC and/or D horizon material, presence of imperfect drainage, and color of the buried soil horizon.

When an undesignated soil was encountered, a profile description was made in accordance with the instructions contained in the Soil Survey Manual. In a few cases, phase of soil series distinctions could not be made. These soils were designated as intergrades between the two series in question and a complete profile description of that soil was written.

Other Site Factor Data

In addition to the vegetation and soil information, attention was given to those measurable site factors that contributed to the understanding of the plant environment. Notes were taken on landform, macrorelief, microrelief, general climate, surface stoniness and bareground and litter percentage, slope percentage and position, aspect, and degree of disturbance in the stand. Reference is made to Appendix C Table 2 for the major subdivisions of each site factor.

Method of Interpretation

The association table is used for synthesizing the qualitative data of seemingly unrelated stands into units of similar ecology. The association table portrays the general floristic composition and dominance of the community and gives the range of conditions under which the association may occur (62, p. 240). Although association tables have been used extensively by European ecologists (5, p. 73-74; 25, p. 48-62; 45, p. 25-30; 72, p. 16-23), they have had limited use in the United States (37, p. 61-62, 91; 65, p. 19; 58, p. 165).

The development of the association table is an essential preliminary step toward statistical analysis since only by means of association table development can one determine the phytosociological populations within which subsequent biometric tests become valid. The failure to develop an association table, therefore, puts one in a position of not knowing which plant populations are being compared.

The species and stand ordination is achieved by initially using a limited number of qualitative measures. In this study, the ecological ordination of species within stands, the grouping of similar stands into one association, and the arrangement of stands within associations is performed by using presence, dominance ratings, and fidelity.

Giving consideration to the presence or absence of the species by stands, those sample data cards which contain the same species or similar species groups are placed together. This preliminary consolidation tends to bring together those stands that have similar patterns of species presence and dominance. The species list for each preliminary group of stands is entered on the left margin of the table under tree, shrub, grass and forb categories; and the stand numbers in each group are entered above each column of the association table. The physical site data for each stand are entered in the columns directly below the stand number.

The species ordination is made initially by species presence and then by species dominance. Each species is arranged vertically in the table so that species with a high presence are above those with a lower presence within each life form category. The species are then grouped on the basis of similar distribution and dominance patterns. As the stand ordination proceeds through many revisions, thought is given to the possible grouping of species with similar ecology, and to the arrangement of stands so that some ascending and/or descending order of the dominance ratings occurs for most species. Eventually, each stand column is horizontally arranged so the xeric-tending stands occupy the left half, and the mesic-tending stands occupy the right half of the association table.

The member stands of each association or associes are critically challenged as belonging to other ecological units by using species presence, age class distribution, and dominance plus a multiple-factor consideration of the soil and other site characteristics. Each ecological unit may contain a minimum of species or species groups which are characteristic of the classification unit under all conditions (62, p. 231; 65, p. 15); while certain other species may not reflect the ecology of the unit at all. Those stands that do not contain all of the characteristic species or that do not have similar physical site factors as typical stands of the classification units are compared to representative stands of other units to determine the best coalescence based on multiple-factor criteria.

When the investigator is satisfied with the stand composition within each ecological unit, the vegetation component of each unit is designated by the two or three dominant, character species of the community. For example, the Pinus ponderosa/Purshia tridentata/Festuca idahoensis association has these three plants as its most important and ever-present species in each layer.

A presence percentage and dominance index are determined for each member species of the ecological unit, and the canopy coverage values of each tree, shrub and grass species are averaged over all representative stands of the ecological unit.[9] A summary association table is constructed which lists each association or associes and gives the presence percentage, dominance index, and mean canopy coverage for the species. The range and mode of the dominance index are automatically shown by listing the index by individual dominance ratings (Appendix B Table 2). The soil and other site data of each stand are summarized by ecological units and is expressed on a table as the percentage of stands in which any particular site factor is found (Appendix A Tables 1, 2 and 3).

[9] Curtis and McIntosh (11) define presence percentage as

$$\frac{\text{Number of stands in which a species occurs}}{\text{Total number of stands examined}} \times 100$$

In this study, dominance index equals

$$\frac{\text{Number of stands having a given dominancy rating}}{\text{Total number of stands examined}} \times 100$$

Therefore, if a species appears in six stands out of a total of ten stands examined; its presence percentage is $6/10 \times 100 = .60$. And if the same species has a dominance rating of 3 in four of these stands and a dominance rating of 2 in the remaining two stands, the dominance index for $3 = 4/10 \times 100 = .40$, and the dominance index for $2 = 2/10 \times 100 = .20$.

The summary vegetation and site factor tables for the associations or associes are helpful in interpreting the ecological relationships among habitat-types, the autecology of the species, the management implications, and vegetational potential of each ecological unit.

RESULTS

Five habitat-types of the *Pinus ponderosa* zone and one habitat-type of the *Abies concolor* zone have been defined in the Upper Williamson River Basin. These habitat-types are characterized by the *Pinus ponderosa/Purshia tridentata* association, the *Pinus ponderosa/Purshia tridentata /Festuca idahoensis* association, the *Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana* var. *pinetorum* association, the *Pinus ponderosa/Ceanothus velutinus-Purshia tridentata* association, the *Pinus ponderosa/Arctostaphylos parryana* var. *pinetorum-Ceanothus velutinus* association, the *Pinus ponderosa/Ceanothus velutinus* associes, and the *Abies concolor/Ceanothus velutinus* association. The general vegetation and site description of each habitat-type is written to facilitate the field identification of the ecological unit. Reference to the summary association tables (Appendix B Tables 1 and 2) and the site factor tables (Appendix A Tables 1, 2 and 3) will aid in comparing habitat-types and species that represent a plant community.

Care was taken to sample stands that were in an essentially virgin, undisturbed condition. However, some stands of the *Pinus ponderosa/Purshia tridentata* and *Pinus ponderosa/Purshia* *tridentata/Festuca idahoensis* associations have been lightly grazed by livestock. Since most of the southern section of the study area has been logged by the selection system, sample plots were located in the undisturbed residual timber stands of old logging shows.

In addition to logging and grazing, a majority of the stands showed evidence of disturbance from natural agencies. Either pieces of charcoal in the soil or fire scars on trees were observed in all the stands sampled. Generally, the last fires that are recorded by the annual rings of *Pinus ponderosa* and *Abies concolor* occurred between 30 to 50 years ago.

Windthrow of *Pinus ponderosa* seems widespread on these pumice soils. The shallow solum and poor root-holding capacity of pumice has resulted in numerous individuals being windthrown in both virgin and cutover stands. Windthrow is especially prominent on ridges and windward slopes at high elevations.

The only recorded natural disturbance to the shrub layer besides periodic fires has been a tent caterpillar (*Malacosoma pluviale*) infestation on *Purshia tridentata* during the summers of 1956, 1957 and 1958 (22, p. 79). Although this infestation eliminated the shrubs of poor vigor, the main result was to leave numerous plants with decadent branches in the live crown.

Bark beetle (Dendroctonus brevicomis) infestations were common on Pinus ponderosa between 1920-1936. Most of this timber has been salvaged by logging. However, beetle-killed trees may still be seen in those stands undisturbed by logging. The over-mature trees that succumb to bark beetle attacks afford an opening in the stand in which reproduction may become established. Presently, bark beetles may appear in some Pinus ponderosa stands, but their activity is restricted to endemic proportions. The important defoliator in Pinus ponderosa, the pine butterfly (Neophasia menapia), has been observed as occurring in endemic proportions throughout the study area.

Dwarfmistletoe (Arcenthobium campylopodum f. camylopodum) on Pinus ponderosa may be observed throughout the study area. This parasite is more prevalent in some habitat-types than others. Usually the dense reproduction patches are more infected than the overstory.

Pinus ponderosa/Purshia tridentata Association

The Pinus ponderosa/Purshia tridentata association (Figure 5) occurs between 4600 and 5300 feet elevation on southwest to north-east slopes that have moderately deep to deep phases of the Lapine or Longbell soil series. The association occupies plateaus and convex slopes in gentle, undulating topography. The slopes may vary from flat to 15 percent.

The physiognomy of this association is characterized by open, park-like stands of Pinus ponderosa and a shrub layer of Purshia tridentata (Appendix B Tables 1 and 2). Purshia tridentata has average canopy coverage of 54 percent and an average height of 24-36 inches, however, some individuals may approach 50-55 inches. Generally, the seedlings of this species are found in dense clusters corresponding to the location of rodent caches (56). Pinus ponderosa reproduction may occur as widely-scattered, small, dense clumps within the stand. The clumps of reproduction appear to be correlated with the presence of dead overstory individuals (22, p. 82). Both Pinus ponderosa and Purshia tridentata are represented by all age classes. Since no other species in either the tree or shrub layer are repeatedly reproducing themselves, Pinus ponderosa and Purshia tridentata may be considered climax species in this association.

Besides Pinus ponderosa and Purshia tridentata, those species which express high presence in the association include Carex rossii, Stipa occidentalis, Sitanion hystrix, Cryptantha affinis, Gayophytum nuttallii, Collinsia parviflora, Mentzelia albicaulis, and Viola purpurea (Appendix B Table 2). Senecio integerrimus *minima* are found in disturbed and undisturbed stands. The herbaceous cover is located in the openings between shrubs and asserts moderate dominance in the community.

Some variation may appear in this association. Well established young plants and mature individuals of *Arctostaphylos parryana* var. *pinetorum* occupy a very subordinate position to *Purshia tridentata* in localities where the *Pinus ponderosa/Purshia tridentata* association approaches the lower environmental limits of the *Pinus ponderosa/ Purshia tridentata-Arctostaphylos parryana* var. *pinetorum* association. *Pinus contorta* is a seral member in those stands which either adjoin cold-air drainages or areas that have a seasonally wet Lapine soil. At elevations between 5500 and 5800 feet *Pinus contorta* and *Abies concolor* occur as scattered individuals in those few stands that are located on plateaus adjacent to local drainage ways.

This habitat-type is an important summer-early fall range component of the Silver Lake deer herd. However, only light to moderate deer use was observed on *Purshia tridentata* in those stands protected from livestock use. Soil disturbance from deer use is minor in the virgin timber stands.

A heavy deposition of needle and bark litter appears under each mature *Pinus ponderosa* tree or reproduction group. The interspaces between *Purshia tridentata* plants have either a light litter cover or a pavement of pumice gravels for the reason that the herbaceous production on these sites is minor and hardly any litter accumulates. In some stands, the interspaces may not seem fully occupied by the lesser vegetation; however, an examination of the A1 and AC soil horizons are being effectively utilized by the roots of the subordinate vegetation.

A large portion of the Pinus ponderosa/Purshia tridentata association has been disturbed by logging and/or heavy livestock grazing. Preliminary investigations indicate these practices may greatly reduce either the cover or the vigor of Purshia tridentata and increase the dominance of Carex rossii, Stipa occidentalis and Sitanion hystrix. Much of the soil surface is greatly disturbed in these stands with only annual forbs growing between the shrubs and grass plants.

Pinus ponderosa/Purshia tridentata/Festuca idahoensis Association

The Pinus ponderosa/Purshia tridentata/Festuca idahoensis association (Figure 8) comprises a very small segment of the total study area. The largest stand sampled was approximately 160 acres in size. The association is characterized by either a shallow, highly-mixed soil profile, or a topographic position, both of which contribute to a favorable environment for plant growth. Most stands occupy the

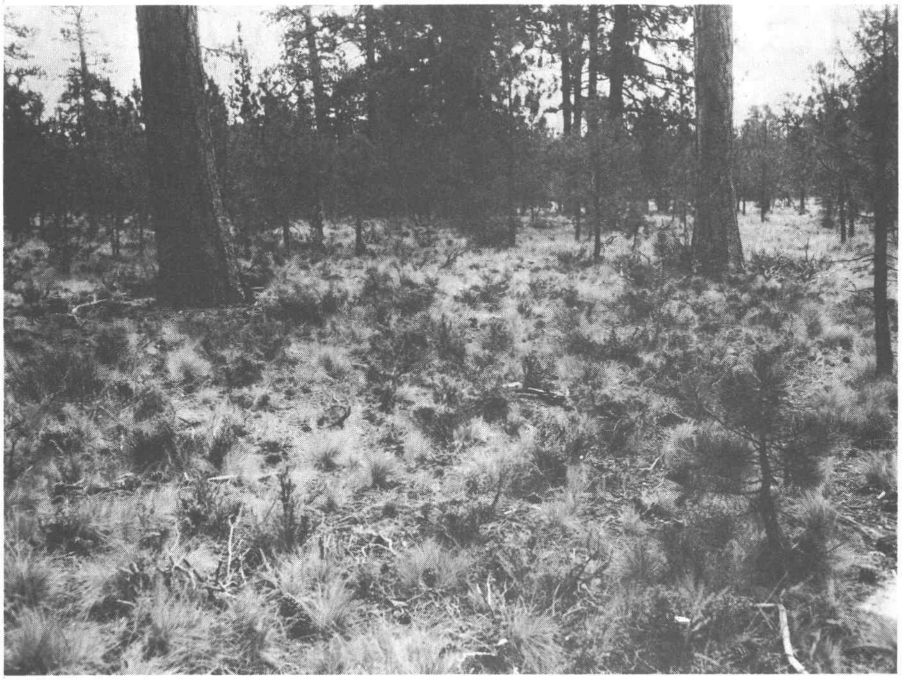

Figure 8. A representative stand of the Pinus ponderosa/ Purshia tridentata/Festuca idahoensis association.

Figure 9. A representative stand of the Pinus ponderosa/ Purshia tridentata-Arctostaphylos parryana var. pinetorum association.

lower-third or bottom position of the gentle slopes (one to eight percent) that border meadows or meandering drainages. These soils are the shallow phase of the Lapine, Longbell or Shanahan series. In addition, the Pinus ponderosa/Purshia tridentata/ Festuca idahoensis association is located on the terraces that either lie adjacent to the Klamath Marsh or are associated with the seeds and subsurface drainage patterns at higher elevations. These terraces have flat or undulating macrorelief. The soils are deep phases of the Longbell, Lapine or Shanahan series in stands that adjoin the Klamath Marsh; and the shallow phase of the Longbell series at higher elevations.

Pinus ponderosa, Purshia tridentata, Carex rossii, Stipa occidentalis, Sitanion hystrix, Festuca idahoensis, Cryptantha affinis, Collinsia parviflora, Gayophytum nuttallii, Viola purpurea, Antennaria geyeri, Antennaria corymbosa, Lupinus caudatus, and Fragaria cuneifolia have high presence in the association. Ranunculus occidentalis, Delphinium menziesii, Horkelia fusca, Cirsium foliosum, Paeonia brownii and Achillea millefolium var. lanulosa exhibit low dominance in the stand but have high fidelity for this association (Appendix B Table 2).

Pinus ponderosa, the dominant species of the tree layer, has an average overstory cover of 40 percent and an average reproduction cover of 36 percent. Instead of assuming a pattern of small dense clumps as in the Pinus ponderosa/Purshia tridentata association, the young trees of Pinus ponderosa may occur as either large dense groups or uniformly scattered individuals. Pinus contorta appears as a seral species in those stands located near meadows and cold-air drainages between 5700 and 5950 feet elevation.

Purshia tridentata is the dominant species in the shrub layer. The cover and vigor of Purshia tridentata are greatly reduced in this habitat-type. This species averages 21 percent cover and mature individuals may vary from 12 to 24 inches in height. Haplopappus bloomeri and Ribes cereum are prominent members of the community in the disturbed stands which lie adjacent to the Klamath Marsh. However, both these species hold subordinate positions in those stands located at higher elevations.

Festuca idahoensis is the dominant member of the herbaceous layer with an average cover of 33 percent. This grass exhibits high fidelity to this habitat-type (Appendix B Table 2). Carex rossii, Stipa occidentalis, and Sitanion hystrix achieve their highest crown spread in this association with an average cover of six to four percent. Production of these grasses varies greatly between stands in relation to solum depth and soil series.

The ability of Festuca idahoensis to utilize the surface soil horizons by extensive root ramification may contribute to the poor vigor observed in Purshia tridentata and Pinus ponderosa. Purshia tridentata seedlings and young plants are sparsely scattered over the stand and many decadent individuals are present. Although numerous seedlings of Pinus ponderosa, 12 - 18 inches tall, may be observed in any representative stand of this habitat-type, the general quality of these plants is poor since a majority exhibit reduced vigor, slow diameter growth and pronounced deformation of the main stem.

Numerous sapling-sized Pinus ponderosa were observed to be 35-45 years old. This stagnation may be attributed to dwarfmistletoe (Arcenthobium campylopodum f. campylopodum) which has infested most of these trees. The incidence of dwarf mistletoe seems quite high in this habitat-type.

The combination of light to moderate livestock use and heavy deer use may also contribute to the poor vigor of the mature Purshia tridentata plants. Because the Festuca idahoensis in the study area has been observed to survive two grazing seasons without any appreciable use of either the seed heads or the lower leaf blades, this plant seems unpalatable to the local cattle, sheep and mule deer populations. For this reason, the major grazing load is supported by Purshia tridentata and the few forbs and other grasses of this community.

Because the grass and forb production is so great within this association, the spaces between plants are covered by a protective litter layer. Soil disturbance usually is evident from minor rodent activity, game trails, or the repeated trailing of sheep through these stands.

Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana var. pinetorum Association

The Pinus ponderosa/Purshia tridentata - Arctostaphylos parryana var. pinetorum association (Figure 9) is found predominately between 5000 and 6200 feet elevation on east, south and west aspects of convex slopes and cinder cones. The community occupies the mid-third and upper-third positions of gentle to moderate slopes (five - 35 percent) and may be associated with the deep, moderately deep, or shallow phases of the Lapine or Longbell series in undulating, rolling or hilly topography. The shallow depth phases usually appear at elevations above 5400 feet, while the moderately deep and deep soil phases occur at lower elevations.

Species exhibiting high presence in the association are Pinus ponderosa, Purshia tridentata, Arctostaphylos parryana var. pinetorum, Sitanion hystrix, Carex rossii, Stipa occidentalis, Cryptantha affinis, Gayophytum nuttallii, and Apocynum androsaemilifolium. Collinsia parviflora, Viola purpurea, Phacelia hastata, Mentzelia albicaulis, and Epilobium angustifolium exhibit moderate presence values in the association and assert moderate dominance in the herb layer. Clarkia rhomboidea and Arabis rectissima appear as occasional species (Appendix B Table 2). Most of the perennial forbs grow within the influence of the shrub canopy in the majority of stands. However, Apocynum androsaemilifolium and the annuals--Cryptantha affinis, Gayophytum nuttallii, Collinsia parviflora, and Mentzelia albicaulis--are present in the openings between shrubs.

Pinus ponderosa remains the dominant species in the tree layer with an average overstory cover of 32 percent and a regeneration cover of 11 percent (Appendix B Table 1). The reproduction may be widely dispersed over the stand or grouped in large dense patches. Within the dense patches, the saplings are usually stagnated and show a high incidence of dwarfmistletoe. In the more extreme sites on cinder cones and other slopes with southeast to southwest aspects, Pinus ponderosa reproduction is found growing through the canopy of Arctostaphylos and Ceanothus.

Purshia tridentata and Arctostaphylos parryana var. pinetorum are codominant members of the shrub layer. Purshia tridentata averages 42 percent cover and approximately 36 inches in height. In some stands, many dead branches or decadent individuals of this species are prevalent. This decadence may have been caused by the tent caterpillar (Malacosoma pluviale) infestation in the summers of 1956, 1957 and 1958. Severe hedging of the available Purshia tridentata appears on the steep southeast to southwest slopes of cinder cones and ridges for these are areas of intensive mule deer use. Purshia tridentata may become more important on Lapine or Longbell moderately deep and deep phase soils at lower elevations where this association approaches the Pinus ponderosa/Purshia tridentata association.

Arctostaphylos parryana var. pinetorum dominates the shrub layer on the west to southeast aspects of cinder cones and slopes at high elevations where the soils are shallow expressions of the Lapine and Longbell series. Arctostaphylos averages 30 percent cover in this association. The species seems sensitive to changes in the density of the overstory canopy. The total cover of Arctostaphylos parryana var. pinetorum decreases in swale microrelief and in stands of thrifty-aged Pinus ponderosa where the canopy becomes closed; and increases on southern aspects and ridges where the tree canopy is fairly open. Ceanothus velutinus is a seral species found in two-thirds of the sampled stands. The species averages ten percent cover and, generally, exhibits a poor distribution of age classes.

Abies concolor may become a minor, seral component in a few stands of this community on the gentle, west slopes of Yamsay Mountain between 5500 and 6200 feet elevation (Figure 14). The sites are characterized by Lapine shallow phase soils and undulating to rolling topography. The physiognomy indicates that these stands containing Abies concolor are probably fragmentary expressions of more mesic-tending communities. Since the effective environment is suitable for the germination of Pinus ponderosa and Abies concolor seed, the resultant seedlings and saplings are the prevalent tree reproduction in the understory. However, the older age classes of Pinus ponderosa retain the overstory dominance. In addition to having the shrub and herbaceous component of the Pinus ponderosa/ Purshia tridentata-Arctostaphylos parryana var. pinetorum association; Pyrola picta, Fragaria cuneifolia, Chimaphila umbellata var. occidentalis and/or Lupinus caudatus may hold positions under the reproduction and shrub canopies.

The Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana var. pinetorum association is found extensively throughout the fault scarp area in the central and southern portion of the study area. The ridges lie in a northwest-southeast direction. On the east slopes, this community occupies the mid-third slope positions with the Pinus ponderosa/Purshia tridentata association lying downslope on the lower-third slope positions. Either the Pinus ponderosa/ Ceanothus velutinus-Purshia tridentata or the Pinus ponderosa/ Arctostaphylos parryana var. pinetorum - Ceanothus velutinus associations occur upslope depending upon the microrelief pattern--the former association appears in swales and the latter association persists on convex slopes and ridge tops. On the west slopes, the Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana var. pinetorum association occupies both the upper-third and mid-third slope positions. The amount of Ceanothus velutinus in these stands may vary with the microrelief. The swales contain slightly more Ceanothus velutinus than the ridges. The exposure of these slopes creates an xeric microenvironment as evidenced by the presence of perennial forbs--Apocynum androsaemilifolium, Arabis rectissima, and Antennaria geyeri--under the shrub canopy, and the occurrence of Pinus ponderosa reproduction within the shrub influence or in small dense patches. Gayophytum nuttallii, Cryptantha affinis, and Mentzelia albicaulis are annual forbs found in the openings between shrubs. The soil surface in these inter-spaces has been greatly disturbed by the local trailing of mule deer. As may be expected, the unprotected Purshia tridentata plants are severely hedged by these animals.

Pinus ponderosa/Ceanothus velutinus-Purshia tridentata Association

The Pinus ponderosa/Ceanothus velutinus-Purshia tridentata association (Figure 10) is found between 4800 and 5800 feet elevation on the mid-third or lower-third positions of either gentle slopes (five - 20 percent) into swales and drainages or moderate slopes (20-35 percent) below escarpments and buttes. The stands appear on southwest to northeast aspects in rolling or hilly topography. The association usually occurs on Lapine deep or moderately deep phase soils below 5400 feet; and on Longbell moderately deep to shallow phase soils or Lapine shallow phase soils between 5400 and 5800 feet elevation.

Pinus ponderosa, Purshia tridentata, Arctostaphylos parryana var. pinetorum, Ceanothus velutinus, Carex rossii, Stipa occidentalis, Cryptantha affinis, Collinsia parviflora, Mentzelia albicaulis, Apocynum androsaemilifolium and Epilobium angustifolium express high presence in the association (Appendix B Table 2). Chimaphila umbellata var. occidentalis, Pyrola picta, and Fragaria cuneifolia are occasionally present and may be found under the influence of the shrub canopy; while Phacelia hastata, Hieracium cynoglossoides and Viola purpurea frequently occur in the openings between shrubs. Pinus lambertiana appears as a subordinate species and is represented by mature, overmature and sapling age classes on sites with north or east

Figure 10. A representative stand of the Pinus ponderosa/ Ceanothus velutinus-Purshia tridentata association.

Figure 11. A representative stand of the Pinus ponderosa/ Arctostaphylos parryana var. pinetorum-Ceanothus velutinus association.

exposures in hilly topography, or on west slopes with compensating microrelief. Reproduction of this species usually becomes established within the canopy influence of Ceanothus velutinus. Pinus contorta is a weak subordinate in stands with slopes adjoining drainages or with swale and concave microrelief. Salix sp. becomes a minor component of the community in the central and southern sections of the study area.

Pinus ponderosa regeneration covers 14 percent of the ground surface area while the older age classes average 30 percent. Reproduction of this species occurs either as scattered individuals or as large groups. These groups are located in relation to the openings in the overstory canopy. Many of the widely-dispersed seedlings and saplings are growing within the influence of the Ceanothus velutinus canopy. Dwarfmistletoe has infected a moderate portion of the sapling and pole age classes.

Purshia tridentata and Ceanothus velutinus are codominant members of the shrub layer (Appendix B Tables 1 and 2). Purshia tridentata is represented by all age classes, averages 24-36 inches in height, and has an average cover of 28 percent. The Purshia tridentata is excessively hedged due to the heavy use of this plant by mule deer during the summer and autumn months. However, those plants growing within the protection of the surrounding

Ceanothus velutinus and Arctostaphylos parryana var pinetorum show good vigor. Purshia tridentata may possess a higher total crown spread than Ceanothus velutinus on sites with east or west exposures and Lapine deep or moderately deep phase soils at the lower elevations of this association. However, Ceanothus velutinus, which averages 38 percent cover, is usually represented by more total crown spread at high elevations, and on favorable slope exposures or soil depth phases.

Ceanothus velutinus generally occurs in small to moderate-sized groups. The individual shrub has a life form characteristic of plants growing in an open habitat i. e., the branches lie close to the ground, are lightly grouped together, and contain a good leaf complement. However, Ceanothus velutinus and Purshia tridentata are occasionally represented by decadent individuals under the large groups of saplings and pole-sized Pinus ponderosa which appear in some stands.

Arctostaphylos parryana var. pinetorum is present in all stands but asserts only moderate dominance in this environment with an average cover of ten percent. In undisturbed situations, Arctostaphylos is represented only by older individuals. However, all age classes are represented in disturbed conditions such as on local skid trails, road cast and windthrow areas. For this reason, the effective environment of this habitat-type is probably marginal for the establishment and survival of Arctostaphylos. Arctostaphylos is represented by decadent plants in portions of the stand that have a moderate tree overstory of pole and thrifty age classes. The species increases in importance in stands which approximate south and southwest exposures, the more xeric effective environments of upslope habitats, and adjacent convex slopes.

In some stands, the openings between shrub groups exhibit very small amounts of litter. The moderate use of Purshia tridentata by mule deer and the restricted movement of these animals by the large groups of impenetrable shrubs has greatly disturbed these interspaces. Sheep grazing has also contributed to this ground surface disturbance in areas where Pinus ponderosa/Ceanothus velutinus-Purshia tridentata stands lie adjacent to usable livestock range.

In the central and southern sections of the study area this association was logged approximately ten to 20 years ago. In these stands, Arctostaphylos parryana var. pinetorum, Ceanothus velutinus, Stipa occidentalis, Sitanion hystrix, and Carex rossii increase on the disturbed sites; and Pinus ponderosa reproduction appears as dense patches in the small openings of the residual stand.

Pinus ponderosa/Arctostaphylos parryana var. pinetorum-Ceanothus velutinus Association

The Pinus ponderosa/Arctostaphylos parryana var. pinetorum-Ceanothus velutinus association (Figure 11) is found on the mid-third or upper-third positions of southeast to northwest slopes between 5200 and 6500 feet elevation. The stands occur on concave or convex microrelief in hilly to mountainous topography which have slopes varying from 15 to 50 percent. The soils are moderately deep or shallow phases of the Lapine series. The association is typically found on cinder cones and buttes but also appears on the west slopes of Yamsay Mountain.

Pinus ponderosa, Purshia tridentata, Arctostaphylos parryana var. pinetorum and Ceanothus velutinus express high presence in this association (Appendix B Table 2). Pinus ponderosa is the dominant member of the overstory with 27 percent cover. Reproduction of Pinus ponderosa (average cover ten percent) and Pinus lambertiana (average cover eight percent) occur either as widely-dispersed individuals growing through the brush canopy or as small groups distributed in relation to the openings in the overstory canopy.

Arctostaphylos parryana var. pinetorum and Ceanothus velutinus appear as codominants in the shrub layer, each with an average cover of 33 percent (Appendix B Table 1). At elevations below 5600 feet, the dominance of either shrub is related to the microrelief. *Ceanothus* becomes slightly dominant over *Arctostaphylos* in stands with swale or concave microrelief, and becomes less vigorous in stands with convex microrelief. At elevations above 5600 feet *Ceanothus* may occur on convex slopes in stands with Longbell soils; and *Arctostaphylos* may occupy concave slopes in stands with a recent fire history.

Purshia tridentata (average height 18-24 inches) is a strong subordinate in the low elevation stands but exhibits an increased decadence, poor growth form and reduced cover in high elevation stands of the association. Throughout the association *Purshia tridentata* has been heavily grazed by mule deer. Plants that are protected by the less palatable *Arctostaphylos parryana* var. *pinetorum* and *Ceanothus velutinus* show improved vigor. In many stands, *Purshia tridentata* seedlings have become established only under the influence of the *Arctostaphylos parryana* var. *pinetorum* or *Ceanothus velutinus* canopy.

The herbaceous layer is represented by *Cryptantha affinis*, *Gayophytum nuttallii*, *Stipa occidentalis*, *Apocynum androsaemilifolium* or *Phacelia hastata* in the openings between shrubs. *Epilobium angustifolium*, *Pyrola picta* or *Clarkia rhomboidea* usually occupy positions beneath the shrub canopy.

The Pinus ponderosa/Arctostaphylos parryana var. pinetorum-Ceanothus velutinus association may adjoin the Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana var. pinetorum or the Pinus ponderosa/Ceanothus velutinus-Purshia tridentata associations below 5700 feet elevation. Many of the east-west ridges of Yamsay Mountain serve to separate these associations. The slopes which lie to the south of these ridges may support the Pinus ponderosa/Arctostaphylos parryana var. pinetorum-Ceanothus velutinus association; the west and north slopes are characterized by the Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana var. pinetorum or the Pinus ponderosa/Ceanothus velutinus-Purshia tridentata associations. In addition, the Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana var. pinetorum association usually occupies the gentle slopes below the Pinus ponderosa/Arctostaphylos parryana var. pinetorum-Ceanothus velutinus association.

In the fault scarp portion of the study area, the Pinus ponderosa/Arctostaphylos parryana var. pinetorum-Ceanothus velutinus association is located on the upper-third portions of east slopes; while the mid-third slope positions support the Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana var. pinetorum association. In this area, the physiognomic difference between the two associations is that

Ceanothus velutinus and Pinus lambertiana greatly increase in dominance while Epilobium angustifolium, Apocynum androsaemilifolium, Clarkia rhomboidea, and Pyrola picta increase in presence and dominance in the Pinus ponderosa/Arctostaphylos parryana var. pinetorum-Ceanothus velutinus association as compared to the Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana var. pinetorum association. In the southwest section of the study area, Castanopsis sempervirens becomes a subordinate member on east and northwest slopes of cinder cones.

Within a matrix of the Pinus ponderosa/Arctostaphylos parryana var. pinetorum-Ceanothus velutinus association, a local fragmentary expression of the Abies concolor/Ceanothus velutinus habitat-type may appear either on the northwest-facing slopes between 5600 and 6250 feet or on the southwest to west-facing slopes of Yamsay Mountain above 6300 feet elevation. On these sites, Abies concolor reproduction is codominant with or subordinate to Pinus ponderosa and Pinus lambertiana and/or Pinus contorta in the understory, while Pinus ponderosa fully dominates the overstory. Although present in these stands, Ceanothus velutinus and Arctostaphylos parryana var. pinetorum decline in dominance and Purshia tridentata is present as a weak subordinate. Individuals of Epilobium angustifolium and Pyrola picta are more numerous in these stands than in other stands of the association. Arctostaphylos nevadensis and/or Chimaphila umbellata var. occidentalis become additional members of the community.

This association is a preferred habitat for mule deer during their mid-day activities since the steep slopes and the dense shrub cover afford a large amount of protection. The heavy use of these stands by mule deer is evidenced by the hedging of Purshia tridentata plants and the high degree of surface soil disturbance in the spaces between shrubs. In some stands, only annual forbs may be found in the disturbed interspaces. In these small stands, the interspaces are practically devoid of plant litter; the litter accumulates only within the influence of the shrub canopy and around the base of mature trees.

Pinus ponderosa/Ceanothus velutinus Associes

The Pinus ponderosa/Ceanothus velutinus associes (Figure 12) is present between 5500 and 6400 feet elevation on either Lapine or Longbell shallow phase soils. The community appears on the mid-third or upper-third positions of moderate (ten - 30 percent) slopes in hilly or mountainous topography. Generally, the slopes have west-northwest to east exposures but the associes may also occur on southwest exposures above 6100 feet elevation. At elevations between 5100 and 5300 feet, the Pinus ponderosa/Ceanothus velutinus associes may occupy northeast exposures of buttes and cinder cones.

These sites are characterized by steep slopes (45-55 percent) and Lapine moderately deep to deep phase soils.

Pinus ponderosa, Abies concolor, Purshia tridentata, Arctostaphylos parryana var. pinetorum, Ceanothus velutinus, Carex rossii, Stipa occidentalis, Cryptantha affinis, Gayophytum nuttallii, Apocynum androsaemilifolium, Epilobium angustifolium and Pyrola picta have high presence in these stands. Pinus lambertiana, Sitanion hystrix, Collinsia parviflora, Viola purpurea, Fragaria cuneifolia and Chimaphila umbellata var. occidentalis are moderately represented. Arctostaphylos nevadensis, Phacelia hastata, Lupinus candatus and Arabis rectissima are occasionally present (Appendix B Table 2).

Pinus ponderosa remains the dominant species in the overstory with an average cover value of 34 percent. Reproduction of this species (average cover ten percent) may occur on either widely scattered individuals or as small groups growing through the Ceanothus velutinus canopy.

Even though Pinus ponderosa is fully represented by all age classes, the reproduction layer is dominated by Abies concolor which has an average cover of 23 percent (Appendix B Table 1). Occasionally mature individuals of Abies concolor and Pinus lambertiana are found in the stand. However, Pinus lambertiana

Figure 12. A representative stand of the Pinus ponderosa/ Ceanothus velutinus associes.

Figure 13. A representative stand of the Abies concolor/ Ceanothus velutinus association.

holds a subordinate position in both the overstory and the reproductive layers. At the lower elevations of this community, thickets of immature Pinus lambertiana may provide a favorable microenvironment for the establishment of Abies concolor seedlings and saplings. At higher elevations, Abies concolor reproduction becomes established under the mature Abies concolor trees. In addition, Abies concolor reproduction may be observed as growing in small patches through the canopy of Ceanothus velutinus, on the shady side of downed logs, and below rock outcrops. As one approaches the Pinus ponderosa/Ceanothus velutinus-Abies concolor/Ceanothus velutinus ecotone, the Abies concolor reproduction becomes widely scattered throughout the stand.

Ceanothus velutinus is clearly the dominant species of the shrub layer with an average cover value of 44 percent. All age classes are represented in each stand. The growth form of this species differs in the Pinus ponderosa/Ceanothus velutinus associes from those plants located in other communities at lower elevations. The shrubs have long, slender, spreading stems with a few leaves dispersed along each branch. These shrubs may either occur as small groups that are widely scattered over the stand or as closely associated individuals that, in aggregation, form large groups. This latter type of sociability is most often found on the northwest to northeast slopes of cinder cones, buttes and stream canyons.

Purshia tridentata is poorly represented by both numbers of individuals and age classes. This species expresses low dominance with an average cover value of nine percent. The effective environment is marginal for the growth of *Purshia tridentata* (average height 12-16 inches) as evidenced by the poor growth form of these plants and the large number of decadent individuals in the stand. The limited numbers of live plants have caused them to become severely hedged by mule deer, especially along the game trails that disect this community.

Although present in all stands, *Arctostaphylos parryana* var. *pinetorum* is a subordinate member of the shrub layer with an average cover of 15 percent. Numerous decadent individuals appear in those stands that occupy north and northeast exposures. Except in stands with west or southwest exposures, *Arctostaphylos parryana* var. *pinetorum* generally exhibits a growth form characterized by reduced or disproportioned stems with a scanty leaf complement.

Arctostaphylos nevadensis is a prostrate, matted shrub of low dominance that appears as dense patches up to three - five feet across. It may grow in the interspaces, beneath the shrub canopy, or at the base of mature trees.

The perennial forbs and grasses are found in the openings between the tree reproduction and shrubs. *Apocynum androsaemilifolium*, Epilobium angustifolium, Carex rossii, and Stipa occidentalis are widespread in the interspaces. Pyrola picta, Chimaphila umbellata var. occidentalis and Fragaria cuneifolia appear in groups of Abies concolor reproduction and within the periphery of the overhead shrubs.

One variation of this associes occurs on the steep, northeast slope of Little Applegate Butte, Round Butte, and in the Walker Rim vicinity to the northwest of the study area. Within this community, Pinus ponderosa, Pinus lambertiana, and Abies concolor are codominants in the overstory primarily because Pinus ponderosa has been logged in the past. Pinus lambertiana reproduction is clearly dominant in the understory. The shrub layer has Ceanothus velutinus and Castanopsis sempervirens as codominants with Arctostaphylos parryana var. pinetorum subordinate to the former shrub species. Apocynum androsaemilifolium, Pyrola picta and Epilobium angustifolium are the common perennial forbs. The sites are characterized by Lapine deep phase soils and uniformly concave microrelief.

Mule deer use is generally limited to trails in this community for most of their activity is directed to the brushy hillsides and lower slopes with west and south exposures. However, this associes is used by deer during severe autumn storms and the hunting season.

Portions of the Pinus ponderosa/Ceanothus velutinus community have been logged in the Fuego Mountain vicinity of the study area. In these stands, Pinus ponderosa reproduction predominates in the disturbed openings where the overstory has been removed, but Abies concolor regeneration is becoming established along the cutting area margins that are within the shade of the residual stand. Ceanothus velutinus remains the dominant member of the shrub layer.

Abies concolor/Ceanothus velutinus Association

The Abies concolor/Ceanothus velutinus association (Figure 13) is found on northwest to northeast aspects of moderate slopes (30-45 percent) that are located above the drainages and creek bottoms of Yamsay Mountain between 5500 and 6400 feet elevation. These sites are on the mid-third to upper-third slope positions in hilly to mountainous topography that have Lapine or Longbell moderately deep or shallow phase soils. The Abies concolor/ Ceanothus velutinus association also occurs on the gentle southwest to northwest slopes of interstream ridges as elevations between 6250 and 6600 feet on Yamsay Mountain. In addition, the association is present on the northwest to southeast slopes of buttes and cinder cones between 5200 and 5900 feet elevation in the southern section of the study area. In these situations, the sites are characterized by mid-third to upper-third slope positions in uniformly concave microrelief. The soils are the deep or moderately deep phase of the Lapine series.

Tree species which have a high presence are Pinus ponderosa, Pinus contorta, Abies concolor, and Pinus monticola (Appendix B Table 2). Pinus ponderosa has an average overstory cover of 18 percent. This species may either share dominance with or be subordinate to Abies concolor (average cover 26 percent) in the overstory. Abies concolor is dominant in the understory with an average reproduction cover of 52 percent. At high elevations or on the lower north slopes into creek bottoms, Abies concolor may become codominant with Pinus monticola, Pinus lambertiana, and Pinus contorta in the understory. The older age classes of Pinus contorta, Pinus monticola, and Pinus lambertiana hold subordinate positions in the overstory.

Arctostaphylos parryana var. pinetorum and Ceanothus velutinus are most frequently present in the shrub layer. Both these species exhibit a growth form typified by long, slender, spreading stems that have a poor leaf complement. Ceanothus velutinus appears as small groups in relation to openings in the tree canopy, while Arctostaphylos parryana var. pinetorum grows as scattered individual plants throughout the stand. On certain sites the reproduction of pole-sized trees grow in such large, dense groups that the ground surface is bare except for needle litter and an occasional perennial herb.

Decadent remanents of *Ceanothus velutinus* or *Arctostaphylos parryana* var. *pinetorum* may be widely scattered within some of these stands of regeneration.

Arctostaphylos nevadensis is the most vigorous component of the shrub layer (Appendix B Table 1). Although this species is present in only half the stands sampled, it expresses a higher cover value than *Arctostaphylos parryana* var. *pinetorum* and is codominant with *Ceanothus velutinus* on these sites. *Arctostaphylos nevadensis* is shade tolerant in that it grows either within the periphery of shrubs and tree reproduction patches or in the openings of the overhead canopy. This species can often be observed to vigorously grow in the matted twigs and crown of old decadent *Ceanothus* plants. With an increase in elevation, *Arctostaphylos nevadensis* generally becomes more vigorous while *Ceanothus velutinus* and *Arctostaphylos parryana* var. *pinetorum* show additional decadence.

Purshia tridentata is occasionally present in stands of this association and expresses low dominance with an average cover value of only six percent. Many of the individuals are decadent. The living plants average 12 inches in height and are low in vigor.

Carex rossii, *Stipa occidentalis*, *Epilobium angustifolium*, and *Pyrola picta* show high presence and moderate dominance in the herbaceous layer. *Cryptantha affinis*, *Collinsia parviflora*, *Lupinus* caudatus, Hieracium cynoglossoides, Arabis rectissima, Apocynum androsaemilifolium, and Fragaria cuneifolia may be occasionally present and show low or moderate dominance. Most of these species occur as scattered individuals in the openings between shrubs or under a dense reproduction overstory.

The ground surface is well protected with a one - two inch litter layer in most stands. The only disturbance is along game trails that traverse across this habitat. The stands located on mid-third to upper-third slope positions above stream bottoms have a disturbed litter layer because game pass through these stands to the stream below.

One variation of the Abies concolor/Ceanothus velutinus association occurs on the north and east slopes of buttes and cinder cones in the southwestern section of the study area and is closely associated with a similar expression in the Pinus ponderosa/ Ceanothus velutinus associes. These stands have Abies concolor as the dominant, and Pinus ponderosa and Pinus lambertiana as subordinates in both the overstory and reproductive layers. These stands were selectively logged for Pinus ponderosa prior to the 1940's. Abies concolor has an average cover of 35 percent in the overstory and understory. Pinus ponderosa and Pinus lambertiana average ten to 15 percent. The shrub layer is strongly dominated by Ceanothus velutinus (average cover 55 percent) and Castanopsis sempervirens (average cover 25 percent). Arctostaphylos parryana var. pinetorum and Salix sp. are present but express weak dominance. The herbaceous layer contains Cryptantha affinis, Gayophytum nuttallii, Epilobium angustifolium, Apocynum androsaemilifolium, Pyrola picta, Penstemon procerus var. brachyanthus and two species of Chimaphila-Chimaphila umbellata var. occidentalis and Chimphila menziesii.

A local expression which appears to be successionally related to the Abies concolor/Ceanothus velutinus association is found on the steep north slopes of stream canyons above 5400 feet elevation on Yamsay Mountain. These stands are located on the lower-third slope positions and have Longbell shallow phase soils. The exceptionally mesic environments determine, to a great extent, the density of the tree layer and the characteristic species of the shrub layer. The overstory is composed of Abies concolor as the dominant species, Pinus contorta and Pinus monticola as codominants, and Pinus ponderosa as a weak subordinate species. In some stands, Pinus ponderosa is absent. Abies concolor, Pinus contorta, Pinus monticola reproduction comprise the understory. The total tree cover may average 130 to 150 percent. Usually Ceanothus velutinus, Arctostaphylos parryana var. pinetorum, Arctostaphylos nevadensis and Purshia tridentata are not present. The shrub layer is represented by a few individuals of Amelanchier alnifolia, Ribes viscosissium, Ribes cereum, Rosa gymnocarpa, Salix sp. or Prunus subcordata. The herbaceous layer includes Carex rossii, Sitanion hystrix, Hieracium cynoglossoides, Fragaria cuneifolia, Lupinus caudatus, Epilobium angustifolium, Pyrola picta, and Chimaphila umbellata var. occidentalis as moderate to weak dominants.

DISCUSSION

General Vegetation-Soil Relationships

A review of the vegetation-soil units described in this study will illustrate the lack of specificity between the plant communities and the soil series upon which these communities appear. With the exception of the Shanahan series being associated with only the *Pinus ponderosa*/*Purshia tridentata*/*Festuca idahoensis* community, either the Lapine or Longbell soil series is found in the majority of representative habitats of every ecological unit. Although, a few plant communities tend to occur more readily on some soil depth phases than on others; every plant community contains stands which appear on deep, moderately deep or shallow soil depth phases.

This lack of strong correlation between the occurrence of any association with a single site factor such as soil illustrates two important points regarding the synecology of the Upper Williamson River Basin. First, factor compensation performs a significant role in determining the habitat-types within the study area; and therefore, an adequate interpretation of the vegetation units cannot be made without using a multiple-factor approach. Secondly, in areas of young soils, the use of soil surveys as the sole basis for making management decisions may be entirely inadequate for effective resource administration.

Dyrness (22, p. 153-155) indicated that soil moisture is of considerable importance in controlling the distribution of plant communities on the pumice soils of the Weyerhaeuser Antelope Unit. Therefore, the appearance of an association on any site is probably due to a compensation of site factors that, when considered together, would produce an environmental regime--of which soil moisture is an important component--that is within the ecological requirements of the plant species comprising the association.

The relative mesism of habitat-types may be inferred by comparing the dominance of their communities' tree and shrub layers. Furthermore, a mesic environment is capable of producing more plant material than a xeric environment. Therefore, the *Abies concolor*/*Ceanothus velutinus* association has a greater total plant cover than either the *Pinus ponderosa*/*Ceanothus velutinus*-*Purshia tridentata* or the *Pinus ponderosa*/*Purshia tridentata* associations (Appendix B Table 1).

The representative stands of any given plant community most frequently occur within a definite elevational range (Appendix A Table 2). However, one must recognize that such site factors as soil series and depth, slope position and exposure, macrorelief and microrelief, or local air-drainage patterns may modify the influence of elevation so that an association may appear above or below the normal elevational range of the habitat-type. For example, the Pinus ponderosa/Purshia tridentata/Festuca idahoensis association is usually found below 5050 feet, but may occupy sites between 5650 and 5950 feet elevation that have Longbell or Shanahan shallow phase soils and uniformly flat or concave microrelief. The Pinus ponderosa/Purshia tridentata association may appear on well-drained plateaus with undulating macrorelief and shallow soils between 5500 and 5800 feet elevation, although the association most often is situated below 5200 feet elevation on deep or moderately deep Lapine soils. Normally, the Pinus ponderosa/Ceanothus velutinus-Purshia tridentata habitat-type is characterized by shallow or moderately deep Lapine or Longbell soils between 5350 and 5750 feet elevation; but the association is also found on sites with deep Lapine soils at 4800 to 5100 feet elevation that have northeast to east exposures and concave microrelief. The Abies concolor/Ceanothus velutinus association and its Pinus ponderosa/Ceanothus velutinus associes normally occur between 5450 and 6400 feet elevation on moderately deep to shallow Lapine or Longbell soils; however, both the association and its associes occupy sites as low as 5100 feet elevation that have concave microrelief and north to east-northeast-facing slopes or a favorable air-drainage pattern.

Site factor compensation may also permit the habitat-type to appear at elevations that are either beyond the ecological amplitude of a few of its plant members or within the ecological amplitude of additional species without greatly disturbing the floristic composition of the plant community. For example, the occurrence of the Abies concolor/Ceanothus velutinus habitat-type at low elevations in the southern section of the study area places the plant community within the ecological amplitude of Castanopsis sempervirens. This species becomes an additional member of the shrub layer that is normally characterized by only Ceanothus velutinus, Arctostaphylos parryana var. pinetorum and Purshia tridentata. In these same stands, Lupinus caudatus, Hieracium cynoglossoides, and Fragaria cuneifolia are absent from the herbaceous layer; but Penstemon procerus var. brachyanthus and Chimaphila menziesii become additional members of this layer.

A general relationship is evident between the soil depth phase and the elevation of the study area (Appendix A Table 4), mainly since the pumice soil depth is closely related to the distance from the pumice source (76,p. 42-43). As one proceeds from the Klamath Marsh to the upper west slopes of Yamsay Mountain, the distance from Crater Lake becomes greater and the soil depth, generally, becomes shallower. Consequently, the deep soil phases of the

Lapine and Longbell series are usually found below 5400 feet elevation; one exception being the deep Lapine soils of Fuego Mountain and vicinity that occur above 5300 feet elevation. The moderately deep soil phases appear throughout the elevation range of the study area; but occur most frequently between 5000 and 6000 feet elevation. The shallow soil phases are usually found at elevations above 5600 feet.

In addition, the genesis of pumice soil profiles seems correlated with the depth of the pumice accumulation and the amount of plant cover. Of the thirty-two Longbell profiles examined, twenty-one of these profiles--nearly two-thirds--occurred as shallow soil depth phases (Appendix A Table 4). These Longbell soils occur more readily at the middle and high elevations where the pumice deposition is shallow and the plant cover is dense. At these elevations, the Longbell soils support stands of the Pinus ponderosa/Purshia tridentata/Festuca idahoensis and Abies concolor/Ceanothus velutinus associations or the Pinus ponderosa/Ceanothus velutinus associes. This is in accordance with Dyrness (22, p. 132), who found that the amount of alteration of the pumice mantle increases with increasing effective moisture and plant cover.

The Shanahan series shows the most profile mixing of the pumice soils sampled. This series is associated only with the

Pinus ponderosa/Purshia tridentata/Festuca idahoensis community in the shady area. The series is more common to the north and east of the study area and has been located only at two sites in the Upper Williamson River Basin.

Successional Relationships

The floristic stability of each plant community is of interest to the land administrator inasmuch as the degree of stability determines the present and future timber and range management practices that are applied to, and the economic returns derived from each synecological unit. A complete explanation as to the reasons for any successional transformation is not within the realm of this paper since the field data are largely qualitative in nature. However, several reasons are proposed with the understanding that they are largely speculative and with the expectation that they will stimulate further investigation.

Undoubtedly, climatic trends over the last 4000 years and the active fire history of this vicinity have determined, to a great extent, the species which compose the tree, shrub, and herbaceous layers of these plant communities. However, the general exclusion of wild fire from these stands for approximately a half century has permitted, at least, the shrub and herbaceous layers of the unlogged, lightly grazed stands to reach equilibrium with the soil and topographic features of the environment.

A few representative stands of the Pinus ponderosa/Purshia tridentata, the Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana var. pinetorum and the Pinus ponderosa/Arctostaphylos parryana var. pinetorum - Ceanothus velutinus associations show indications of present successional development. In spite of this evidence of current successional change, these ecosystems together with those stands of the Pinus ponderosa/Purshia tridentata/Festuca idahoensis, the Pinus ponderosa/Ceanothus velutinus-Purshia tridentata and the Abies concolor/Ceanothus velutinus associations which occur on young pumice soils at elevations typical of each association are considered as edaphic climaxes. Since some of these associations are probably many generations removed from a possible common, zonal climax and presently exist as identifiable entities in relation to the soil and topographic features of the environment; the author has retained the climax interpretation of C. T. Dyrness (22) until additional studies clarify the seral relationships among them.

In addition, those low elevational stands of the Pinus ponderosa/Ceanothus velutinus - Purshia tridentata and Abies concolor/Ceanothus velutinus associations together with the high elevational stands of the Pinus ponderosa/Purshia tridentata/Festuca idahoensis association occur at these elevations because of compensating physiographic factors and are, for the purposes of this study, defined as topo-edaphic climaxes.

The Pinus ponderosa/Ceanothus velutinus associes was considered an early successional state of the Abies concolor/ Ceanothus velutinus association by Dyrness (22, p. 103-106); the results of the present study substantiate this hypothesis. The high presence and total crown spread of Abies concolor in the Pinus ponderosa/Ceanothus velutinus stands, and the comparable presence or dominance values of Arctostaphylos nevadensis, Lupinus caudatus, Epilobium angustifolium, Pyrola picta and Fragaria cuneifolia between the Pinus ponderosa/Ceanothus velutinus associes and the Abies concolor/Ceanothus velutinus association illustrates the similarity between these two communities (Appendix B Tables 1 and 2). Abies concolor occurs in 88 percent of the Pinus ponderosa/ Ceanothus velutinus stands sampled and is the dominant species in the tree reproduction layer. This species has been observed to outgrow Pinus ponderosa in the reproduction layer. Pinus ponderosa remains the overstory dominant with 34 percent average cover. Both Arctostaphylos parryana var. pinetorum and Purshia tridentata are weak subordinates in these plant communities as compared to their occurrence in other communities.

A habitat-type is characterized by having a fairly consistent effective environment throughout its range. If the Pinus ponderosa/ Ceanothus velutinus is successionally related to the Abies concolor/ Ceanothus velutinus association, then both of their physical environments should exhibit many resemblances to one another (Appendix A Tables 1, 2. and 3). The majority of the Pinus ponderosa/Ceanothus velutinus and Abies concolor/Ceanothus velutinus stands occur above 5300 feet elevation on northwest to east exposures of uniformly concave or convex slopes in hilly to mountainous topography. The soils are either shallow or moderately deep phases of the Lapine or Longbell series.

A few stands of both the Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana var. pinetorum and the Pinus ponderosa/ Arctostaphylos parryana var. pinetorum - Ceanothus velutinus associations have an understory containing minor amounts of Abies concolor reproduction (Figure 14). Most consistently, these stands are located at elevations above 5500 or 5600 feet on west-southwest to northwest exposures and has Lapine moderately deep to shallow phase soils. The stands are adjacent to either Abies concolor-populated creek bottoms and draws or stands of the Pinus ponderosa/ Ceanothus velutinus associes upslope. In addition, widely-scattered Abies concolor saplings were observed in a few stands of the Pinus

Figure 14. The establishment of Abies concolor in a Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana var. pinetorum stand.

Figure 15. A stand of Pinus ponderosa/Purshia tridentata burned by the Chiloquin fire of September 1959. Photo taken September 1962.

ponderosa/Purshia tridentata association which were located on plateaus between 5500 and 5800 feet elevation. These high plateaus have Lapine or Longbell shallow soils and adjoin drainages supporting Abies concolor sapling and thrifty age classes. The recent establishment of Abies concolor reproduction in stands of these associations has created a mesic microenvironment within the influence of the canopy that has enabled Lupinus caudatus, Epilobium angustifolium, Pyrola picta, Chimaphila umbellata var. occidentalis, Fragaria cuneifolia and/or Arctostaphylos nevadensis to become established in stands whose microenvironment previously supported species characteristic of drier sites.

Hansen (35) indicated that the climate over the last 2000 years has been favorable for the increase of the mesic Abies concolor and Pinus monticola in areas of thin pumice mantle. Moreover, Pearson (59) suggested that the combination of high temperatures during the growing season and the accumulation of sufficient moisture during the dormant season favors the growth of mesic species in the Pinus ponderosa type of eastern Oregon and Washington. The past occurrence of numerous wildfires in 35 to 50 year intervals in all plant communities of the Upper Williamson River Basin has excluded Abies concolor and Pinus monticola from many of the stands which would normally be climatically suitable for these species. In their place, the fire tolerant Pinus ponderosa was able to grow and reproduce as a pyric climax species on many of these high elevation sites.

However, effective fire control measures has permitted the dilution of the more xeric plant communities by a few species of the Abies concolor/Ceanothus velutinus habitat-type in areas which lie adjacent to Abies concolor - dominated communities or sources of Abies concolor seed pressure. The invasion of these species has occurred in localized shade spots and other cooler and more mesic, local microenvironments.

Disregarding such evident disturbances as wild fires, logging and overgrazing or such imperceptible disturbances as unfavorable changes in climatic trends; the migration of mesic species into low elevational sites will be governed by the rate at which these effective environments become suitable for the germination and survival of the mesic species. In this respect, quite a few generations of Pinus ponderosa are required before many of the drier, low elevation sites will progress into the Abies concolor - dominant condition. This Abies concolor dominance at low elevations requires that the associations, as defined, be successionally related. But presently, the effective environments and plant assemblages of each habitat-type seem so diverse that the dynamic relationships between associations are not clearly evident. In the future, the migration of mesic species to lower elevations will probably be hindered by silvicultural and grazing practices which will open up the overstory, disturb the understory, and tend to hold at least all but the Abies concolor/Ceanothus velutinus habitat-type in their present climax condition.

Species Autecology

In the previous discussion of successional relationships within several habitat-types of the study area, some consideration was given to the environmental requirements of the more indicative tree and herbaceous species. Indeed, any attention to the synecology of an area necessitates some familiarity with the autecology of the species; and conversely, any consideration of the species' environmental requirements demands some acquaintance with the plant community in which the species grows. For this reason, the autecology of the most prevalent species in the tree, shrub and herbaceous layers will be discussed in relation to the synecology of the study area.

Soil moisture is the most critical factor in the establishment of Pinus ponderosa (10; 50; 54; 60); but, once established, Pinus ponderosa is able to endure soil moisture tensions below the permanent wilting point (26). Dyrness (22, p. 149-152) found that the soil moisture in the A1 and AC horizons under Pinus ponderosa/ Purshia tridentata stands was reduced to the permanent wilting point by mid-July or early-August, and in the Pinus ponderosa/ Purshia tridentata-Arctostaphylos parryana var. pinetorum stands by mid-August. The natural regeneration of Pinus ponderosa on these extreme sites is achieved either by seedling establishment within the protective influence of the Arctostaphylos and Ceanothus overstory or by seedling establishment in the microenvironments that are released by the death or windthrow of older individuals. In this respect, Dyrness (22, p. 82) noted that the Pinus ponderosa/ Purshia tridentata association so approximates the environmental tolerance limits of Pinus ponderosa that the species only regenerates successfully in snag patches. Therefore, a heavy timber harvest may have such a desiccating effect that the site is no longer within the ecological amplitude of the Pinus ponderosa seedlings.

The microrelief and soils characteristic of the Pinus ponderosa/ Purshia tridentata/Festuca idahoensis habitat-type are favorable for the initial establishment of Pinus ponderosa; however, the survival of these seedlings is impaired by the dense, deeply-growing grass roots which afford intensive competition for soil moisture during the subsequent growing season. The Festuca idahoensis roots do extend, in some cases, through the pumice soil to the buried soil below in stands with shallow Longbell or Shanahan profiles. On these sites, Pinus ponderosa reproduction grows very slowly until the sapling roots outgrow the grass influence and then are able to develop freely in the buried soil and fractured underlying basalt.

Pinus ponderosa is poorly represented on sites that have a fluctuating or high water table (75; 90) or in basins which accumulate cold air (73; 90). Without exception, these sites support _Pinus contorta_, a species which has a higher soil moisture and a cooler air temperature requirement than _Pinus ponderosa_ (69). On the slopes above these cold-air basins and fluctuating water table sites, the soil moisture and air temperature regimes are less favorable for _Pinus contorta_, so _Pinus ponderosa_ is the overstory dominant. At high elevations, _Pinus contorta_ becomes an important seral component on the interstream ridges and in creek bottoms within the _Abies concolor/Ceanothus velutinus_ habitat-type.

Fire has been an important factor in maintaining _Pinus ponderosa_ on high elevational sites where the effective environment is favorable for the establishment of mesic species (6; 23). This is especially evident in the lower portions of the _Pinus ponderosa/Ceanothus velutinus_ associes and in the high elevational stands of the _Pinus ponderosa/Arctostaphylos parryana_ var. _pinetorum-Ceanothus velutinus_ associes and in the high elevational stands of the _Pinus ponderosa/Arctostaphylos parryana_ var. _pinetorum-Ceanothus velutinus_ association where the _Abies concolor_ and _Pinus monticola_ reproduction is 35 - 50 years old--a time period related to the beginning of fire control in the Klamath Basin. In addition, fire may influence the location of species by the pattern it creates as it spreads over the landscape (85, p. 100). The older Abies concolor stands of the steep north slopes of stream canyons and cinder cones between 5200 and 5600 feet elevation could be attributed to the cool, moist growing conditions of these protected sites as compared to the more xeric environments of ridge tops, south slopes and level to rolling topography that are more frequently burned and support Pinus ponderosa.

Generally, Pinus lambertiana requires as favorable a soil moisture regime as Abies concolor but is less shade tolerant than the latter species (27; 47). For this reason, Pinus lambertiana is usually associated with Pinus ponderosa in stands that have only small to moderate amounts of Abies concolor in the overstory and understory. Although Pinus lambertiana may occur on north and northwest slopes, its best reproductive vigor is achieved on the northeast aspects of cinder cones and interstream ridges between 5200 and 6400 feet elevation.

The available surface soil moisture and cool atmospheric temperature requirement plus the shade tolerance of Abies concolor determines the environments in which this species can germinate and become established (49). Abies concolor normally occurs on the southwest to northwest slopes of interstream ridges above 5800 feet elevation. Since this species reproduces exceptionally well on sites which have a moist litter layer under the partial shade of an overstory, Abies concolor can also germinate and survive between 5600 and 6000 feet elevation in a few of the open stands of Pinus ponderosa/Purshia tridentata, the Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana var. pinetorum and the Pinus ponderosa/Arctostaphylos parryana var. pinetorum-Ceanothus velutinus associations. Because of this autecological requirement, selective logging methods will favor the regeneration of Abies concolor in these mixed-conifer stands that are presently dominated by Pinus ponderosa in the overstory (49; 50; 84). Below 5600 feet elevation, the mid-day temperatures and soil moisture regime become unfavorable for the establishment of Abies concolor on all sites except the north to northeast slopes of cinder cones or the north slopes of steep stream canyons.

In the study area, Pinus monticola will not become successfully established on sites unless the ground surface is shaded by a dense overstory canopy. Therefore, Pinus monticola is found in stands of the Abies concolor/Ceanothus velutinus association that have over a 110 percent total tree cover. This species also occurs as a weak subordinate in stands of the Pinus ponderosa/Arctostaphylos parryana var. pinetorum-Ceanothus velutinus habitat-type which are above 6200 feet elevation. Since the overstory of these stands is quite open, the Pinus monticola reproduction grows in patches that are closely associated with Abies concolor.

The wide-spread growth of Ceanothus velutinus and Arctostaphylos parryana var. pinetorum in certain habitat-types of the study area was initially governed by periodic fires prior to 1900-1910 and then by high-risk logging during the first half of this century. Both species are well adapted, physiologically, to these disturbances in that Ceanothus velutinus crown sprouts and germinates after burning or logging (7; 9; 20) while Arctostaphylos parryana var. pinetorum, although killed by fire, prolifically germinates following disturbance in the stand (85; 88). Extensive stands of Ceanothus velutinus and/or Arctostaphylos parryana var. pinetorum in the Pinus ponderosa/ Purshia tridentata-Arctostaphylos parryana var. pinetorum, the Pinus ponderosa/Ceanothus velutinus-Purshia tridentata, and the Pinus ponderosa/Arctostaphylos parryana var. pinetorum-Ceanothus velutinus associations may be attributed to the prehistorical fires and relatively recent logging in the central and southern portion of the study area. While comparable stands of Arctostaphylos and Ceanothus in the same associations on the west slopes of Yamsay

Mountain have developed only from prehistorical fire disturbance. Since these latter stands have been relatively undisturbed in recent years, the plant communities have attained equilibrium with the soil and topographic features of their environment.

The high dominance and improved vigor of Arctostaphylos in the Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana var. pinetorum association, and on the southeast to southwest exposures of the Pinus ponderosa/Arctostaphylos parryana var. pinetorum-Ceanothus velutinus habitat-type (Appendix B Tables 1 and 2) indicates that this species has a low soil moisture and high air temperature requirement. These sites are characterized by soils that have very little available moisture by mid-summer and by slopes that have exceptionally warm mid-day air temperatures during the growing season.

Ceanothus velutinus becomes dominant over Arctostaphylos parryana var. pinetorum in the Pinus ponderosa/Ceanothus velutinus-Purshia tridentata association and the Pinus ponderosa/Ceanothus velutinus associes and on west to northwest slopes of the Pinus ponderosa/Arctostaphylos parryana var. pinetorum-Ceanothus velutinus habitat-type where the air temperatures are warm during the growing season and the available soil moisture of the surface horizons is very seldom depleted during the summer months.

However, both Ceanothus velutinus and Arctostaphylos parryana var. pinetorum are intolerant to shading as evidenced by the increased decadence and poor growth form of these species in stands of the Abies concolor/Ceanothus velutinus association that exhibit a high crown spread and increased side shading from the tree layer, or in stands of the Pinus ponderosa/Arctostaphylos parryana var. pinetorum-Ceanothus velutinus association which have dense patches of tree reproduction.

Purshia tridentata achieves its best development in the Pinus ponderosa/Purshia tridentata and the Pinus ponderosa/Purshia tridentata - Arctostaphylos parryana var. pinetorum associations and gradually declines in dominance, presence and vigor with an increase in elevation (Appendix B Tables 1 and 2). In this regard, Purshia tridentata can tolerate more xeric environments than either Arctostaphylos parryana var. pinetorum or Ceanothus velutinus for the soils of both habitat-types reach the permanent wilting point by late July or August and the mid-day air temperatures remain warm from late spring through early autumn.

Garrison (29) has noted that Purshia tridentata leader growth is very sensitive to the amount of precipitation accumulated in the soil profile over the winter and spring months. However, at elevations above 5500 feet where soil moisture is adequate, *Purshia tridentata* exhibits a stunted growth form characterized by reduced stems and a sparce leaf complement. These sites are marginal for the growth of *Purshia tridentata* because of the cool air and soil temperatures and low light intensity which reaches the forest floor.

Much of the *Purshia tridentata* in the *Pinus ponderosa*/*Purshia tridentata*/*Festuca idahoensis* association exhibits a reduced crown spread, average plant height and growth form as a result of intensive *Festuca idahoensis* competition for the available soil moisture. The resultant poor vigor of *Purshia tridentata* in this association may have permitted additional damage to these plants by tent caterpillars.

Periodic fires are detrimental to the establishment and survival of *Purshia tridentata* (56; 68). Much of the stands of the associations in which *Purshia tridentata* is the outstanding shrub dominant were probably dominated by *Stipa occidentalis*, *Sitanion hystrix* and *Carex rossii* in the herbaceous layer prior to the formation of fire protection organizations in the Klamath Basin (83). Presently, this grass dominance is only evident in the lower portions of the Chiloquin Burn where fire swept through stands of the *Pinus ponderosa*/*Purshia tridentata* association in September 1959 (Figure 15).

The forbs and grasses that comprise the herbaceous layer are largely dependent upon the A1 and AC horizons as their rooting medium. The ability of these soil horizons to fulfill the moisture and fertility requirements of the herbaceous layer is reflected in the degree of presence and vigor by which the herbaceous species are expressed in the stands of a habitat-type.

Dyrness (22, p. 143-153, 168-169) illustrated that the moisture regime of the A1 and AC horizons varied greatly, while the fertility level changed very little among habitat-types. For this reason, the difference in the presence of forbs and grasses among habitat-types is largely dependent upon the difference in their soil moisture depletion characteristics. He found that within stands, the moisture content and fertility level of the A1 and AC horizons varied greatly between the interspaces and the microenvironment beneath the shrub canopy. In the interspaces, the permanent wilting point of the surface soil horizons was reached one to three weeks before the permanent wilting point of the same horizons was attained under the shrub canopy (22, p. 158). In addition, the A1 horizon under Ceanothus velutinus and Arctostaphylos parryana var. pinetorum was high in exchangeable calcium, magnesium, potassium and total nitrogen than in the open; and the AC horizon was higher in available phosphorus and exchangeable potassium under the shrubs than in the open (22, p. 171-173). Therefore, the additional soil moisture and nutrients found under shrubs may provide a means by which some forbs can survive on otherwise extreme sites.

Throughout the study area Stipa occidentalis, Carex rossii, and Sitanion hystrix are most prominent in the openings between shrubs. These grasses generally express small cover values in all habitat-types, but are very responsive to disturbances in the stand which remove most of the competing perennial vegetation. Therefore, upon logging or heavy opening of the stand this grass layer does increase tremendously in dominance and thus produces additional herbage.

Since the annual forbs--Cryptantha affinis, Gayophytum nuttallii, Collinsia parviflora, and Mentzelia albicaulis--are quite sensitive to the amount of available moisture in the A1 horizon, their numbers may vary greatly from year to year. In the low elevations more individuals of these ephemeral species are found within the shrub periphery than in the openings between shrubs. The annual forbs complete their seed dissemination by early July in the lower elevations. The plants in the openings complete their life cycle two to three weeks before those individuals located under the shrub influence.

The mesic conditions characteristic of the Pinus ponderosa/ Purshia tridentata/Festuca idahoensis habitat-type affords an ideal environment for the expression of various herbaceous plants which either show high fidelity for this association or are found less abundantly in other associations. The phenology of many perennial forbs is such that they mature by mid-summer and prior to the occurrence of soil drought in this association.

Except for Festuca idahoensis, Ranunculus occidentalis, Delphinium menziesii, Achillea millefolium var. lanulosa, Horkelia fusca, Lomatiun triternatum, Cirsium foliosum, and Paeonia brownii which grow specifically in the Pinus ponderosa/ Purshia tridentata/Festuca idahoensis association; most of the herbs show no strong fidelity to any single habitat-type (Appendix B Table 2).

Antennaria geyeri, Madia minima, Senecio integerrimus and Lupinus minimus attain their best development in the open micro-environments of the Pinus ponderosa/Purshia tridentata and/or Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana var. pinetorum habitat-types; but may also occur in the openings between shrubs in a few stands of the Pinus ponderosa/Ceanothus velutinus-Purshia tridentata or the Pinus ponderosa/Arctostaphylos parryana var. pinetorum-Ceanothus velutinus association. Phacelia hastata, Viola purpurea, Spraguea umbellata and Arabis rectissima are a group of forbs which occur over a seemingly wide range of effective environments. However, they exhibit specific site requirements by occupying the openings between shrubs only in those stands which have xeric-tending microenvironments.

Both Apocynum androsaemilifolium and the dwarf form of Epilobium angustifolium are important members of the herbaceous layer at middle and high elevations. On the warm southeast to southwest exposures of convex slopes, Epilobium angustifolium grows under the Arctostaphylos and Ceanothus brush of the Pinus ponderosa/Arctostaphylos parryana var. pinetorum-Ceanothus velutinus association and adjacent stands of the Pinus ponderosa/ Purshia tridentata-Arctostaphylos parryana var. pinetorum association, while Apocynum androsaemilifolium grows in the openings. On the west to north exposures of concave or convex slopes in the Pinus ponderosa/Arctostaphylos parryana var. pinetorum-Ceanothus velutinus, the Pinus ponderosa/Ceanothus velutinus - Purshia tridentata associations and the Abies concolor-Ceanothus velutinus habitat-type, these two perennial forbs appear in the shady openings between shrubs or groups of tree reproduction.

Lupinus caudatus, Fragaria cuneifolia, Hieracium cynoglossoides, Pyrola picta, Chimaphila umbellata var. occidentalis and Penstemon procerus var. brachyanthus express their highest presence and dominance in the interspaces of the Pinus ponderosa/Purshia tridentata/Festuca idahoensis and/or Abies concolor/Ceanothus velutinus habitat-types. These perennial forbs may grow under the shrub canopy in stands of the Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana var. pineforum, Pinus ponderosa/

Ceanothus velutinus-Purshia tridentata and Pinus ponderosa/ Arctostaphylos parryana var. pinetorum-Ceanothus velutinus associations.

Practical Implications

The present study has illustrated the importance of using an ecosystem or total environmental approach to vegetation classification. Merely using a soil survey would have led to an oversimplification of the vegetation complex, while purely a vegetation inventory would have omitted much of the causation for differential site productivity. The characterization of vegetation-soil units as related to the local topographic variability is of practical importance in that the landscape is then differentiated into units of equivalent vegetative potential which act as a basis for resource inventory and subsequent effective resource management. Because many of the timber management problems which are associated with the central Oregon pumice region have been discussed by Dyrness (22, p. 200-203) and have been implied in the present study, the following discussion considers two ecological conditions as they apply to range management in the Upper Williamson River Basin.

Since forbs and grasses are so responsive to slight physical and chemical changes in the microenvironment, the relative position of perennial forbs in forest stands of the study area is of practical significance not only in grass seeding but also in the planting of shrubs and trees. For example, the presence of the mesic-tending perennial forbs in the interspaces may indicate a site which has a surface soil moisture, air temperatures, nutritional capacity or a soil series and depth phase that are favorable for very successful nursery of stock survival and growth. However, the presence of Festuca idahoensis and its associated forbs may indicate sites that are suitable for seeding palatable range grasses but are too disease-infested to economically plant trees. In this respect, the herbaceous layer has been used as a general indicator of site quality in some forest stands (38;87).

The study area is an important summer-early fall range for cattle, sheep and mule deer. The cattle primarily graze the grasslands associated with the Klamath Marsh, Upper Williamson River and the narrow meadows of adjoining creek drainages, and use the adjacent forest ranges for shade or shelter. The sheep and mule deer graze the remaining forest range. Purshia tridentata is the most important ingredient in the diets of both sheep and mule deer during the summer-early fall period, but they also graze the subordinate grasses, sedges and ephemeral forbs (13).

The impact of grazing upon Purshia tridentata depends largely upon the amount of Purshia tridentata available and the initial vigor of the plant. The uncut Pinus ponderosa/Purshia tridentata, Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana var. pinetorum and Pinus ponderosa/Ceanothus velutinus-Purshia tridentata stands contain the most vigorous plants and the most extensive stands of Purshia tridentata. Since the grazing pressure in these stands is absorbed by so many plants, the plants exhibit light to moderate use except for a few deer concentration or sheep bedground areas. The uncut Pinus ponderosa/Purshia tridentata/ Festuca idahoensis, the Pinus ponderosa/Archostaphylos parryana var. pinetorum-Ceanothus velutinus and the Abies concolor/ Ceanothus velutinus habitat-types support less extensive stands of Purshia tridentata. The vigor of this plant in these habitat-types is reduced because of either intensive grass root competition for available soil moisture as in the Pinus ponderosa/Purshia tridentata/Festuca idahoensis association or heavy use of the few available plants as in all three habitat-types. In addition, selective logging has affected the density of Purshia tridentata by the physical destruction of its numbers and, subsequently, a reduction of the grazing capacity of these logged stands for approximately seven to ten years (21; 30).

Presently, the utilization of the available browse in uncut portions of the study area is balanced so that the domestic sheep and some deer graze the open habitat-types of lower elevations and the more accessible stands at high elevations; while the remaining deer concentrate in the inaccessible stands of steep slopes, brushy hillsides or high plateaus at moderate elevations and trail through the dense mixed-conifer stands of high elevations and stream canyons. However, the method by which these uncut timber stands are logged may determine to what extent livestock and wildlife grazing will conflict or be compatible with timber production.

The logged-over stands in the central and southern sections of the study area serve to illustrate the management problems that may arise from poorly-regulated timber cutting. The extensive high-risk logging in past decades has permitted Ceanothus velutinus, Arctostaphylos parryana var. pinetorum or Abies concolor to increase in many cutover stands of the Pinus ponderosa/ Arctostaphylos parryana var. pinetorum-Ceanothus velutinus, the Pinus ponderosa/Ceanothus velutinus-Purshia tridentata, the Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana var. pinetorum, or the Abies concolor/Ceanothus velutinus habitat-types and has caused the residual Purshia tridentata to become unavailable or to decline in cover. The deer use has become more intensive on the available Purshia tridentata and has, consequently, reduced its vigor. The increase of Ceanothus velutinus and Arctostaphylos parryana var. pinetorum at these moderate elevations has restricted the domestic sheep use to the lower slopes and broad canyon bottoms.

The failure to balance grazing pressure with the decrease in the palatable herbage which follows logging disturbances has reduced the general range condition and plant vigor in these areas. This decrease in available forage must be taken into consideration in the management of both the timber and range resources (31).

Since the resulting imbalance between animal numbers and grazing capacity resulting from logging practices may adversely affect the timber, range, and recreation resources, a solution to the problem should be a compromise on the part of all interests. A logging system which permits the continued establishment of *Pinus ponderosa* as a seral species at high elevations would also maintain the understory shrub cover of these sites. In addition, felling and yarding practices which retain a majority of the original shrub stand followed by the possible seeding of short-lived grasses may prevent a notable reduction in the grazing capacity of these stands. However, until more is known about the response of seeded grasses or shrubs to pumice soil environments, much of the range improvement practices should involve regulating livestock distribution by watering and salting, herding or riding, or fencing techniques to obtain more efficient use of the available forage. Furthermore, livestock grazing seasons could be regulated on a logging unit basis in which the more recent logging shows are grazed for shorter time periods and in a later part of grazing season than older cutover areas. This reduces site disturbance on recently logged sites and permits tree and shrub regeneration to become established.

If the resultant grazing pressure is not within the grazing capacity provided by the residual shrubs and the additional forage provided by seeding, then as the last alternative, the livestock or big game numbers should be regulated. This implies not only closer administrator-rancher or administrator-hunter relations, but also additional education of the public in wildlife - livestock - land use problems and of the land administrator in the ecological characterization and responses of the resources to management.

A solution to such a problem requires the land administrator to become familiar with all aspects of the plant and animal environment since effective progress is made only if biological principles are understood and adhered to, and the economic requirements are fulfilled within the framework of these biological limitations. A classification based upon the ecological units of the plant and animal environment facilitates the formation of a platform of basic knowledge upon which an understanding of the ecosystem and its management may grow. This research is the first step in building that platform in the Upper Williamson River Basin.

SUMMARY

A phytosociological investigation of the Upper Williamson River Basin was performed using a qualitative reconnaissance technique to obtain analytical vegetation and site data, and an association table to synthesize these analytical data into units of similar ecology. A species list and an estimation of age-class distribution, five-point dominance ratings and canopy coverage of the vegetation together with a description of the soil and physiographic features were taken at each sample location.

Five habitat-types of the Pinus ponderosa zone and one habitat-type of the Abies concolor zone are described as occurring on the Lapine, Longbell or Shanahan soil series over varying elevation and relief patterns. The Pinus ponderosa zone is characterized by the Pinus ponderosa/Purshia tridentata association, the Pinus ponderosa/Purshia tridentata/Festuca idahoensis association, the Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana var. pinetorum association, the Pinus ponderosa/Ceanothus velutinus-Purshia tridentata association, and the Pinus ponderosa/ Arctostaphylos parryana var. pinetorum-Ceanothus velutinus association. The Abies concolor zone is represented by the Pinus ponderosa/Ceanothus velutinus associes and the Abies concolor/Ceanothus velutinus association. The vegetation and

environmental characteristics, inherent variability, and extraneous disturbances of each plant community are described.

Factor compensation is important in determining the occurrence of plant communities within the study area since any single plant community may occur over several different soil and physiographic situations. The appearance of a plant community on any given site is apparently due to a compensation of site factors that, in aggregate, produce an environmental regime which is within the ecological amplitude of its member species. In this respect, a plant community may occur either above or below its normal elevational range and, in so doing, may extend beyond the ecological amplitude of a few of its plant members or fall within the ecological amplitude of additional species.

The *Pinus ponderosa*/*Purshia tridentata*/*Festuca idahoensis* association, although restricted to the Shanahan soil series northeast of the study area, appears most frequently on the Lapine and Longbell series in the Upper Williamson River Basin. The representative stands of the remaining plant communities occur on either the Lapine or Longbell series. The genesis of pumice soils appears related to the depth of pumice deposition and the amount of plant production. The Longbell soil series--which exhibits only pockets of raw pumice in its profile--occurs more readily at the middle and high elevations where the pumice deposition is shallow or the series is associated with those stands at lower elevations which have a dense herbaceous layer.

The present successional status of the plant associations seems temporarily stabilized by the soil and topographic features of the environment. Since a lack of adequate information presently exists to clarify any seral relationships among these associations, those representative stands which occur on young pumice soils at elevations typical of each association are considered edaphic climaxes. However, those representative stands which appear above or below the characteristic elevational range of an association because of compensating physiographic factors are called topo-edaphic climaxes.

The Pinus ponderosa/Ceanothus velutinus associes is considered an early successional stage of the Abies concolor/Ceanothus velutinus association as evidenced by the rapid encroachment in the Pinus ponderosa/Ceanothus velutinus understory of mesic-tending tree and herbaceous species. In addition, the characteristic species which are common to both communities express similar presence and dominance values, and their physical environments are similar. A few species of the Abies concolor/Ceanothus velutinus habitat-type may appear in those few stands of the Pinus ponderosa/Purshia tridentata, the Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana var. pinetorum and Pinus ponderosa/Arctostaphylos parryana var. pinetorum - Ceanothus velutinus associations which lie adjacent to areas of heavy seed pressure. The presence of these association fragments is governed by the localized mesic micro-environments which occur in these more xeric-tending habitat-types. The continued migration of the mesic species downslope will probably be hindered by future land management practices that will create microenvironments beyond the tolerance limits of the mesic species.

The autecology of the characteristic species is discussed in relation to the synecology of the study area. The variability in their presence and relative dominance within and among habitat-types can be partially explained by the autecological requirements of the species in relation to the physical environments of each habitat-type. The response of some species to the effective environments which approach their tolerance limits is reflected in the growth form, vigor and phenology of these species and their competitive position to other species in the stand.

The classification of vegetation-soil units upon an ecological basis permits the subdivision of the landscape into units of equivalent vegetative potential which act as a basis for resource inventory and subsequent effective resource management. The application of this ecological study to the timber, range and wildlife resources of the upper Klamath Basin is considered. In forested areas where livestock and wildlife are mainly dependent upon one forage plant (Purshia tridentata), efficient resource management requires a balance between the grazing pressure and the available, preferred forage that remains following timber cutting. Several possibilities to regain this balance are discussed. It is emphasized that effective resource management requires an understanding of the plant and animal environment, a realization of the biological principles related to these environments, and the management of resources based upon economic principles which are compatible with these biological limitations.

VEGETATION KEY TO PLANT COMMUNITIES WITHIN THE PONDEROSA PINE ZONE OF THE UPPER KLAMATH BASIN

I. Pinus ponderosa the dominant species in the overstory; and replacing itself in the stand as evidenced by the sequence of age classes.

A. Apocynum androsaemilifolium, Epilobium angustifolium, Pyrola picta or Chimaphila umbellata var. occidentalis conspicuous components of herbaceous layer. Purshia tridentata codominant to weak subordinate in the shrub layer. Pinus contorta, Abies concolor, and Pinus lambertiana, if present, subordinate to Pinus ponderosa in overstory; reproduction of former tree species, when present, well represented in understory.

I. Ceanothus velutinus dominant member of shrub layer.

a. Purshia tridentata a strong subordinate in the shrub layer. Arctostaphylos parryana var. pinetorum present, but subordinate to Purshia tridentata and Ceanothus velutinus in all stands.

Pinus ponderosa/Ceanothus velutinus-Purshia tridentata association.

aa. Purshia tridentata absent or if present, a weak subordinate. Arctostaphylos parryana var. pinetorum present in all stands but subordinate. Arctostaphylos nevadensis, if present, weak to strong subordinate.

Pinus ponderosa/Ceanothus velutinus associes.

II. Ceanothus velutinus not dominant member of shrub layer.

a. Ceanotus velutinus codominant.

(1) Ceanothus velutinus codominant with Purshia tridentata. Arctostaphylos parryana var. pinetorum subordinate in all stands. Pinus monticola absent.

Pinus ponderosa/Ceanothus velutinus-Purshia tridentata association.

(11) Ceanothus velutinus codominant with Arctostaphylos parryana var. pinetorum. Purshia tridentata subordinate in all stands. Pinus monticola, if present, poorly represented.

Pinus ponderosa/Arctostaphylos parryana var. pinetorum-Ceanothus velutinus association.

aa. Ceanothus velutinus weak subordinate in shrub layer. Purshia tridentata codominant with or strongly subordinate to Arctostaphylos parryana var. pinetorum.

Pinus ponderosa/Purshia tridentata-Arctostaphylos parryana var. pinetorum association.

AA. Apocynum androsaemilifolium, Epilobium angustifolium, Pyrola picta or Chimaphila umbellata var. occidentalis absent or if present, very inconspicuous components of herbaceous layer. Purshia tridentata dominant in shrub layer. Pinus contorta, and Abies concolor, if present, much subordinate to Pinus ponderosa in overstory; reproduction of former tree species, when present, poorly represented in the understory.

I. Festuca idahoensis strongly dominates herbaceous layer. Ribes cereum may be present but subordinate to Purshia tridentata in shrub layer. Character species with high fidelity include Ranunculus occidentalis, Delphinium menziesii, Horkelia fusca, Cirsium foliosum, Paeonia brownii or Achillea millefolium var. lanulosa.

Pinus ponderosa/Purshia tridentata/Festuca idahoensis association.

II. Festuca idahoensis absent or if present, patchy, and very subordinate to Stipa occidentalis, Carex rossii, and Sitanion hystrix in herbaceous layer. Arctostaphylos parryana var. pinetorum usually absent or if present, a very weak subordinate. Ranunculus occidentalis, Delphinium menziesii, Horkelia fusca, Cirsium foliosum, Paeonia brownii and Achillea millefolium var. lanulosa not present.

Pinus ponderosa/Purshia tridentata association.

II. Pinus ponderosa shares dominance with or is subordinate to Abies concolor and Pinus contorta in the overstory; these latter tree species fully replacing themselves as evidenced by abundant reproduction in the understory. Apocynum androsaemilifolium, Epilobium angustifolium, Pyrola picta and Chimaphila umbellata var. occidentalis very conspicuous components of herbaceous layer. Either Ceanothus velutinus or Arctostaphylos nevadensis dominant in shrub layer. Purshia tridentata a weak subordinate of poor vigor. Arctostaphylos parryana var. pinetorum present but a weak subordinate. Pinus lambertiana or Pinus monticola present in overstory and understory as subordinates.

Abies concolor/Ceanothus velutinus association.

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APPENDICES

APPENDIX A

APPENDIX A

Table 1. The percent occurrence of seven plant communities on three pumice soil series and depth phases.

Plant communities	n[1]	Lapine			Longbell			Shanahan	
		deep	moderately deep	shallow	moderately deep	deep	shallow	moderately deep	shallow
Pipo/Putr[2]	21	.24	.43	.19	.05		.10		
Pipo/Putr/Feid	14	.14	.07	.07	.21		.36	.07	.07
Pipo/Putr-Arpapi	24	.13	.21	.33	.04	.08	.21		
Pipo/Ceve-Putr	15	.33	.27	.20		.13	.07		
Pipo/Arpapi-Ceve	17	.18	.41	.24	.06	.06	.06		
Pipo/Ceve	17	.18	.18	.35			.29		
Abco/Ceve	14	.14	.21	.28		.07	.28		

1/ n equals number of stands sampled/ population.

2/ See Appendix C, Table 4 for scientific name abbreviations.

APPENDIX A

Table 2. The location of seven plant communities in relation to elevation.

Plant communities	n[1/]	Elevation above sea level in feet 4600-4790	4800-4990	5000-5190	5200-5390	5400-5590	5600-5790	5800-5990	6000-6190	6200-6400
Pipo/Putr[2/]	21	.14	.38	.14	.10	.10	.10	.05		
Pipo/Putr/Feid	14	.36	.14	.14			.28	.07		
Pipo/Putr-Arpapi	24		.04	.25	.13	.13	.17	.25	.04	
Pipo/Ceve-Putr	15		.27	.13	.13	.27	.20			
Pipo/Arpapi-Ceve	17			.06	.29	.12	.06	.18	.12	.12
Pipo/Ceve	17			.06	.18	.06	.06	.47	.12	.06
Abco/Ceve	14			.07	.07	.07	.21	.07	.21	.28

1/ n equals number of stands sampled/population.

2/ See Appendix C, Table 4 for scientific name abbreviations.

APPENDIX A

Table 3. A summary of the characteristic environmental factors of seven plant community habitats. 1/

Plant communities	n 2/	Aspect				Landform				Macrorelief				Microrelief				Slope position		
		SSW-SW-WSW-W	WNW-NW-NNW-N	NNE-NE-ENE-E	ESE-SE-SSE-S	Swale, terrace drainage or meadow downslope	Escarpment upslope	Cinder cone, butte, or ridge slopes	Plateaus	Flat	Undulating	Rolling	Hilly to mountainous	Swale	Uniform (flat)	Uniform (concave)	Uniform (convex)	Bottom, lower third	Middle third	Upper third
Pipo/Putr 3/	21	.30	.55	.20	.05	.05		.42	.53		.85	.10	.05	.24	.05	.19	.52	.35	.20	.48
Pipo/Putr/Feid	14		.65	.35		.93	.07			.28	.65	.07		.22	.28	.28	.22	.86	.07	.07
Pipo/Putr-Arpapi	24	.55	.25	.08	.12			.96	.04		.41	.17	.42			.17	.83	.13	.33	.54
Pipo/Ceve-Putr	15		.25	.35	.40	.60	.13	.27			.14	.53	.33	.13	.07	.33	.47	.27	.60	.13
Pipo/Arpapi-Ceve	17	.30	.46	.12	.12		.18	.82			.06	.94			.06	.47	.47		.30	.70
Pipo/Ceve	17	.12	.52	.36				.94	.06		.06	.12	.82	.06		.35	.59	.06	.41	.53
Abco/Ceve	14	.15	.50	.28	.07	.07		.93				.07	.93	.14		.43	.43	.14	.36	.50

1/ Soil series and depth phases. and elevation are listed separate in Appendix A, Table 1 and 2, respectively.

2/ n Equals number of stands sampled/population.

3/ See Appendix C, Table 4 for scientific name abbreviations.

APPENDIX A

Table 4. The occurrence of the pumice soil series and depth phases with respect to elevation.

Soil series	Elevation above sea level in feet 4600-4790	4800-4990	5000-5190	5200-5390	5400-5590	5600-5790	5800-5990	6000-6190	6200-6400	n[1/]
Lapine										
deep phase	.13	.38	.25	.13	.04	.04	.04			24
moderately deep phase	.06	.10	.23	.23	.13	.10	.10	.03	.03	31
shallow phase			.06	.06	.19	.16	.23	.06	.23	31
Longbell										
deep phase	.60		.20				.20			5
moderately deep phase			.17	.17	50				.17	6
shallow phase		.05	.05	.05	.05	38	.23	.05	.10	21
Shanahan										
deep phase	1.00									[illegible]
shallow phase						1.00				1

[1/] n equals number of profiles sampled/depth phase.

APPENDIX B

APPENDIX B

Table 1. The average and range of cover percent for the tree, shrub and grass species of seven plant communities.

Species	Age[1] Class	Pipo/Putr[2] cover percent Av.	Pipo/Putr[2] range	Pipo/Putr/Feid cover percent Av.	Pipo/Putr/Feid range	Pipo/Putr-Arpapi cover percent Av.	Pipo/Putr-Arpapi range	Pipo/Ceve-Putr cover percent Av.	Pipo/Ceve-Putr range	Pipo/Arpapi-Ceve cover percent Av.	Pipo/Arpapi-Ceve range	Pipo/Ceve cover percent Av.	Pipo/Ceve range	Abco/Ceve cover percent Av.	Abco/Ceve range
Pinus ponderosa	Young	.09	Tr -.20	.36	.10-.70	.11	.01-.35	.14	.01-.40	.10	.01-.30	.10	.01-.35	.02	Tr -.05
	Old	.40	.30-.65	.40	.20-.80	.32	.05-.60	.29	.15-.50	.27	.10-.50	.34	.10-.50	.18	.10-.30
Pinus contorta	Young	.03	Tr -.05	.07	.01-.15	.01	Tr -.01	.03	.01-.05	.07	.01-.20	.06	Tr -.20	.15	Tr -.35
	Old	.03	.01-.05	.03	Tr -.05	.03	.01-.05	.03	.01-.05	.09	.01-.35	.04	.01-.10	.11	.05-.30
Abies concolor	Young	.04	.01-.15	Tr[3]	Tr	.33	.05-.65	.01	Tr -.01	.08	.01-.30	.23	.10-.50	.52	.20-.90
	Old	.01	Tr -.01	-	-	.06	.01-.10	.01	Tr -.01	.05	.01-.10	.11	.05-.25	.26	.05-.40
Pinus lambertiana	Young	-	-	-	-	.02	Tr -.05	.09	.05-.70	.08	.01-.20	.12	.01-.40	.09	.01-.15
	Old	-	-	-	-	.07	Tr -.15	.08	.05-.10	.11	.05-.30	.10	.05-.20	.06	Tr -.15
Pinus monticola	Young	-	-	-	-	-	-	-	-	.01	Tr -.01	-	-	.10	.01-.25
	Old	-	-	-	-	-	-	-	-	.03	.01-.05	-	-	.08	.01-.25
Total Young Growth		.16		.43		.47		.27		.34		.51		.88	
Total Old Growth		.44		.43		.46		.41		.55		.59		.69	
Tree Total		.60		.86		.53		.68		.89		1.10		1.57	
Purshia tridentata		.54	.25-.80	.21	.05-.60	.42	.15-.65	.28	.15-.60	.14	Tr -.40	.09	.01-.25	.06	.01-.10
Arctostaphylos parryana var. _pinetorum_		.05	.01-.10	.03	.01-.05	.30	.05-.70	.10	.05-.35	.33	.15-.45	.15	Tr -.40	.09	.01-.25
Haplopappus blommeri		.04	.01-.05	.05	.01-.30	.05	.01-.10	.05	Tr -.10	.06	.05-.10	.03	.01-.05	-	-
Chrysothamnus nauseous		-	-	.01	Tr -.01	-	-	-	-	-	-	-	-	-	-
Amelanchier alnifolia		-	-	.01	Tr -.01	-	-	-	-	-	-	-	-	.01	Tr -.01
Rosa symnocarpa		-	-	Tr	Tr	Tr	Tr	-	-	-	-	-	-	.03	Tr -.05
Ribes cereum		-	-	.09	.05-.10	-	-	.03	Tr -.05	.01	Tr -.01	Tr	Tr	.02	.01-.05
Ceanothus velutinus		-	-	-	-	.10	.05-.25	.38	.25-.60	.33	.05-.70	.44	.15-.70	.29	.01-.70
Arctostaphylos nevadensis		-	-	.03	Tr -.05	.01	Tr -.01	-	-	.23	.10-.35	.13	Tr -.40	.20	.10-.35
Prunus emarginata		.01	Tr -.01	-	-	.01	Tr -.01	-	-	.01	Tr -.01	.05	Tr -.15	.01	Tr -.01
Castanopsis sempervirens		-	-	-	-	-	-	-	-	.16	.01-.30	.28	.25-.30	.22	.15-.30
Ribes viscosissium		-	-	-	-	-	-	-	-	-	-	.01	Tr -.01	.03	.01-.05
Salix sp.		-	-	-	-	-	-	.03	.01-.05	-	-	.01	Tr -.01	.07	.01-.20
Prunus subcordata		-	-	-	-	-	-	-	-	-	-	-	-	.01	Tr -.01
Shrub Total		.64		.43		.87		.89		1.27		1.21		1.06	

APPENDIX B

Table 1. (Continued)

Species	Age[1] Class	Pipo/Putr[2] cover percent Av.	range	Pipo/Putr/Feid cover percent Av.	range	Pipo/Putr-Arpapi cover percent Av.	range	Pipo/Ceve-Putr cover percent Av.	range	Pipo/Arpapi-Ceve cover percent Av.	range	Pipo/Ceve cover percent Av.	range	Abco/Ceve cover percent Av.	range
Carex rossii		.03	Tr-.10	.06	Tr-.30	.04	Tr-.10	.03	Tr-.10	.01	Tr-.05	.03	Tr-.10	.02	Tr-.05
Stipa occidentalis		.04	.01-.10	.07	.10-.30	.03	Tr-.10	.03	.01-.10	.02	Tr-.05	.04	Tr-.10	.01	Tr-.01
Sitanion hystrix		.01	Tr-.05	.04	.01-.15	.01	Tr-.05	.03	.01-.05	.01	Tr-.05	.03	Tr-.10	.01	Tr-.01
Festuca idahoensis		Tr	Tr	.33	.15-.60	.01	.00-.01	.01	.00-.01	-	-	-	-	-	-
Poa pratensis		-	-	.03	.01-.05	-	-	-	-	-	-	.01	.00-.01	-	-
Bromus tectorum		-	-	.07	.00-.15	-	-	-	-	-	-	-	-	-	-
Grass Total		.08		.60		.10		.09		.04		.11		.04	
GRAND TOTAL COVER		1.32		1.89		1.50		1.66		2.20		2.42		2.67	

1/ The young age class refers to seedling, sapling and pole sized trees while the thrifty, mature and overmature individuals comprise the old age class.

2/ See Appendix C Table 4 for scientific name abbreviations.

3/ Tr designates when a species occurs as a trace, or with less than .01 cover.

APPENDIX B

Table 2. The presence percentage and dominance index of the species that comprise seven plant communities of the Upper Williamson River Basin.

		Pipo/Putr		Pipo/Putr/Feid		Pipo/Putr-Arpapi		Pipo/Ceve-Putr		Pipo/Arpapi-Ceve		Pipo/Ceve		Abco/Ceve	
Species	D. R.[3/]	P[1/]	D. I.[2/]	P	D. I.	P	D. I.	P	D. I.	P	D. I.	P	D. I.	P	D.I.
TREE															
Pinus	P	100		100		100		100		100		100		100	
ponderosa	5		.43		.57		.50		.60		.24		.35		
	4		.57		.43		.50		.40		.76		.59		.50
	3												.06		.50
	2														
	1														
Pinus	P	29		50		8		33		35		29		78	
contorta	5														
	4										.12				.28
	3		.10		.29						.05		.24		.50
	2		.14		.14		.04		.27		.18		.05		
	1		.05		.07		.04		.07						
Abies	P	24		7		25		7		53		88		100	
concolor	5														
	4						.12				.05		.64		1.00
	3		.05				.08				.29		.24		
	2		.14				.04		.07		.12				
	1		.05		.07						.05				
Pinus	P					8		33		53		41		43	
lambertiana	5														
	4										.18		.12		
	3						.04		.13		.29		.12		.36
	2						.04		.20		.05		.12		.07
													.05		
Pinus	P									12				57	
monticola	5														
	4														.07
	3														.43
	2										.06				.07
	1										.06				
SHRUB SPECIES															
Purshia	P	100		100		100		100		88		88		57	
tridentata	4		1.00		.71		.92		.93		.29		.12		
	3				.14		.04		.07		.47		.47		.21
	2				.14		.04				.06		.24		.21
	1										.06		.06		.14
Arctostaphylos	P	14		21		1.00		1.00		1.00		1.00		86	
parryana var	4						.83		.13		1.00		.12		.07
pinetorum	3						.17		.53				.58		.50
	2		.10		.07				.20				.18		.21
	1		.04		.14				.13				.12		.07

Table 2. (Continued)

Species	D. R.[3]	Pipo/Putr		Pipo/Putr/Feid		Pipo/Putr-Arpapi		Pipo/Ceve-Putr		Pipo/Arpapi-Ceve		Pipo/Ceve		Abco/Ceve	
		P[1]	D.I.[2]	P	D.I.	P	D.I.	P	D.I.	P	D.I.	P	D.I.	P	D.I.
Shrub Species (Cont.)															
Haplopappus	P	14		57		29		7		23		12			
bloomeri	4														
	3		.05		.14		.12		.07		.05		.06		
	2		.10		.36		.12				.18		.06		
	1				.07		.05								
Chrysothamnus	P					7									
nauseous	4														
	3														
	2						.07								
	1														
Amelanchier	P			7										7	
alnifolia	4														
	3														
	2														
	1				.07										.07
Rosa	P			14		4								7	
gymnocarpa	4														
	3														.07
	2														
	1				.14		.04								
Ribes	P			64				7		5		5		28	
cereum	4				.07										
	3				.21										.07
	2				.36										.21
	1								.07		.05		.05		
Ceanothus	P					66		100		94		100		71	
velutinus	4						.08		1.00		.76		1.00		.43
	3						.25				.18				.07
	2						.25								.14
	1						.08								.07
Arctostaphylos	P			7		4				12		35		50	
nevadensis	4										.06		.05		.43
	3										.06		.12		.07
	2				.07		.04						.18		
	1														
Prunus	P	5				4				6		18		7	
emarginata	4														
	3												.12		
	2		.05								.06		.06		
	1						.04								.07
Castanopsis	P									12		12		14	
sempervirens	4										.06		.12		.07
	3														.07
	2														
	1										.06				

Table 2. (Continued)

Species	D. R.[3]	Pipo/Putr		Pipo/ Putr/ Feid		Pipo/ Putr-Arpapi		Pipo/ Ceve-Putr		Pipo/ Arpapi-Ceve		Pipo/Ceve		Abco/ Ceve	
		P[1]	D.I.[2]	P	D.I.	P	D.I.	P	D.I.	P	D.I	P	D.I	P	D.I.
Shrub Species (Cont.)															
Ribes	P											6		36	
viscosissium	4														
	3														.14
	2														.07
	1												.06		.14
Salix	P							13				18		28	
sp.	4														
	3														.07
	2								.13				.06		.14
	1												.12		.07
Prunus	P													7	
subcordata	4														
	3														
	2														.07
	1														
GRASS AND SEDGES															
Carex	P	76		57		92		87		70		82		78	
rossii	4														
	3		.66		.14		.63		.53		.24		.53		.21
	2		.10		.43		.29		.33		.41		.29		.50
	1										.06				.07
Stipa	P	100		93		100		100		88		94		71	
occidentalis	4		.05		.07										
	3		.95		.57		.66		.80		.35		.65		.14
	2				.14		.33		.20		.53		.29		.50
	1				.14										.07
Sitanion	P	86		93		75		67		53		53		36	
hystrix	4														
	3		.24		.64		.25		.40		.06		.12		
	2		.48		.28		.46		.20		.35		.35		.36
	1		.14				.04		.07		.12		.06		
Festuca	P	5		100		4		7							
idahoensis	4				1.00										
	3														
	2								.07						
	1		.05				.04								
Poa	P			14								6			
pratensis	4														
	3														
	2				.14										
	1												.06		
Bromus	P			7											
tectorum	4														
	3														
	2				.07										
	1														

Table 2. (Continued)

Species	D. R.[3]	Pipo/Putr		Pipo/ Putr/ Feid		Pipo/ Putr- Arpapi		Pipo/ Ceve- Putr		Pipo/ Arpapi- Ceve		Pipo/Ceve		Abco/ Ceve	
		P[1]	D.I.[2]	P	D.I.	P	D.I.	P	D.I.	P	D.I.	P	D.I.	P	D.I.
FORB															
Cryptantha	P	90		78		96		93		32		82		43	
affinis	3		.57		.43		.83		.67		.53		.47		.14
	2		.24		.36		.08		.20		.29		.29		.28
	1		.10				.04		.07				.06		
Gayophytum	P	90		64		71		67		88		88		28	
nuttallii	3		.66		.50		.50		.47		.59		.41		.07
	2		.24		.14		.21		.13		.29		.47		.21
	1								.07						
Collinsia	P	71		78		67		73		59		59		43	
parviflora	3		.43		.64		.38		.27		.12		.18		.07
	2		.29		.07		.29		.47		.35		.41		.36
	1				.07						.12				
Viola	P	48		50		67		47		18		41		7	
purpurea	3		.24		.07		.21		.07						.07
	2		.19		.21		.38		.33		.18		.18		
	1		.05		.21		.08		.07				.24		
Phacelia	P	26		28		62		40		41		24		7	
hastata var.	3		.19				.25		.20		.24		.06		
leucophylla	2		.10				.29		.07		.18		.18		.07
	1				.28		.08		.13						
Mentzelia	P	66		28		62		40		41		24		7	
albicaulis	3		.28		.07		.25		.20		.24		.06		
	2		.28		.21		.29		.07		.18		.18		.07
	1		.10				.08		.13						
Antennaria	P	24		43		38		27		12		18			
geyeri	3		.19		.21		.08		.13		.06		.06		
	2				.21		.12		.13				.12		
	1		.05				.17				.06				
Antennaria	P	19		43		12		13		6		6			
corymbosa	3				.14										
	2		.19		.21		.04		.07		.06				
	1				.07		.08		.07				.06		
Collomia	P	10		7		12		20				6			
tinctoria	3														
	2		.10		.07				.13						
	1						.12		.07				.06		
Madia	P	38		21		25				6					
minima	3		.14		.21		.04								
	2		.24				.17				.06				
	1						.04								
Senecio	P	42		36		4		13							
integerrimus	3				.21										
	2		.28		.14		.04								
	1		.14						.13						

Table 2. (Continued)

Species	D. R.[3]	Pipo/Putr P[1]	Pipo/Putr D.I.[2]	Pipo/Putr/Feid P	Pipo/Putr/Feid D.I.	Pipo/Putr-Arpapi P	Pipo/Putr-Arpapi D.I.	Pipo/Ceve-Putr P	Pipo/Ceve-Putr D.I.	Pipo/Arpapi-Ceve P.	Pipo/Arpapi-Ceve D.I.	Pipo/Ceve P	Pipo/Ceve D.I.	Abco/Ceve P	Abco/Ceve D.I.
Forb (Continued)	P	5				8		7							
Lupinus	3		.05						.07						
minimus	2						.08								
	1														
Eriogonum	P	10													
nudum	3		.05												
	2		.05												
	1														
Eriophyllum	P	5		7											
lantum var.	3														
integrifolium	2														
	1		.05		.07										
Ranunculus	P			36											
occidentalis	3														
	2				.28										
	1				.08										
Delphinium	P			21											
menziesii	3														
	2				.14										
	1				.07										
Horkelia	P			36											
fusca	3														
	2				.14										
	1				.22										
Cirsium	P			21											
foliosum	3														
	2				.07										
	1				.14										
Paeonia	P			14											
brownii	3														
	2														
	1				.14										
Fritillaria	P			7											
autropurpurea	3														
	2				.07										
	1														
Achillea	P			43											
millefolium var.	3				.36										
lanulosa	2				.07										
	1														
Lomatium	P			21				7							
triternatum	3														
	2				.14										
	1				.07				.07						

Table 2. (Continued)

Species	D. R.[3]	Fipo/Patr		Pipo/Putr/Feid		Pipo/Putr-Arpapi		Pipo/Ceve-Putr		Pipo/Arpapi-Ceve		Pipo/Ceve		Abco/Ceve	
		P[1]	D.I.[2]	P	D.I	P	D.I	P	D.I.	P	D.I.	P	D.I.	P	D.I.
Forb (Continued)															
Scutellaria nana	P			21		12		7							
	3						.04								
	2				.14		.08		.07						
	1				.07										
Lithophragma parviflora	P			21		4				6					
	3														
	2				.14										
	1				.07		.04				.06				
Microseris nutans	P							7		6					
	3								.07						
	2														
	1										.06				
Phlox gracilis	P							7				6			
	3														
	2								.07						
	1												.06		
Hieracium cynoglossoides	P					4		13				12		50	
	3												.12		.14
	2								.07						.21
	1						.04		.07						.14
Pteridium aquilinum var. lanquinosum	P					4									
	3														
	2						.04								
	1														
Castilleja applegatei var. applegatei	P					12								7	
	3														
	2						.04								
	1						.08								.07
Spraguea umbellata	P	19		7		25		33		24					
	3		.05				.04				.06				
	2		.10				.08		.33		.18				
	1		.05		.07		.12								
Clarkia rhomboidea	P	5		14		33		13		29		12			
	3		.05		.07		.17		.13		.12		.06		
	2				.07		.12				.18		.06		
	1						.04								
Lupinus caudatus	P	5		64		8		13				24		50	
	3				.07										.36
	2				.43		.04		.13				.12		.14
	1		.05		.14		.04						.12		
Fragaria cuneifolia	P	10		57		21		33		12		53		64	
	3		.05		.43		.08		.27				.29		.50
	2				.07		.04		.07		.12		.18		.14
	1		.05		.07		.08						.06		

Table 2. (Continued)

Species	D. R.[3/]	Pipo/Putr		Pipo/ Putr/ Feid		Pipo/ Putr- Arpapi		Pipo/ Ceve- Putr		Pipo/ Arpapi- Ceve		Pipo/Ceve		Abco/ Ceve	
		P[1/]	D.I.[2/]	P	D.I.	P	D.I.	P	D.I.	P	D.I.	P	D.I.	P	D.I.
Forb (Continued															
Arabis	P	14		7		38		33		12		24		57	
rectissima	3		.05				.04				.06				.07
	2				.07		.12		.13						.21
	1		.09				.21		.20		.06		.24		.28
Apocynum	P	19				79		73		88		76		50	
androsaemilifolium	3		.14				.46		.47		.64		.59		.43
	2		.05				.29		.20		.24		.12		.06
	1						.04		.07				.06		
Epilobium	P	14				58		87		76		82		100	
angustifolium	3		.05				.29		.53		.59		.82		.86
	2		.05				.21		.27		.06				.14
	1		.05				.08		.07		.12				
Pyrola	P					25		33		47		82		86	
picta	3										.12		.12		.21
	2								.13		.29		.41		.50
	1						.25		.20		.06		.29		.14
Chimaphila	P					17		27		18		41		28	
umbellata var.	3										.06		.06		.07
occidentalis	2						.04		.13		.06		.24		.07
	1						.12		.13		.06		.12		.14
Silene	P					4				6		12		7	
menziesii	3												.06		
	2						.04				.06		.06		.07
	1														
Penstemon	P			7								12		28	
procerus var.	3				.07										
brachyanthus	2														
	1												.12		.28
n		21		14		24		15		17		17		14	
Species/ Community		32		46		40		43		36		39		36	

[1/] P equals presence percentage as defined on p. 52.

[2/] D.I. equals dominance index as defined on p. 52.

[3/] D.R. equals dominance ratings, see Appendix C. Table 2.

APPENDIX C

APPENDIX C

Table 1. Weather data for Chemult and Chiloquin, Oregon between 1942 and 1961 inclusive.[1/]

	n[2/]	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean annual	Units
Chemult (4760 feet)															
Median precipitation	20	4.05	3.56	2.34	.94	1.58	1.18	.14	.31	.50	1.31	4.24	3.00	25.77	in. water
Mean monthly temperature	20	24.9	29.4	32.4	39.8	46.3	53.2	59.6	57.1	51.9	43.1	33.7	27.9	41.5	°F
Mean maximum temperature	14	36.5	41.9	44.7	56.7	63.8	72.4	82.7	80.2	73.3	60.2	47.3	39.3		°F
Mean minimum temperature	14	14.8	17.5	20.3	24.4	30.0	34.4	37.0	34.2	30.3	26.0	20.7	16.7		°F
Chiloquin (4198 feet)															
Median precipitation	20	2.27	[illegible]	1.25	.86	1.29	1.10	.15	.12	.34	1.26	2.18	2.08	18.08	in. water
Mean monthly temperature	20	28.2	32.5	36.3	42.8	48.9	55.2	62.7	60.6	54.9	45.8	35.9	31.0	44.4	°F
Mean maximum temperature	20	39.6	44.8	49.4	58.2	66.3	74.3	85.3	82.1	77.0	63.8	49.1	42.6		°F
Mean minimum temperature	20	15.4	20.0	22.9	26.8	31.5	36.2	40.3	37.5	32.3	27.7	21.4	19.0		°F

1/ The U. S. Weather Bureau records (78) serve as the source of data.

2/ n equals number of years over which data was collected.

Appendix C Table 2

Criteria for Vegetation and Site Factor Reconnaissance

Age Class Distribution

Trees	Shrubs
Seedlings and saplings	Seedlings
Poles	Well-established seedlings and young plants
Thrifty	Reasonably mature - rapid growing plants
Mature and overmature	Mature and overmature

The dominant age class is indicated by a double line:

Dominance Ratings

5.... Represents the dominant species in the stand based on the amount or bulk of material produced per unit area. A species is not rated 5 unless it is clearly the dominant in production and microenvironment. Only one 5 rating is given per stand.

4.... Species are codominant or share dominance with respect to bulk or material produced per unit area and/or impact upon the ecosystem. More than one species may be rated in this class.

3.... Species are easy to see as one stands in one place and looks casually about; one need not look intently or move around in order to see a species which should be classed in this category. These species are not outstanding in their dominance. Many of the species fall within this category.

2.... One must look rather intently while standing in one place to see these species, or move around in order to find them, but they are not so rare as to require that one look in and around other vegetation to see them.

1.... One must actually hunt for species to find them. They are seen only by looking in and around other vegetation, or by moving around occasionally and looking with considerable care.

Species that occur as widely spaced, inconspicuous clusters are given a No. 2 rather than No. 1.

Landform

a. Escarpment
b. Fan
c. Flood-plain
d. Plateau
e. Terrace
f. Ridge-top
g. Slope off butte
h. Slope off ridge
i. Slope into drainage
j. Valley bottom

Macrorelief

a. Flat
b. Undulating
c. Rolling
d. Hilly
e. Mountainous

Microrelief

a. Uniform (flat, concave, convex)
b. Interrupted
c. Small depressions
d. Knolls
e. Pits
f. Swales
g. Ridge/swale
h. Mound/swale

General Climate

Estimated annual precipitation with such indications of general temperature conditions as are available.

Stand Disturbance Factors

a. Grazing
b. Logging
c. Erosion
d. Fire
e. Insects
f. Rodents

Soil Series Depth Phases

The depth phases for the Lapine, Longbell, and Shanahan series refer to the depth at which the D horizon (buried soil) is located below the surface of the A1 horizon. Three phases are so designated:

Shallow phase - D horizon 0-24 inches below A1 horizon surface

Moderately deep phase - D horizon 25-48 inches below A1 horizon surface

Deep phase - D horizon greater than 48 inches below A1 horizon surface.

APPENDIX C Table 3

Soil Series Profile Descriptions

The modal profile of the Lapine series is located 300 feet south and 150 feet east of the northeast corner Sec. 12 T. 32S., R. 8 E., about one-half mile south of Little Wocus Bay on the Klamath Marsh, (76, p. 161-162).

Soil Profile:	Lapine loamy coarse sand, 0-40% north slope (deep phase)
A00 & A0 1 1/4 - 0"	Dark gray to very dark gray (10YR 3/1.5) Ponderosa pine needle mat, very dark brown (10YR 2/2) when moist; partially decomposed layer, 1/4 - 0"; very strongly acid (pH 5.0); abrupt, slightly wavy lower boundary. 1/2 - 2 inches thick.
A1 0 - 2"	Dark grayish brown (10YR 4/2) loamy sand, coarse or sandy loam, very dark brown (10YR 2/2) when moist; very weak thin plates falling apart to very weak fine and very fine granules; very soft, very friable, non-sticky and non-plastic; abundant fine fibrous roots; many, medium interstitial pores; medium acid (pH 5.6); clear, smooth lower boundary. 1 1/2 - 2 1/2 inches thick.
AC 2 - 11"	Very pale brown (10YR 7/3) fine gravelly loamy coarse sand, dark yellowish brown (10YR 4/4) when moist; very weak medium subangular blocky; very soft, very friable, non-sticky and non-plastic; abundant roots; common fine and medium interstitial pores; 20-30% fine and medium gravels ranging from 3 mm - 3 cm in size; medium acid (pH 5.8); clear, irregular lower boundary. 4 - 10 inches thick.

C11 11 - 34"	White and very pale brown (10YR 8/1, 8/4) very gravelly, loamy coarse sand, brownish yellow (10 YR 6/8) when moist; structureless, single grain; loose, non-sticky and non-plastic; plentiful roots; pores mainly interstitial, rich in ferromagnesium minerals including hornblende and augite, 60 - 70% fine and medium gravels ranging in size from 2 mm - 4 cm; medium acid (pH 6.0) gradual, smooth lower boundary. 12 - 30 inches thick.
C12 34 - 43"	Light yellowish brown, pale yellow and yellow (2.5Y 6/4, 8/4, 8/6) when moist, very gravelly loamy coarse sand; structureless, single grain; loose, non-sticky and non-plastic; plentiful roots; pores entirely interstitial, 70-80% gravels ranging from 2 mm - 3 cm in size; neutral (pH 6.6); clear, smooth lower boundary. 8 - 15 inches thick.
C2 43 - 72"	White or light gray (2.5Y 8/2, 7/2) when moist; gravels; structureless; loose, non-sticky and non-plastic; plentiful roots; pores entirely interstitial, gravels range in size from 2 - 3cm and comprise 95% of the volume of this horizon, the balance being composed of ferromagnesian sands; neutral (pH 6.6).

The modal profile location of the Longbell series is SW 1/4, SW 1/4 Sec. 5, T. 32 S., R. 13 E., Lake County, Oregon about 50 feet north of the road on section line between sections 5 and 6 (personal communication with C. T. Youngberg, Ph.D., Professor of Soils. Oregon State University, Corvallis. July 1962).

Soil Profile:	Longbell loamy coarse sand, shallow to loamy material, native forest (shallow phase)
A00 1 - 0"	Undecomposed and partially decomposed litter, mainly ponderosa pine needles, 0 - 2" thick.
A1 0 - 3"	Dark gray (10YR 4/1) loamy coarse sand, very dark brown (10YR 2/2) when moist; single grained; soft, very friable, non-sticky and non-plastic; abundant roots; many interstitial pores; pH 6.0; clear smooth boundary. 1 1/2 - 3" thick.
AC 3 - 11"	Light grayish brown (10YR 6/2) loamy coarse sand, dark yellowish brown (10YR 3/4) when moist with dark yellowish brown (10YR 4/4) pumice sand grains or pebble gravels; massive; soft, very friable, non-sticky and non-plastic; roots common; many interstitial pores; pH 6.3; gradual smooth boundary; 4 - 10 inches thick.
C 11 - 20"	Dark yellowish brown (10YR 4/4 moist; coarse sand with pockets of yellowish brown (10YR 5/4) moist pumice of fine gravel size; massive; very friable, non-sticky and non-plastic; roots common; pH 6.5; abrupt smooth boundary; 7 — 30" thick.
D 20+"	Dark yellowish brown (10YR 3/4) moist, loam; weak medium subangular blocky structure; friable; slightly sticky and slightly plastic, roots common; pH 6.6.

The modal profile location of the Shanahan series is the SE 1/4 Sec. 8, T. 29 S., R. 12 E., Lake County, Oregon about 200 feet southwest of road junction (personnel communication, C. T. Youngberg, Ph.D., Professor of Soils, Oregon

State University, Corvallis, July 1962).

Soil Profile:	Shanahan sandy loam, shallow to loamy material, forested (shallow phase).
A00 1 - 0"	Undecomposed and partially decomposed litter mainly ponderosa pine needles, 0 - 2 inches thick. L & F horizon, no H.
A1 0 - 2"	Grayish brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) when moist; weak very fine granular structure; soft, very friable, slightly sticky and slightly plastic; abundant roots; pH 5.8-6.4; clear smooth boundary; 1 1/2 - 3 inches thick.
AC 2 - 10"	Light brownish gray (10YR 6/2) coarse sandy loam, dark brown (10YR 4/3) when moist; weak fine to medium subangular blocky structure; soft, very friable, very slightly sticky, very slightly plastic; abundant roots; pH 6.0-6.4; clear irregular boundary with tongues in the C horizon; 6 - 10 inches thick.
C 10 - 14"	Dark brown (10YR 4/3) moist; loamy coarse sand containing high content of very fine pumice gravels; massive; loose dry and moist, non-sticky, non-plastic; roots plentiful; pH 6.4 - 6.6; abrupt, smooth boundary; 3 - 15 inches thick.
D 14 - 22"	Dark brown (7.5YR 3/4) when moist, sandy clay loam with moderate fine to medium subangular blocky structure; slightly brittle; friable to firm, sticky, plastic; roots common; pH 6.4 - 6.8.

APPENDIX C TABLE 4

Scientific Name, Common name and Abbreviation of Plants Cited in Manuscript[1]

Abbr.	Scientific Name	Common Name
Trees		
Abco	Abies concolor Lindl.	white fir
Lide	Libocedrus decurrens Torr.	California incense-cedar
Pico	Pinus contorta Dougl.	lodgepole pine
Pila	Pinus lambertiana Dougl.	sugar pine
Pimo	Pinus monticola Dougl.	western white pine
Pipo	Pinus ponderosa Laws.	ponderosa pine
Shrubs		
Amal	Amelanchier alnifolia Nutt.	Saskatoon serviceberry
Arne	Arctostaphylos nevadensis Gray	pinemat manzanita
Arpapi	Arctostaphylos parryana var. pinetorum (Rollins) Wies & Schr.	manzanita
Arur	Arctostaphylos uva-ursi (L.) Spreng.	bearberry
Case	Castanopsis sempervirens (Kell.)	bush chinquapin
Ceve	Ceanothus velutinus Dougl.	snowbrush
Chna	Chrysothamnus nauseous (Pall.) Britt.	rubber rabbitbrush
Habl	Haplopappus bloomeri (Gray) H. M. Hall	rabbitbrush goldenweed
Prem	Prunus emarginata (Dougl.) Walp	bitter cherry
Prsu	Prunus subcordata (Benth.) Hartw.	Klamath plum

Abbr.	Scientific Name	Common Name
Putr	Purshia tridentata (Pursh) D. C.	antelope bitterbrush
Rice	Ribes cereum Dougl.	squaw currant
Rivi	Ribes viscosissium Pursh.	sticky currant
Rogy	Rosa gymnocarpa Nutt.	rose
SALIX	Salix sp. (Tourn.) L.	willow
Spdome	Spiraea douglasii var. menziesii (Hook.) Presl.	spiraea
VACCI	Vaccinium sp. L.	huckleberry

Grasses and Grass-like

Agpa	Agropyron pauciflorum (Schwein.) Hitchc.	slender wheatgrass
Agal	Agrostis alba L.	redtop
Alpr	Alopecurus pratensis L.	meadow foxtail
Brte	Bromus tectorum L.	downy chess
Cado	Carex douglasii Boott.	dry sedge
Cane	Carex nebraskensis Dew.	Nebraska sedge
Capr	Carex praegracilis Boott.	meadow sedge
Caro	Carex rossii Boott.	Ross sedge
Daca	Danthonia californica Boland.	California oatgrass
Dain	Danthonia intermedia Vas.	timber oatgrass
Deca	Deschampsia caespitosa (L.) Beauv.	tufted hairgrass
Elci	Elymus cinereus Scribn. & Merr.	giant wild rye
Elgl	Elymus glaucus Buckl.	blue wild rye
Feid	Festuca idahoensis Elm.	Idaho fescue
Hono	Hordeum nodosum L.	meadow barley
June	Juncus nevadensis Wats.	meadow rush
Kocr	Koeleria cristata (L.) Pers.	Junegrass
Musq	Muhlenbergia squarrosa (Trin.) Rydb.	mat muhly
Pocu	Poa cusickii Vas.	Cusick bluegrass
Popr	Poa pratensis L.	Kentucky bluegrass
Sihy	Sitanion hystrix (Nutt.) J. G. Sm.	bottlebrush squirreltail
Stoc	Stipa occidentalis Thrub.	western needlegrass

Abbr.	Scientific Name	Common Name
Forbs		
Acmila	Achillea millefolium var. lanulosa (Nutt.) Piper	western yarrow
Acno	Antennaria corymbosa E. Nels.	corymbosa pussytoes
Angez	Antennaria geyeri Gray	pinewoods pussytoes
Apan	Apocynum androsaemilifolium L.	spreading dogbane
Arre	Arabis rectissima Greene	rockcress
Caapap	Castilleja applegatei var. applegatei Fern.	indian paintbrush
Chme	Chimaphila menziesii (R. Br.) Spreng.	Menzies pipsissewa
Chumoc	Chimaphila umbellata var. occidentalis (Rydb.) Blake	western pipsissewa
Cifo	Cirsium foliosum (Hook.) D.C.	thistle
Clrh	Clarkia rhomboidea Dougl.	common clarkia
Copa	Collinsia parviflora Dougl.	littleflower collinsia
Coti	Collomia tinctoria Kell.	collomia
Craf	Cryptantha affinis (Gray) Greene	cryptantha
Deme	Delphinium menziesii Hook	Menzies larkspur
Epan	Epilobium angustifolium L.	fireweed
ERIGE	Erigeron sp. L.	fleabane
Ernu	Eriogonum nudum Dougl.	naked eriogonum
Erlain	Eriophyllum lanatum var. integrifolium (Pursh) Forbes	wooly eriophyllum
Frcu	Fragaria cuneifolia Nutt.	strawberry
Frau	Fritillaria autropurpurea Nutt.	purplespot fritillary
GALIU	Galium sp. L.	bedstraw
Ganu	Gayophytum nuttallii Torr. & Gray	bigflower groundsmoke
Hicy	Hieracium cynoglossoides Arv. - Touv.	houndstongue hawkweed
Hofu	Horkelia fusca Lindl.	tawny horkelia

Abbr.	Scientific Name	Common Name
Lipa	Lithophragma parviflora (Hook.) Nutt.	woodland star
Lotr	Lomatium triternatum (Pursh) C. & R.	nineleaf lomatium
Luca	Lupinus caudatus Kell.	tailcup lupine
Lumi	Lupinus minimus Dougl.	least lupine
Mami	Madia minima (Gray) Keck	tarweed
Meal	Mentzelia albicaulis Dougl.	whitestem mentzelia
Minu	Microseris nutans Schultz	nodding microseris
Pabr	Paeonia brownii Dougl.	Browns peony
Peprbr	Penstemon procerus var. brachyanthus (Pennell) Cronq.	beard tongue
Phhale	Phacelia hastata var. leucophylla (Torr.) Cronq.	varileaf phacelia
Phgr	Phlox gracilis (Hook.) Greene	phlox
Pogl	Potentilla glandulosa Lindl.	cinquefoil
Ptaqla	Pteridium aquilinum var. languinosum (Bong.) Fernald	bracken (fern)
Pypl	Pyrola picta Smith	whitevein pyrola
Raoc	Ranunculus occidentalis Nutt.	western buttercup
Scna	Scutellaria nana Gray	dwarf skullcap
Sein	Senecio integerrimus Nutt.	lambstongue groundsel
Sime	Silene menziesii Hook.	catchfly
Smst	Smilacina stellata (L.) Desf.	wild-lilly-of-the-valley
Spum	Spraguea umbellata Torr.	pussy-paws
Trlo	Trifolium longipes Nutt.	longstalk clover
Vipu	Viola purpurea Kell.	goosefoot violet

[1] Authorities for the scientific and common names of the trees, shrubs, sedges and forbs are (1) Kelsey and Dayton (43); (2) Peck (61); (3) Hitchcock et al. (41;42). The authority for grasses is Hitchcock (40).