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Forested Plant Associations of the Colville National Forest

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FORESTED PLANT ASSOCIATIONS OF THE COLVILLE NATIONAL FOREST

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ABSTRACT

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A classification of forest vegetation is presented for the Colville National Forest in northeastern Washington State. It is based on potential vegetation with the plant association as the basic unit. The classification is based on a sample of approximately 229 intensive plots and 282 reconnaisance plots distributed across the forest from 1980 to 1983. The hierarchical classification includes 5 forest tree series and 39 plant associations or community types. Diagnostic keys are presented for each tree series and plant association or community type. Descriptions include information about plant association or community species composition, occurrences, distribution, environment, soils, forest productivity, management implications and relations to other vegetation classifications. Background information is also presented on the ecology, geology, soils, climate, and fire history of the Colville National Forest.

Keywords: Vegetation classification, climax plant communities, potential vegetation, plant association, vegetation series, forest ecology, fire, wildife, range, northeastern Washington.

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INTRODUCTION

Various forest-cover type and site classifications have been found inadequate to answer many questions being asked by resource managers today. "Management of natural resources on range and forested lands has become increasingly critical as a result of greater resource needs and increased public awareness. Nowhere is this more evident than in the management of public lands" (Williams 1978). Hall (1967) states that management of non-arable lands (forest and rangelands) is primarily concerned with deriving products from the natural vegetation, and as resource management intensifies, knowledge about vegetation must increase."

The recurrence of similar plant assemblages across a forest can be used to stratify the landscape (Daubenmire 1976, Pfister *et al.* 1977). The vegetation, soils, and physical characteristics can usefully indicate plant responses to management, productivity potential and future species composition of an area However, not all questions about a piece of land can be answered by a plant community classification (Hemstrom *et al.* 1982).

Classification of plant associations allows one to:

- Plan management strategies - evaluate resource condition, productivity, and responses to manipulation.

- Communicate - record successes or failures of management actions, provide a common description of forest types and conditions for various disciplines.

- Apply research — provide a direct link between research results and practical land management.

- Describe and delineate different environments which exist across a landscape based partially on plant association distribution patterns.

The classification of Daubenmire and Daubenmire (1968) for eastern Washington and northern Idaho has been useful to resource managers of the Colville National Forest. In time, managers became more skilled in the use of classifications and desired even more detail. They found that the Daubenmires' work was at times too generalized for their needs and that many sites, especially on the western half of the Forest, appeared to better fit preliminary types of Pfister *et al.* (1977) in western Montana. The Forest was mapped in 1973 using habitat types of Daubenmire and Daubenmire (1968) and Pfister *et al.* (1977) which created a confusing mixture of types.

The lack of "fit" of the Daubenmires' (1968) classification appears to have more than one cause: 1) Their main purpose was "to record the structure and composition of remnants of virgin forest vegetation that are rapidly disappearing" and "to provide a classification of this vegetation on an

ecosystem basis" (Daubenmire and Daubenmire 1968). Much of the land that now makes up the Colville National Forest was homesteaded or burned during the last 100 years, making virgin stands relatively uncommon. Since their work was orientated towards climax or near climax stands, the Daubenmires" had relatively few sample plots on the Colville National Forest; 2) The Colville National Forest represents a transition area between an intense rainshadow in the west formed by the North Cascades and the inland expression of a maritime climate in the east caused by the convergence and uplifting of moist air masses. Thus, there is considerable east-west variation in precipitation from the Idaho border to the Okanogan County line.

The preceding comments are not intended to minimize the importance and value of the Daubenmires' work. Indeed we strongly recommend that all serious users of this guide should become familiar with their classic study. Their work has no equal for penetrating insight of ecological processes, keen field observations and lucid, concise language. Other pertinent studies include those of Pfister *et al.* (1977) for Montana and Cooper *et al.* (1991) for northern Idaho. The latter work is of particular interest because part of their study area adjoins the Colville National Forest, with a major topographic divide as the common boundary. While the two areas share many similar plant communities, there are some notable differences which are discussed in the descriptions. The work of Williams and Lillybridge (1983) and Clausnitzer and Zamora (1987) to the west and south, respectively, also share similar types and offer useful insights.

OBJECTIVES AND CONSTRAINTS

The objectives were to:

- Develop a vegetation classification based on relatively stable plant communities.
- Collect adequate data to characterize the physical attributes of each type, including soils, slope, aspect, microreliefand landform.
- Determine and present estimates of site productivity.
- Document the effects of disturbance and make management recommendations.

Because utilitarian administrative needs formed the impetus for the work; some assumptions and areas of emphasis differ from similar work done by universities or research agencies. Constraints of time, monies and staffing dictated that:

- Work will concentrate on commercial forest lands where management impacts are the greatest. This did not mean that other areas were not of concern. Other areas including riparian, meadows and other non-commercial forest lands will be studied later.
- Tree productivity estimates by plant association were needed.
- Classification units must be identifiable by field personnel with a minimum of training.

STUDY AREA

The Colville National Forest is located in northeastern Washington (Figure 1) and administers nearly 1.1 million acres of land. It lies within portions of Ferry, Stevens and Pend Oreille Counties.

Physiography

Easterbrook and Rahm (1970) refer to the area from the Okanogan River to the Idaho border as part of the Okanogan Highlands. The Okanogan Highlands are a geologically distinct area with closer affinities to the Northern Rocky Mountains in terms of climate and vegetation than with the Cascade Mountains to the west. Alt and Hyndman (1984) describe three major geological provinces in the Okanogan Highlands. From east to west they are: 1) the old North American continent, 2) the Kootenay arc, and 3) the Okanogan subcontinent. These three geological provinces have a profound influence on the topography of the forest and to a lesser extent the distribution of plant communities.

The Kootenay arc is dominated by heavily folded and partially altered sedimentary rocks that formed originally as the coastal plain of the old North American continent. The Okanogan subcontinent compressed and folded the old coastal plain sediments into the Kootenay arc when plate tectonics moved the subcontinent into its current position. The North American continent and Okanogan subcontinent are mainly composed of granitic rock types (see following geology section). The general topography of the area is characterized by north-south tending 5,000 to 7,000 foot mountain ranges with the intervening valleys of the Pend Oreille, Columbia, Colville, Kettle and San Poil Rivers.

The Kettle Mountain Range divides the Columbia River drainage from that of the San Poil River and is an extension of the Monashee Mountains to the north and is part of the old Okanogan subcontinent. The Republic graben divides the Okanogan subcontinent into three distinct areas. The Kettle dome is composed of granitic rocks which forms the Kettle Range, the Republic graben is dominated by volcanic rocks, primarily andesite flows, and granitic rocks characterize the Okanogan dome to the west of Republic. The Selkirk Mountains extend north-northeast from the area east of Chewelah to extreme northeastern Washington and are part of the old North American continent (Alt and Hyndman 1984). This range of mountains has a gap where the Pend Oreille River flows through and then the mountains continue north into Canada. The main Selkirk Mountain Crest lies east of the Colville National Forest in northern Idaho.

The Columbia River generally follows the boundary between the Okanogan subcontinent and the Kootenay arc. A triangular area of land between the Kettle and Columbia Rivers and south of the Canadian border (locally called "the wedge") is within the Kootenay arc and is part of the Huckleberry Mountains that extend south between the Colville Valley and the Columbia River. The boundary between the North American continent and the Kootenay arc is less clearly demarcated than that of the Kootenay arc and Okanogan subcontinent.

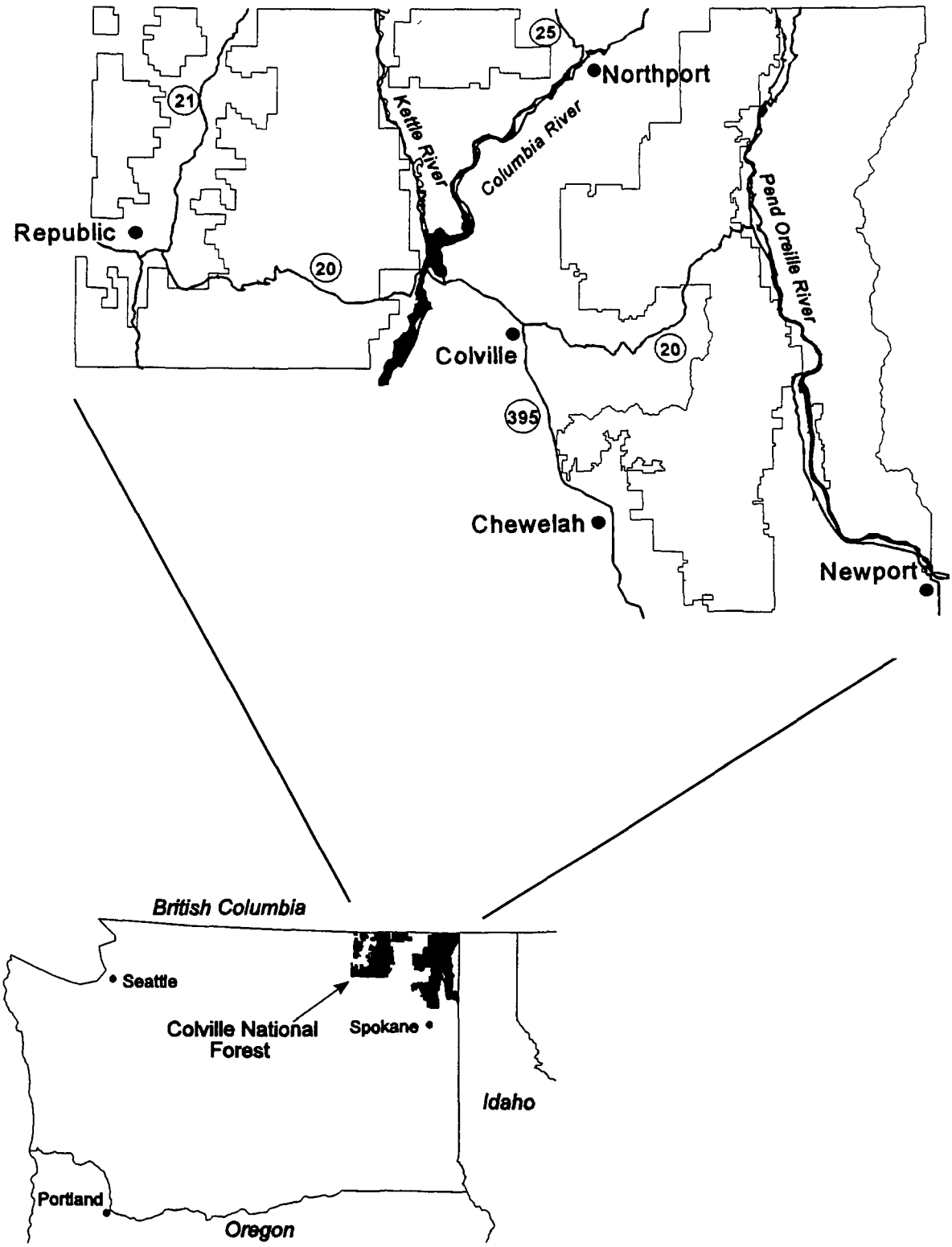


Figure 1. Location of the Colville National Forest.

During the Pleistocene all but the highest peaks were covered by a massive continental ice sheet that originated in the Cariboo Mountains of British Columbia (McKee 1972). At least two major advances of glacial ice have been documented (Richmond *et al*. 1965). Ice thickness varied from 7,000 feet or more near the Canadian border to 3,000 feet or less near the southern extent of the ice sheet (Richmond *etal*. 1965). The last retreat of glacial ice was approximately 12,000 years before the present (Alt and Hyndman 1984). Peaks which escaped the ice sheet (nunataks) often display characteristics associated with alpine glaciation. The continental glaciers produced the rounded summits and relatively gentle mountain slopes typical of this region. The broader valley bottoms are characterized by outwash and kame terraces and by lacustrine deposits. Many narrow drainages have remnants of similar deposits on lower slope positions but most have been removed or altered by subsequent fluvial action.

Alt and Hyndman (1984) give an interesting account of some of the major geologic patterns along major highways and relate them to plate tectonics. Vegetation patterns roughly follow some of their major geologic sections but matters of scale, glaciation and ash deposits often mask influences of bedrock geology upon vegetation.

Geology**

The accompanying bedrock geology map of the Colville National Forest (Figure 2) is necessarily generalized and belies the complexity of the geology in this part of the State. This complexity results from the work of diverse geological processes which range from stable, continental-margin sedimentation to possible continental collision and accretion.

Approximately one-half of the Forest is underlain by medium-to-coarse grained rocks of granitic composition. East of the Columbia River these consist of numerous quartz monzonite, granodiorite, and granite intrusives which together make up the Kaniksu Batholith. The batholith intrudes older marine sediments which were deposited more than 400 million years ago on the margin of a stable land mass to the east. Deformation and metamorphism accompanying intrusion folded and faulted the sediments and converted them to siltite, argillite, quartzite, phyllite, and weakly recrystallized limestone and dolomite.

Contrasting with the slow, uniform accumulation of sediments to the east were conditions of rapid deposition and vulcanism west of the Columbia River. These processes produced conglomerates, dirty sandstones, tuffaceous sediments, minor limestone, and volcanic flow rocks of varied composition well into the Mesozoic Era (140 million years ago). Intense regional metamorphism toward the end of this period gently upwarped and recrystallized these rocks in the area of the Kettle Range. Where temperatures and pressures were greatest the sediments and volcanics were metamorphosed to feldspathic quartzite, mica schists, marbles, amphibolites and gneisses. Low grade metamorphism elsewhere produced meta-conglomerates, phyllites and greenstones.

*** (The "Geology" section and Figure 2 were contributed by Rod Lentz, U.S.D.A. Forest Service geologist, Okanogan and Colville National Forests.)*

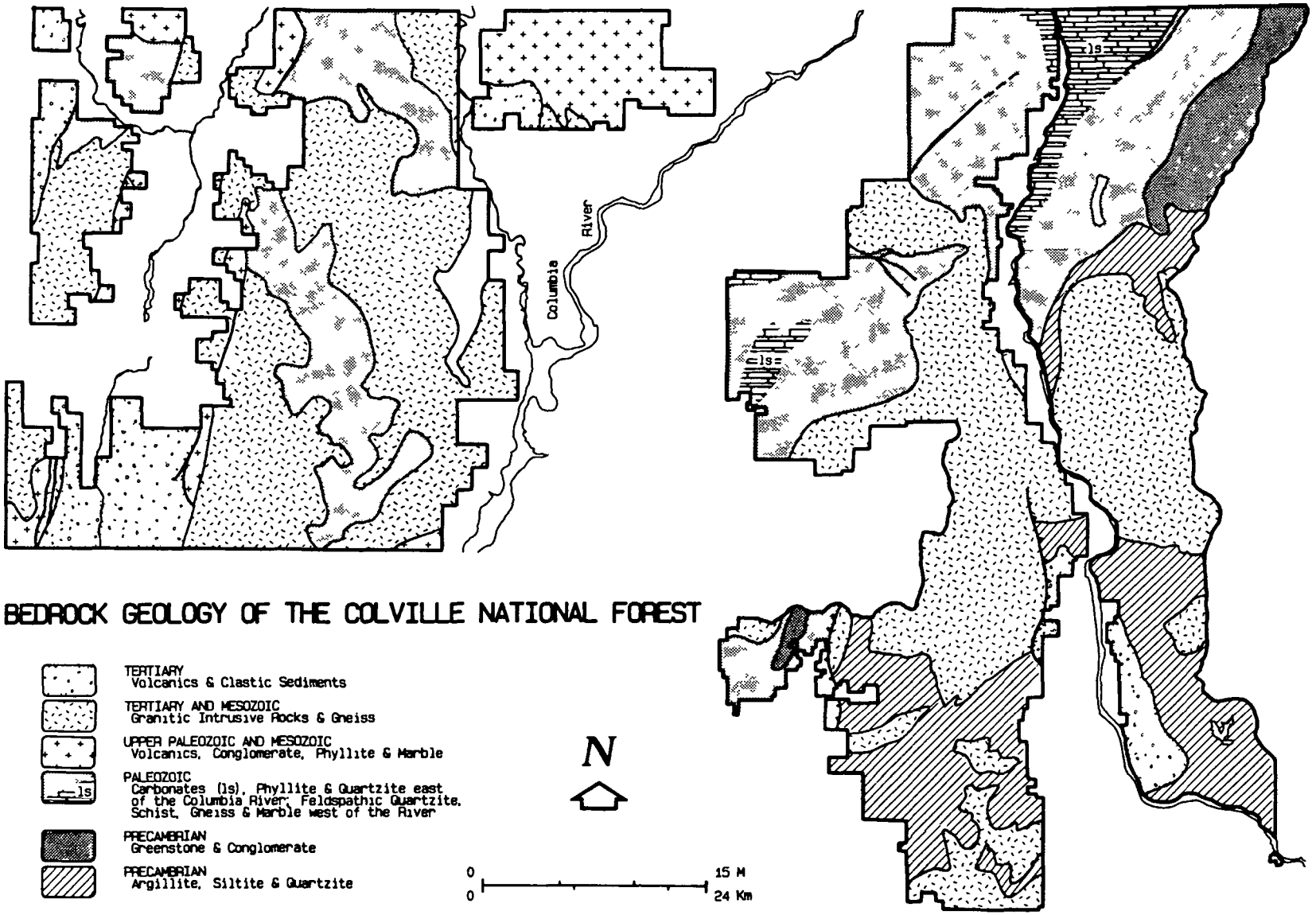


Figure 2. Bedrock geology map.

Contemporaneous with uplift came invasion by granitic plutons like those to the east. Included with these rocks on the map are younger granitic intrusives in the Republic/Curlew area and granitic gneiss of possible younger meta-sedimentary or meta-igneous origin.

During the Tertiary Period (beginning 63 million years ago) erosion and renewed volcanism filled continental basins such as the Republic graben and the ancestral valley of the Pend Oreille River with clastic sediments and volcanic flow and tephra deposits. More recently, continental glaciers scoured all but the highest peaks leaving a mantle of till and outwash deposited over much of the area, even at higher elevations. Ash falls from Cascade and local volcanic eruptions as recently as 15 years ago have also contributed to surficial deposits and soils in the region.

Climate

The forest has a climate with both maritime and continental characteristics because it receives air masses from the continent and the Pacific Ocean. The north-south tending mountain ranges and narrow valleys also create variations in climate (Phillips and Durkee 1972). The western portion of the Forest is under the influence of an intense rainshadow formed by the North Cascades, while the eastern portion has a moist, near-maritime climate created by the westerly air flow being forced over the 5,000 to 7,000 foot peaks of the Kettle River and Selkirk mountain ranges. Precipitation levels are enhanced in the northeast portion of the forest by additional moist air masses moving into the region from the north from Canada.

Throughout the year, maritime air from the Pacific exerts a moderating influence on temperatures while more extreme temperatures come with drier air from the interior of the North American continent. A interesting anomaly is the pattern of vegetation along the Kettle Mountains where the windward side of the mountain range is less maritime (more xeric vegetation) than the lee slopes. Apparently because maritime air masses move more readily up the Columbia River than over the mountains, the lee slopes support more mesic forest vegetation than do the windward slopes. This is the reverse of the typical pattern observed in the Cascade Range to the west.

Precipitation is greatest in winter and spring. Most valleys receive 15 to 25 inches of precipitation per year. Precipitation increases in the mountains to 30-40 inches along the higher ridges of the Kettle Mountain Crest and 50 inches or more in parts of the Selkirks (Figure 3). During the warmest summer months, afternoon temperatures in the valleys range from the mid to upper 80's and minimums range from the upper 40's to the mid-50's. In average years summer temperatures exceed 100°F for 1 to 5 days (Phillips and Durkee 1972). During an average winter afternoon temperatures are near freezing with minimums from 10°F to 20°F. while winter minimum temperatures below 0°F occur 5 to 12 nights a year.

The general climatic trends in the area can be characterized by increasing average annual temperatures and precipitation from west to east across Forest (Table 1). These differences in temperature and precipitation patterns are reflected in the distribution of current forest vegetation. Relatively dry, open Douglas-fir forests predominate along the Okanogan-Ferry County line while moist cedar-hemlock forests are the rule near the Idaho-Washington border.

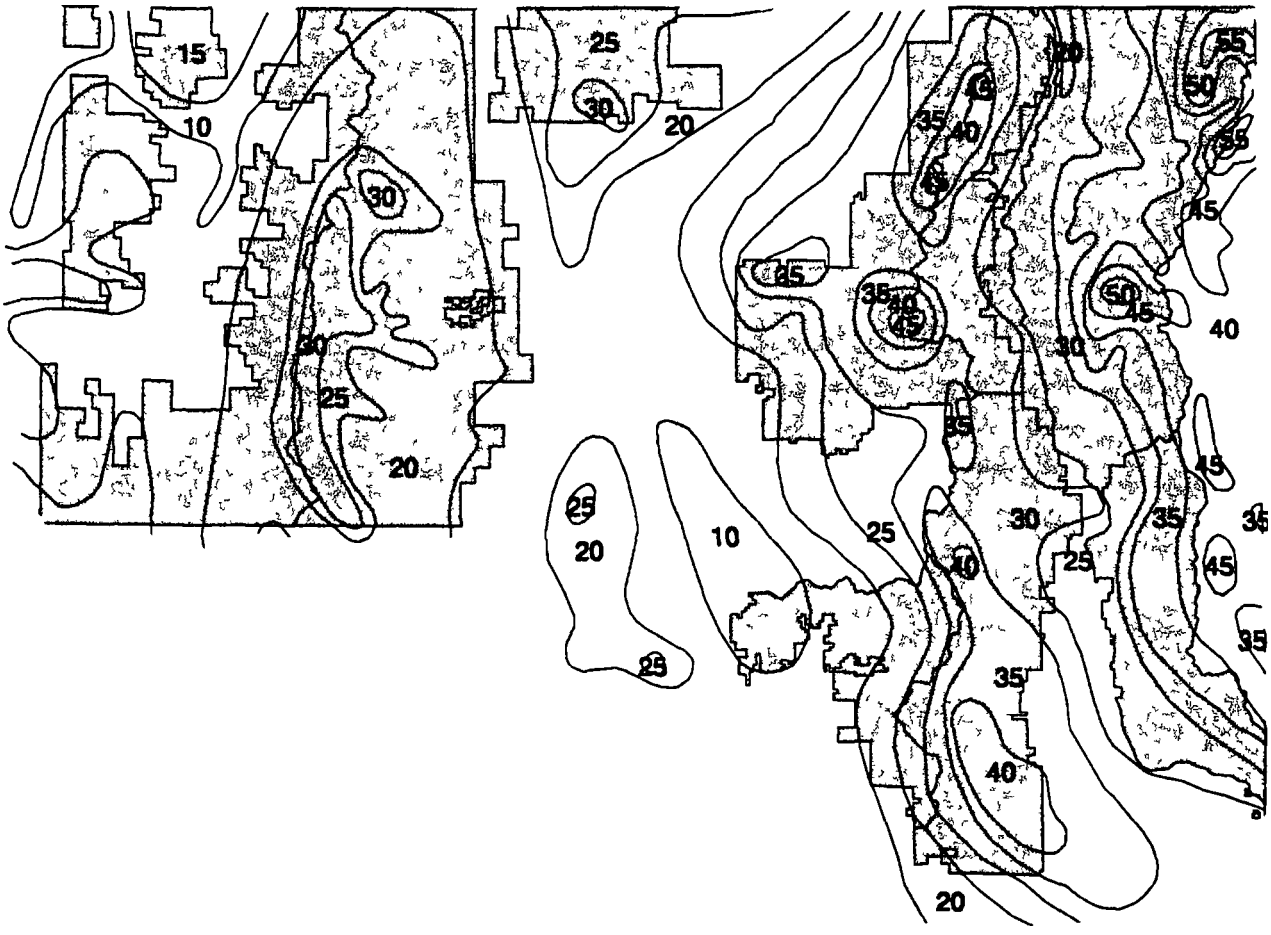


Figure 3. Precipitation patterns (inches) on the Colville National Forest

Soils

Soils on the Colville National Forest formed mainly from glacial till, outwash, lacustrine deposits, colluvium and alluvium Tills and outwashes can be influenced by a variety of rock types from the complex local geology In addition, there is a mantle or admixture of volcanic ash which is present over much of the Forest Volcanic ash mantles are up to several feet thick in some areas Steeper south and west aspects normally have less evidence of ash deposition The geologically recent glaciation and ash falls have resulted in relatively undeveloped soils, primarily Inceptisols, on forested sites. South and west aspects with grasses as the main type of vegetation have soils with a dark surface layer and higher base saturation (Mollisols)

The ashy surface mantle has important management implications It provides an excellent medium for plant growth. Ash has a higher water holding and cation exchange capacity compared to the glacial deposits Undisturbed, it is porous with weak granular or blocky structures and minimizes erosion. It is highly subject to erosion if disturbed These soils are also easily compacted by heavy equipment, especially when moist Additionally, forested sites have a thin "A" horizon that contains

Table 1. Mean annual snowfall, temperature and precipitation (inches) for selected locations in northeast Washington.

Location	Elevation fft.)	Mean Annual Snowfall	Mean Annual Precipitation	Mean Annual Temperature
Omak	850	21.1	12.93	49.9
Chesaw	2850	48.1	13.41	41.7
Republic	2610	53.2	16.26	43.0
Colville	1640	41.4	18.46	46.9
Northport	1330	56.8	19.03	47.1
Laurier	1640	57.8	19.88	46.1
Chewelah	1670	44.1	20.82	45.9
Newport	2140	61.7	26.78	45.1
Metaline Falls	2110	87.0	27.25	45.1

the bulk of the organic matter and nutrients in the soil. The ashy surface soil layers have generally increased the productivity potential of soils in this glaciated area. Compaction or displacement of the ashy surface soil layers will reduce site productivity potential and increase the risk of run-off and erosion.

Glacial tills beneath the ash mantle are often compacted which limits root penetration and may contribute to windthrow of trees which have shallow root systems. Limited data suggest that soil moisture content generally begins to decline in July. The soil moisture pattern fluctuates until the more consistent late fall rains begin. Sites associated with the Douglas-fir series appear to experience greater moisture losses at the 12- and 20-inch depths than sites in other series.

VEGETATION OVERVIEW

Development of Current Vegetation

Daubenmire (1975) traces the development of the current flora through the Cenozoic Era (beginning 65 million years ago) for eastern Washington and northern Idaho. Hansen (1947) and Mack *et al.* (1978a and 1978b) discuss vegetation development at specific locations for approximately the last 12,000 years from pollen records in bogs from sites within or near the Colville N.F. These studies indicate a marked change in the flora over both geologic time scales and in the relatively short time since de-glaciation (beginning approximately 12,000 years before present). Interpretation of the pollen record of Big Meadow (T37N R42E S7, Willamette Meridian) suggests that the current forest composition developed about 2,700 years before present (Mack *et al.* 1978a). Interpretation of another pollen profile in the San Poil River drainage suggests that the current vegetation composition was established 2,400 years ago (Mack *et al.* 1978b).

Even with the uncertainties of pollen and fossil records (Pielou 1991), it is clear that flora (species) and vegetation (patterns of communities on the landscape) are dynamic. Vegetation appears stable only in the context of a human time scale. Vegetation change in response to climatic fluctuation and other environmental and biological conditions is certain. Whether the changes are beneficial or not is entirely a matter of perspective. Introduced biota are already major modifiers of the native vegetation. Climate has and does fluctuate. A recent example is the well documented "Little Ice Age" from about 1350 to 1870 (Pielou 1991). Such climatic fluctuations are evident in the present vegetation as relict distributions of species and communities unable to persist under the current climatic regime. With the accumulating evidence of an impending (some would say beginning even now) major global climatic change *(e.g.* "global warming") driven (at least in part) by man's activities, the future will likely bring unexpected changes in our flora and vegetation.

Climate plays a major role in the distribution of vegetation. But within a specific climate much spatial variation exists dependant on other factors such as geology, soils, microclimate and site history. Disturbance and ecosystem response are an integral part of vegetation ecology. Type, intensity and timing between disturbances are essential components of the ecology of individual species and plant communities. Factors often referred to as disturbances include (but are not limited to) fire, animals (including insects and predators), pathogens and man's activities. All of these factors affect the kinds and development of vegetation for a specific area. Human activities often alter vegetation in conspicuous ways but more subtle changes may have much more long-term importance. For example, a recent clear-cut is conspicuous, yet the introduction of an alien pathogen such as white pine blister rust *(Cronatium rubicold)*, while not as readily noticed, may have more profound effects on forest composition than logging. Other examples include the long-term effects of air pollution, soil compaction, disturbance or displacement, changes in fire frequency or intensity, and introduction or extirpation of fauna or flora. All play important roles in the biology and sustainability of a forest community.

Both spatial and temporal scales are important considerations when looking at vegetation patterns and development. The overall forest composition of a large area may remain essentially stable for thousands of years while individual stands are a dynamic, ever shifting mosaic of composition, structure and pattern. A specific acre may support essentially the same plant community for centuries because disturbances passed it by *(e.g.* natural fires) and then may be repeatedly disturbed in a few decades.

Many patterns repeat themselves in time and space. Therein lies the value of vegetation classifications such as this. Essentially the same pattern may repeat itself on the same acre if environmental and biotic factors remain relatively constant. Some factors such as fire and insects operate in complex, inter-related cycles within a time sequence measured in decades to hundreds of years (Amman 1990). The net result is a forest landscape in dynamic balance with the local environment and biota. Introduced species and rapid climatic or other environmental change *(e.g.* acid rain) may drastically alter this dynamic balance and result in rapid change. Vegetation will adapt to the new conditions but may or may not do so in a manner humans find desirable.

Plant Succession

A simple definition of plant succession is the replacement of a species or a community by another. Generally it is somewhat orderly and predictable for a specific area. However it can and does vary according to a multitude of factors including: soils, climate, previous vegetation, adjoining vegetation, type and magnitude of disturbance, history of use, etc. Traditionally, succession has been termed "primary" or "secondary", with primary succession concerning the development of vegetation on sites that have not previously supported plants. Examples are strip mine spoils and bare rock. Managers commonly deal with secondary succession which refers to the development of vegetation on a site that previously supported plants. Much of secondary succession concerns the interaction of plants between and among themselves. Tolerance to shade, competition and various forms of disturbances are major considerations. Table 2 is a listing of the autecological characteristics of selected conifers found on the Colville N.F.

The list in Table 2 is approximate and placement of one species to another may vary somewhat, though the general order is correct. Over time, species more tolerant of shade will normally out-compete intolerant species in closed stand situations. Tolerant species often require more favorable site conditions in terms of soils and climate than do intolerant species. In part, intolerant species are favored by conditions of early succession where rapid establishment and early growth are important survival mechanisms. Tolerant species are better at competing with other plants for light, moisture and nutrients than are intolerant species. Fire tolerant species are more likely to survive a given intensity of fire until the fires are too intense for any species to survive. Appendix 1 contains a list of selected shrubs and herbs and their fire survival adaptation. Factors other than shade and fire tolerance are also important, but are generally less well understood. Resistance to diseases, animals, insects, mechanical damage, frost, annual heat and water budgets and chemical warfare by other plants (allelopathy) are just some of the characteristics important in determining the range and development of a species.

Allelopathy is an especially interesting process wherein chemicals exuded by plants directly or indirectly inhibit or prevent the growth and development of other plants. Engelmann spruce has been shown to limit survival and growth of other plants (including itself) with chemicals leached from the litter. Lodgepole pine is especially sensitive to Engelmann spruce leachates (Taylor and Shaw 1982). Other trees, shrubs and herbs have been shown to hinder the growth and survival of other plants. The most notable of these is bracken fern, where recent work in northern Idaho suggests that some non-forested openings may be partially or wholly the result of conifer regeneration being inhibited by this species (Ferguson and Boyd 1988). The tables on tree characteristics and appendix 1 provide useful information in predicting vegetation response from a given event such as a fire. They can also be used to make interpretations for other activities such as logging by providing information on reproductive strategies.

Much of the information on plant succession is discussed in the series descriptions. Patterns exist between climax tree series as well as between associations and different stands within an association. Table 3 shows the complex successional relationships between conifer species and the various plant associations found on the Colville N. F. This discussion should indicate to the reader that the forest community we see is extremely complex and inter-related. Linkages between and among communities

Table 2. Comparative autecological characteristics of selected Colville National Forest conifers. Data are compiled from various literature sources (Minore 1979) and field observations.

Species	Shade Tolerance[1]	Frost Tolerance[2]	Drought Tolerance[2]	Snow Damage Resistance[2]	Fire Resistance[2]	Root Rot Resistance[2]	Seed Weight	Seed Crop Frequency[2]
ABGR	T	M	M	M	L	L	M	M
ABLA2	T	M	L	H	L	L	M	M
LAOC	VIT	M	M	M	H	M	L	L
PIEN	T	H	L	H	L	M	L	M
PIAL	VIT	H	H	H	L	U	H	M
PICO	IT	H	M	M	L	M	M	H
PIMO	I	H	M	M	M	M	M	H
PIPO	IT	L	H	L	H	H	H	L
PSME	I	L	M	L	H	L	M	M
TSHE	VT	L	L	H	L	M	L	M
THPL	VT	L	L	M	L	L	L	H

[1] VT - Very Tolerant; T - Tolerant; I - Intermediate; IT - Intolerant; VIT - Very Intolerant
[2] H - High; M - Moderate; L - Low; U - Unknown.

and species are greater and more complex than we imagine. In reality we know and understand only a small part of the complex biology of a forest stand.

Vegetation Zones

Vegetation patterns on the Colville National Forest differ from other National Forests in eastern Washington State. The west to east transition from intense rainshadow to moist maritime conditions is a major influence on plant species and community distributions. The locally common coniferous tree species differ from each other in their autecologic characteristics, ecologic roles, elevational and geographic distributions. Due to these factors, some plant species have limited distributions.

In order to better understand and describe the relationships between the environment and spatial vegetation patterns, a large-scale vegetation modelling project has been initiated on Area 11 forests. In order to accomplish this task, plant associations have been grouped into Vegetation Zones and Plant Association Groups (PAG). Vegetation Zones represent areas of land which are characterized by a single modal type of potential vegetation. These areas support the modal tree(s) species (and thus related plant associations) for which the zone is named. In theory, the Douglas-Fir/Grand Fir

Table 3. Distribution of tree species by type, showing their successional status.

	TREE SPECIES												
Association	TSHE	THPL	ABGR	ABLA2	PIEN	PSME	PIPO	PICO	PIMO	LAOC	BEPA	POTR	POTR2
TSHE/GYDR	C'	c	S	i	i	s	.	s	8	s	8	.	s
TSHE/MEFE	C	s	i	S	S	s	.	S	s	s	.	.	.
TSHE/XETE	C	S	.	S	S	i	.	S	s	s	.	.	.
TSHE/RUPE	C	c	i	S	S	i	.	S	s	s	8	.	s
TSHE/ARNU3	C	c	S	.	i	S	i	S	S	S	S	S	.
TSHE/CLUN	C	c	S	s	i	S	i	S	s	s	8	s	s
THPL/OPHO	c	C	S	.	.	s	.	8			8	.	8
THPL/ARNU3	i	C	S	.	S	S	s	s	8	s	s	s	8
THPLA/AME		C	S	s	i	S	.	S	8	s	s	8	.
THPL/CLUN	i	C	S	i	i	S	s	S	s	s	8	8	8
ABGR/ACGLD /CLUN		1	C	.	i	S	S	S		s	8	s	8
ABGR/VAME/ CLUN		1	C	1	1	S	s	S	s	s	8	8	.
ABGR/VACA	i	i	C	i	i	S	s	S	s	s	8	8	.
ABGR/PHMA		i	C	.	.	S	S	S	8	s	.	.	.
PIEN/EQUIS				c	C	s	.	8			8	.	8
ABLA2/RHAL-XETE	i	i	.	C	c	i	.	8	i	s	.	.	.
ABLA2/RHAL	i	i	i	C	S	s	.	S	8	s	.	.	.
ABLA2/COCA	i			C	C	S	i	S	1	s	8	8	8
ABLA2/TRCA		i	s	C	c	s	.	S		s	.	.	.
ABLA2/XETE	i	i		C	S	s	.	S	8	s	.	.	.
ABLA2/CLUN	i	i	i	C	c	s	.	S	s	s	8	8	.
ABLA2A/AME		i	s	C	S	S	.	S	8	s	8	8	.
ABLA2A/ACA		i	i	C	c	S	.	S	8	s	1	8	.
ABLA2/LIBOL				C	C	S	.	S	8	s	8	8	s
ABLA2/VASC				C	c	i	.	S					
ABLA2/CARU				C	s	S	.	s		8	.	8	.
PSMBPHMA-L1BOL	i		i	i	i	C	S	s	s	s	1	.	.
PSME/PHMA			I	.	.	C	S	s					
PSME/VACA				i	i	C	s	S		s	.	8	.
PSMEA/AME	i			i	i	C	i	S		s	8	8	.
PSME/SYAL						C	S	S		8	.	8	.
PSME/SYOR						C	S			s			
PSME/CARU			i	i	.	C	S	s		s	.	.	.
PIPO-PSME/AGSP						c	C						
PICO/SHCA	?	?	?	?	?	s	I	S	8	s	8	8	.

' C = major climax species, c = minor climax; S = major serai, s = minor serai; i = incidental; ? = unknown. Table format from Pfister *et at.* (1977).

Vegetation Zone (as defined here) represents an area of land which has the "potential" to support Douglas-fir or grand fir plant associations and all of the related successional seres. The Vegetation Zone is a concept similar to tree series, except that it refers to the land area where a particular series(s) occurs (Henderson *etal*. 1989, 1992). These zones can (and will) have inclusions of either drier or wetter vegetation than the described modal type. There are five Vegetation Zones which ecologists are currently delineating on the Colville National Forest: 1) Douglas-Fir/Grand Fir, 2) Western Hemlock/Redcedar, 3) Subalpine Fir, 4) Parkland and 5) Alpine. Figure 4 shows the first approximation of the distribution of these zones across the Forest. This map will be improved through time as more information on climate and vegetation becomes available, allowing the climatic (temperature, precipitation, etc.) and vegetation models to be calibrated more accurately.

Plant Association Groups (PAG)

Plant Association Groups (PAG) represent aggregates of plant associations based on similarities in floristics, environment, and productivity. This grouping represents a finer delineation of the environment than that of the Vegetation Zones. These groups are useful for mapping similar environments across a given landscape, and as such, are also useful in helping to describe other landscape attributes such as potential fire regimes. These groups, along with the corresponding Colville Plant Associations, are listed in Table 4. These groups will form the basic units for future vegetation modelling and mapping efforts on the Colville National Forest by Area II ecologists. A more detailed discussion of the PNV modelling effort will be available in the future in a separate document.

Fire History

Fire has played a major role in the development of forests in the Northern Rocky Mountains (Amo 1980, Gruell 1983, Shearer and Stickney 1991, Wellner 1970), so much so that Shearer and Stickney (1991) make the statement that "Fire has been the agent of the most extensive disturbances in the Northern Rocky Mountains." Their conclusion is valid for the Colville N.F., with virtually all Colville N.F. ecology plots containing evidence of past fire such as fire-scarred trees, charred logs, stumps or wood, or charcoal in the soil. Daubenmire and Daubenmire (1968) state that incidence of fire is a virtual certainty within 400 to 500 years in northern Idaho and eastern Washington. During this study (with sampling biased towards the oldest stands) 1,700 trees were aged. Only nine were more than 400 years old at breast height. Several of these were western redcedars located in sheltered, moist habitats. The oldest sampled tree was a 570 year old western larch that had survived multiple fires. A series of large fires has burned over much of the Colville N.F. in the last 100 years (Figure 5). The large gaps in fires shown in Figure 5 are a result of incomplete fire history data reported for those areas, but it is recognized that those areas have been impacted as well.

Additionally, a large proportion of national forest lands were homesteaded in the 1800's and early 1900's, with subsequent reversion to federal control following homestead failures during the Great Depression era. Because of these large scale disturbances, commercial logging has concentrated in the most accessible areas containing the largest (and generally oldest) trees. Consequently, old and

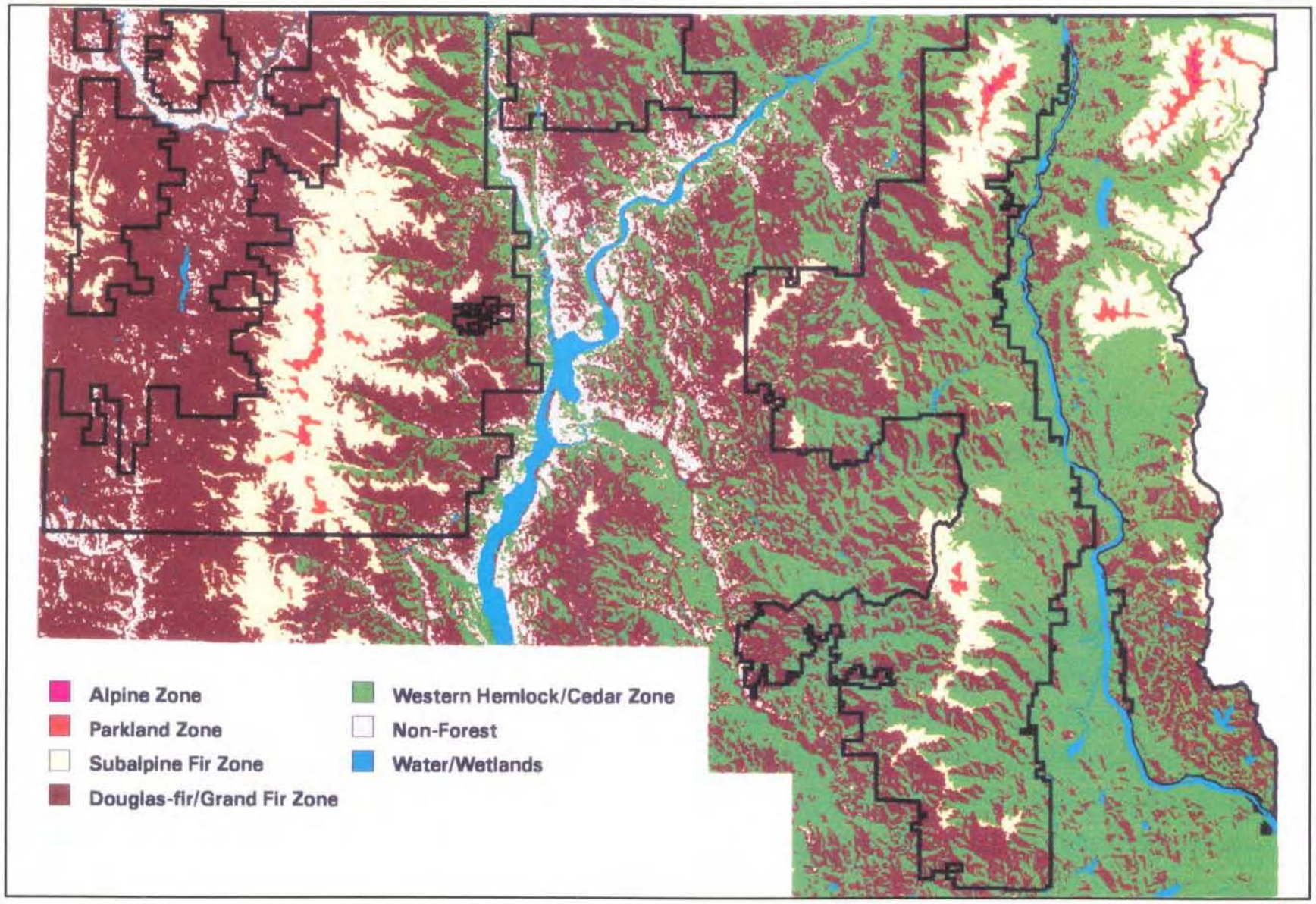


Figure 4. Distribution of Potential Natural Vegetation (PNV) Zones on the Colville National Forest (first approximation, May 1995).

Table 4. List of Plant Association Groups (PAG) and corresponding Colville Plant Associations[1].

Plant Association Group (PAG)	**Plant Association Group (PAG)**
Hot, dry PIPO-PSME - bunchgrass	Cold, dry ABLA2 - shrub
• PIPO-PSME/AGSP	• ABLA2/XETE • ABLA2/VAME
Warm, moist PSME - low shrub	Very moist ABLA2 bottoms
• PSME/SYAL	• ABLA2/TRCA3 • ABLA2/COCA • PffiN/EQUIS
Warm, dry PSME-ABGR - tall shrub	Cold, mesic ABLA2 - tall shrub
• PSME/PHMA • PSME/SYOR • PSME/PHMA-LmOL • ABGR/PHMA	• ABLA2/RHAL • ABLA2/RHAL-XETE
Cool, dry PSME-grassy	Cold, dry ABLA2 - low shrub
• PSME/CARU • PSME/ARUV	• ABLA2/VASC
Cool, mesic PSME-ABGR - low shrub	Cool. mesic THPL/TSHE - forb/shrub
PSME/VACA PSME/VAME ABGR/VAME/CLUN **ABGR/VACA** **ABGR/ACGLD/CLUN**	• THPL/CLUN • THPL/VAME • TSHE/CLUN • TSHE/XETE
Cool, dry ABLA2 - grassy	Cold, mesic TSHE - tall shrub
• ABLA2/CARU	• TSHE/MEFE
Cold, mesic ABLA2 - forb/shrub	Very moist THPL/TSHE bottoms
• ABLA2/CLUN • ABLA2/LfflOL • ABLA2/VACA	THPL/OPHO THPL/ARNU3 TSHE/RUPE TSHE/GYDR TSHE/ARNU3

[1]current grouping as of November 1994.

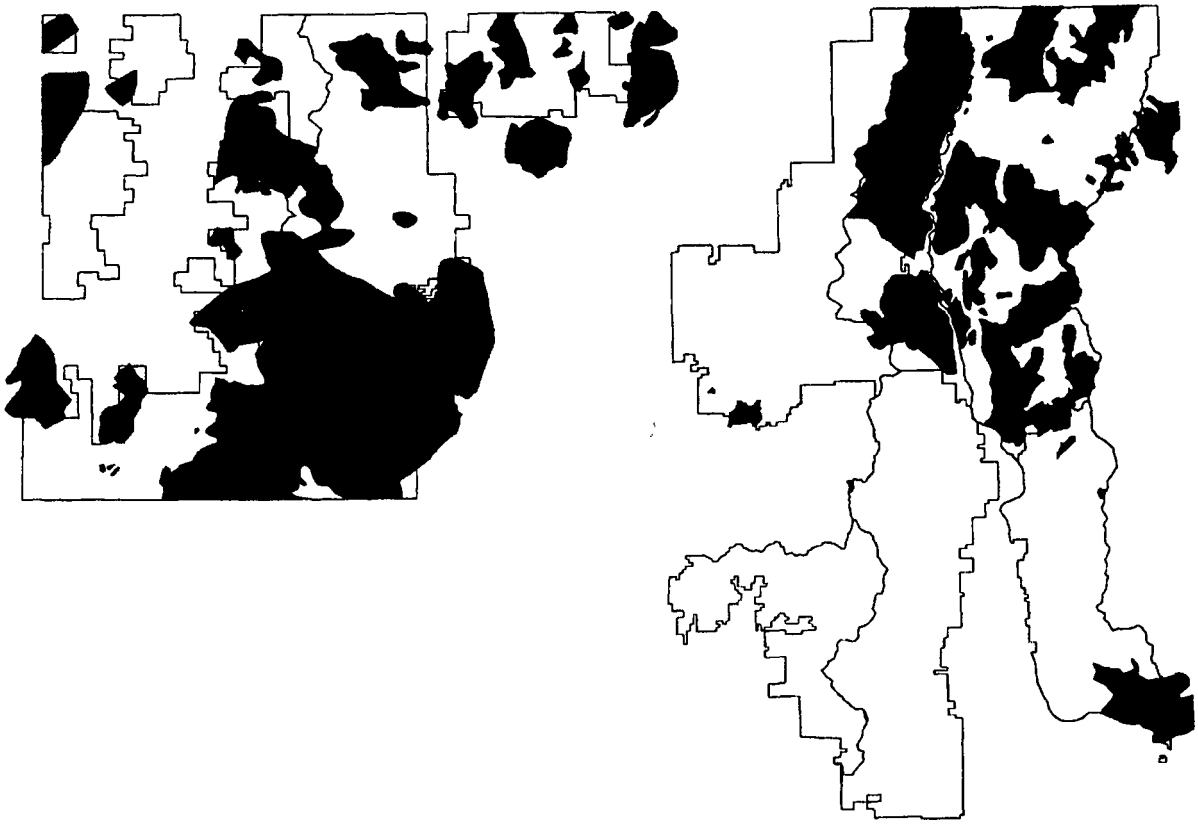


Figure 5. Locations of major fires (perimeters) between 1909-1994 on the Colville National Forest.

mature forests (stands 150 years or older) make up a small proportion of the present landscape.

Older forest stands were likely to have been a more common landscape element prior to Anglo-American settlement, but still would have occupied a relatively small percent of the area because of the integral role fire has in the ecology of northeast Washington's forests. Gruell (1983), using old photographs, suggests such a conclusion for the northern Rocky Mountains. The pattern of several large, catastrophic fires early in this century appear within the cycle of natural fire patterns that were part of the landscape ecology of the area for the past 2,000 years or more. Large fires took place at irregular intervals depending upon variations in weather. Native Americans also used fire to manipulate vegetation (Agee 1993, Amo 1980, Bakeless 1964, Butzer 1990).

Moist, highly productive (in biomass) forests are more common east of the Kettle and Columbia Rivers. Such forests accumulate considerable organic matter in short time periods and rapidly develop complex vertical structures. The moist environment reduces the flammability of the forests

but the dense complex structures and high fuel loading predisposes the stands to crown fires when fires do occur. The more xeric forests characteristic of the area between the Kettle Mountains and the Okanogan River had a higher fire frequency but the relatively xeric conditions favored more open forest with much lower fuel loadings. Consequently most fires were relatively low intensity "ground fires". Intense stand replacing fires also occurred depending on local fuels and weather patterns.

Fire suppression has had the largest effect on the character of forest stands on sites with a natural history of repeated underbums. This is especially true of drier habitats within the Douglas-fir and Grand Fir Series. Dry habitats typically support a grass, low shrub or forb dominated undergrowth with low fuel loadings and light, flashy fuels. Periodic, low-intensity underbums with a 5-40 year interval between fires were typical. Relatively frequent, low intensity fires maintained open forests characterized by widely spaced large (and old) individuals of fire resistant species such as ponderosa pine, western larch and Douglas-fir. Fire sensitive species such as grand fir, subalpine fir and Engelmann spruce were normally minor stand components except, perhaps, in riparian zones. Crown fires often led to dominance for the first 100 years or so by lodgepole pine or western larch if a seed source was available.

Under fire suppression, fire sensitive but more competitive and shade-tolerant grand fir, subalpine fir and Engelmann spruce have increased in proportion to shade-intolerant serai species. Douglas-fir has also increased on the Douglas-fir Series. Consequently, stand structures have changed from relatively open single or two storied stands dominated by large individuals of serai, fire resistant species to denser, smaller-stemmed, multi-layered stands with a higher proportion of fire sensitive, late serai or climax species.

Periodic underbums on these drier sites also kept logs and other woody materials on the forest floor at relatively low levels. As the large, open grown, fire tolerant species die they become large snags or logs. Western larch, western white pine and ponderosa pine are unable to replace themselves in competition with more tolerant species so the large snag and log component will decline. With fire suppression, log and snag densities increase but snags and logs are usually much smaller in average size. Different tree species which become snags and logs have unique structures, decay attributes and chemical compositions, so snag and log dependent biota may also change. After several decades of fire control, sites with a natural history ofunderburns develop stand structures and conditions similar to those with a natural history of less frequent but more intense crown fires. Selective harvest of commercially valuable large, old serai trees *(e.g.* ponderosa pine, western larch) has accelerated these changes in composition and structure (Hungerford *et al.* 1991).

Such changes approximate late serai vegetation (primarily species composition) on habitats that normally supported early to mid-seral vegetation, and these late serai conditions now favor different biota than early serai conditions once did. Some insect populations are especially favored by extensive areas of late serai vegetation, as are various root diseases. Prior to fire suppression, late serai stands were a smaller proportion of the landscape and rarely occupied extensive contiguous areas. Fire suppression and other management activities have contributed to the development of extensive contiguous areas of late serai forest conditions that have no precedent in pre-settlement landscapes. This has also led to an increase in structural and species diversity.

Underbums were much less important in stand development on moist or cold habitats within the Subalpine Fir, Western Hemlock and Western Redcedar Series. The typical fire pattern was one of occasional intense fires on a 150 to 300+ year return interval, though these stands also exhibited patchy low-intensity underbuming on occasion. Current stand development under fire control on moist sites does not appear markedly different than that prior to Anglo-American settlement because the time since fire suppression is well within the variation between major fires (150 - 300 years). Barrett *et al.* (1991) describe a similar pattern of fire occurrence in western larch-lodgepole pine forests in Montana. The fire regimes they discuss generally agree with our observations. For more information on their findings refer to the Fire Ecology discussion for the Subalpine Fir Series.

Ponderosa pine climax stands are uncommon on Colville National Forest lands, but are more prevalent on lands of other ownerships at lower elevations below the Forest boundary. These stands also had a history of frequent underbuming. Fire suppression has not changed species compositions as much because the dry environments do not allow for more shade tolerant but moisture-requiring conifers such as Douglas-fir or grand fir to thrive. Other factors such as dead wood and shrub and herb composition have been altered with the change in fire regime.

It is obvious that fire and vegetation have interacted together over long periods of time in the Pacific Northwest. This is evident from the many fire-adaptations which various species exhibit such as thick corky bark, serotinous cones or seeds (which require fire to germinate), and vigorous re-sprouting of some shrubs and herbs after fire (Agee 1993). As reported by Christensen (1988), flammable features of plants can influence fire regimes and subsequent successional trajectories. Thus, fire (or the lack of) plays an important ecological role in the evolution of natural ecosytems in eastern Oregon and Washington (Agee 1993, Gast *etal*. 1991). The long-term implications of recent changes in fire regimes are not clear but important ecosystem processes such as nutrient cycling, pathogens and accumulation of organic materials may be altered (Cochran and Hopkins 1991). It is not probable (or perhaps possible) that the natural role of fire can be reapplied successfully to historical levels and intensities across the landscape (Agee 1993). However, the use of fire still represents an important and promising tool for managing for long-term productivity of forests in eastern Oregon and Washington (Gast *et al*. 1991).

*Insects and Disease***

The interrelationships between natural fire, insects and disease is receiving much attention because of large-scale insect population increases (Amo *et al*. 1991). Tree ring analysis in the southern Rocky Mountains suggests that periodic attacks by defoliating insects have been common for centuries but that the intensity and extent of recent outbreaks may be greater because of human-caused changes in forests (Swetnan and Lynch 1989). An assessment (preliminary draft) of forest health of the Colville National Forest was recently completed by a pathologist and entomologist (Hessburg and Flanagan 1991). Part of the their summary of current conditions is reproduced below.

*** (Portions of this and other discussions concerning insects and disease were contributed by Paul Flanagan and Jim Hadfield, entomologist and pathologist, respectively, U.S.D.A. Forest Service, Forestry Sciences Laboratory, Wenatchee, WA.)*

- Forest diseases are responsible for significant resource damage on the Colville N.F. We believe that there has been an increase in damage since the turn of the century when fire prevention programs were initiated. Damage continued to escalate with selection logging and aggressive fire suppression to the present day. Resource impacts today are directly related to the susceptibility of existing vegetation on the Forest.

- Historic conditions were low to moderate hazard and damage, depending upon the plant association and time since stand replacement fire. Current conditions range from moderate to very high hazard and damage. The areas most severely damaged have been logged several times and are successionally advanced. The areas least damaged are those that were most recently fire-regenerated and have not been entered due to their small timber size and/or high density.

- Over many areas of the Forest that have been entered, stocking levels are excessive in the understory, a direct result of effective fire suppression and past selective harvesting. The composition of these understories represents an increase in susceptibility to damage by forest diseases. The soil of harvested areas is more compacted and disrupted. Both of these effects create conditions which are conducive to greater damage by root diseases and bark beetles and perhaps other forest pests.

- In the historic context, forest pathogens and the diseases they caused were neither good nor bad. Most of the effects of forest pathogens were beneficial under natural disturbance regimes. Fire regulated the extent of those effects to typically low or moderate levels. Root diseases predisposed trees to windthrow providing down woody material for small mammal habitat, soil moisture retention, and refugia for essential soil microorganisms. Dwarf mistletoes provided roosting and nesting habitat for a variety of birds as well as the green fuel ladder for stand replacement fires that would regenerate the serai plant community. Stem decay pathogens in the serai species were prevalent on the Forest, providing essential habitat for cavity nesting birds and mammals and the impetus for small gap formation.

- Damage associated with the western spruce budworm and bark beetles is dramatic and visible and captures the attention of people who typically consider or observe the forest from a distance. Root diseases and dwarf mistletoes though, produce change on the landscape at a slow steady rate, seldom capturing the attention of the public or forest managers. Their effect on growth and survival of vegetation in the long term is much greater than that of all other forest insects (Hessburg and Flanagan 1991).

Insects and disease are essential components of the biology of the Colville N. F. They have essential roles in nutrient and organic matter cycling, providing habitat diversity and other vital ecosystem functions (Harvey *et al.* 1987, Hessburg and Flanagan 1991). However, introduced pathogens and insects may greatly reduce or even eliminate native species that have little or no natural resistance. In such instances a "balance" between hosts and "pests" does not exist. Man's activities can also alter the balance between pathogens and host species (McDonald *et al.* 1987a), with the case of fire suppression and introduced pathogens serving as examples. Table 5 lists some of the common fungal pathogens of conifers found on the Colville National Forest, as well each tree species' susceptability.

Table 5. Damaging agent-host susceptibility matrix for the conifer species found on the Colville National Forest. (table and information has been adapted from Harvey and Hessburg 1992).

AGENT	PSME	ABLA2	ABGR	TSHE	THPL	LAOC	PIPO	PICO	PIMO	PEN	HARD-WOODS
Laminated root rot *(Phellinus •weirii)*	H"	I	H	I	R	T	T	T	T	I	i
Armillaria root rot *(Armillana ostoyae)*	H	I	H	I	I	T	I	I	I	I	R
Annosus root rot *(Heterobasidian annosum)*	T	H	H	I	R	R	*f*	I	T	I	R
Tomentosus root rot *(Inonotus tomentosus)*	T	I	T	I	R	T	*I*	H	T	H	R
Brown cubical butt rot *(Phaeolus schweimtzii)*	H	T	T	T	R	H	H	H	I	H	R
Rust-red stringy rot *(Echinodontium tinctorium)*	R	H	H	H	R	i	i	i	i	R	i
Red ring rot *(Phellinus pini)*	H	I	H	H	R	I	H	I	H	H	R
Brown trunk rot *(Fomitopsis officinalis)*	H	R	R	R	i	H	H	H	I	T	i
Redcedar pencil rot *(Oligoporus sericeomollis)*	R	I	T	R	H	R	R	R	R	R	i

' Susceptibility: H=High, ^Intermediate, T=Tolerant, R=Resistant,i=Immune

[b] PIPO is susceptible on dry climax PIPO sites.

Western white pine was once a major forest species in the inland Pacific Northwest; particularly on eastern portions of the Colville N.F. It was a major serai tree under the natural fire regime of periodic large stand-replacing fires. Following the introduction of white pine blister rust early in this century, western white pine mortality (accompanied by timber harvest) has been so great in natural stands that the species now plays a minor role in natural succession in areas where it formerly was an important component. This same pattern is now also occurring in whitebark pine *(Pinus albicaulis)* stands across much of the Pacific Northwest (Keane and Arno 1993), including the Colville N.F.

CLASSIFICATION CONCEPTS AND DEFINITIONS

Plant community classification consists of grouping a potentially infinite number of stands into a relatively few classes, groups, or types that can be more easily comprehended. Individual members of types should be more similar to each other than they are to members of other classes. The definition of types gives a "pigeon hole" into which information applicable to all members of a type can be placed. Therefore the classification in this guide should be viewed as an information storage and retrieval system where the units characterize conditions important for vegetation development. The development of classes or types involves an abstraction from reality. The sampled stands are real entities but grouping them into a class or type places them into an abstract, conceptual framework. Since classes are abstractions, a variety of different types of classification are possible. As the purposes of classification change, so may the classification.

Plant communities present after a relatively long period of time (approximately 300 years in our experience) under relatively consistent climatic conditions while free of disturbance and with stable composition have manifested their ability to exist under competition over time. These communities are termed plant associations and represent the potential climatic climax (Tansley 1935) plant community. The plant association (climax plant community) is an abstraction but it is useful as a reference point for plant succession and as a indicator of environmental diversity. Whether or not the "climax" community will ever develop on a site given the periodicity of disturbances is of minor consequence. What is important is that the association provides a conceptual end-point to plant succession and gives an indication of the direction of succession.

The concept of a climax dominant tree series is used in the same sense as Daubenmire (1968) where all associations capable of supporting a given climax tree species form a series. The series is named for the most shade tolerant and environmentally demanding tree species capable of reproducing itself. The series concept is useful even though it may be difficult to apply in some instances. It is meaningful to discuss the Western Hemlock Series as distinct from the Douglas-fir Series because of important differences in environments and plant communities encompassed by each. Single species names for tree series are used in this classification, but it is recognized that single species dominance may be an exception rather than a rule. Current stand dominants are often of minor value in determining the series.

Daubenmire (1968) used association as the climax plant community and habitat type as the land area that supports or may support a particular plant association. This very useful concept of habitat type has been used in many parts of the west (see Clausnitzer and Zamora 1987, Cooper *et al.* 1991,

Hoffman and Alexander 1976, Pfister *et al.* 1977 and Steele *et al.* 1981). Unfortunately, the term "habitat type" or more often "habitat types" is often applied by biologists to mean "types of habitat" used by wildlife. Therefore, the term "plant association" is used to represent the climax or assumed climax plant community and the land area it may occupy as the "habitat" or" site" to avoid the confusion around the term "habitat type". Habitat type is used in this guide in the same sense of Daubenmire (1968).

The term "community type" is used for plant communities where climax status is not known or reasonably inferred. In this context, five important upland forest tree series, 33 plant associations and four community types are defined in this guide. Whether plant associations occur as discrete entities or not has been a subject of considerable debate (Cottam and Mclntosh 1966, Daubenmire 1966). However, regardless of philosophy, even if a vegetation continuum exists it must still be subdivided into discrete units to make it comprehensible. Very often, the differences between various classifications reflect "where" and "how" the individual researchers decided to split these environment gradients.

METHODS

Field

As part of a larger vegetation classification effort on National Forest lands in eastern Washington State, reconnaissance sampling of the Colville National Forest took place in 1980 and intensive sampling in 1982 and 1983 . A total of 282 reconnaissance and 229 intensive plots form the data base for this report. Approximately 1,090,000 acres are administered by the Colville National Forest. This equates to a sampling intensity of approximately one plot for every 2,100 acres whereas the Daubenmires* (1968) sampling intensity as reported by Cooper *et al.* (1991) is about one plot for every 128,000 acres. Because of the size of the area it was first sampled with a reconnaissance technique. This sampling developed familiarity with vegetation patterns and variability and was used to develop preliminary plant community groups as a stratification to plan intensive sampling. Reconnaissance sampling methods were adapted from Franklin *et al.* (1970), Pfister *et al.* (1977) and Williams (1978). Plot size was from Pfister *et al.* (1977) and was a 375-square-meter circular plot.

Plots were selected "subjectively without preconceived bias" (Mueller-Dombois and Ellenberg 1974). Plots were located within homogeneous stands with uniform undergrowth, and apparent lack of recent disturbance. Random or systematic sampling techniques were rejected as too time consuming and inefficient. Most plots were located near roads to reduce travel time and were marked with aluminum tags to aid relocation. Reconnaissance data included information on slope, aspect, elevation, slope position, slope shape, and geographic location. A species list was made within the circular plot and foliar cover estimated for herbs, shrubs, tree understory and tree overstory by species. Foliar cover was estimated to the nearest 1% for values under 10% and to the nearest 5% for values above 10%. Tree cover was subdivided into mature and decadent categories in the tree overstory, and pole and young trees in the understory.

Reconnaissance plots representative of the variation within each association and throughout its

geographic range were selected for revisiting. This was not to necessarily revisit a specific plot but to more efficiently sample the range of characteristics, locations and conditions of a given association. If the old reconnaissance plot was not quickly located, another suitable stand in the locale was substituted. If stands suitable for sampling were encountered, the crew was flexible to install plots as judgment and experience indicated.

Intensive plot data included everything taken on reconnaissance plots as well as measurements of tree height, diameter at breast height, basal areas, sapwood thickness, and growth rates for five individuals (if possible) of each tree species in the stand. There were a total 1,861 trees sampled on the Colville NF. Additional data were added to some associations from plots located on the adjacent Okanogan N.F. Stand basal areas were measured and herbage production determined. A complete soil profile description was made near the plot center. Data on snags and logs were recorded, and observations on fire scars, wildlife and general stand conditions were also made.

Floristic, snag and log data were taken using the same size plot (375 sq. meters) as the reconnaissance plot, but tree data were taken with dimensionless plot techniques *(e.g.* use of prisms). Sampled trees may have been outside the floristic plot, but all had to be within the plant community the sample was designed to characterize. All plots were marked with aluminum tags and a cedar stake was put at plot center. In addition to the intensive and reconnaissance classification plots, approximately 2,200 Potential Natural Vegetation (PNV) plots were sampled on the Colville N.F. during 1993. These data, collected for vegetation modelling, are used in this guide to augment information about plant association distribution and environmental relationships for plant associations.

Office

Data were entered on a computer at the end of each field season and analyzed. Computer programs used in data analysis included synthesis tables, similarity index, cluster analysis, discriminant analysis (Volland and Connelly 1978), two way indicator species analysis (TWINSPAN) (Hill 1979b) and detrended correspondence analysis (DECORANA) (Hill 1979a). Synthesis tables and DECORANA were used most often in the analysis.

Initial groupings were based upon climax tree series. Plot data unassignable to a tree series were analyzed separately as community types. Secondary subdivisions were made within each tree series by identifying shrubs and herbs, that by their presence or dominance, suggested meaningful vegetation patterns. These floristic units were then examined for consistency in environmental characteristics and productivity estimates. If the floristic pattern appeared related to consistent environmental and productivity characteristics, then the type (association or community type) was described.

The following indices were determined from intensive plot data: Site Index (SI) to estimate height growth. Growth Basal Area (GBA) (Hall 1983) to estimate stockability, and Stand Density Index (SDI) (Reineke 1933) to estimate stand densities. Cubic feet per year productivity estimates were calculated using a combination of Site Index and Growth Basal Area (Hall, personal communication). Clipped herbage was air-dried and weighed to estimate herbage production in pounds per acre. All of these techniques have limitations, but because they were applied consistently to each plot they

provide a reasonable means of comparing plots or associations. They are not directly comparable to estimates based on other methods or indices.

Site index tables and other equations used in our summary tables are included in appendix 2. Many, if not all, site index tables appear to poorly fit our stands. We recognize others may prefer different tables and equations than the ones we employed so our intensive plot data from all 229 intensive plots are available as a computer file. The file is available from the Area II Ecology Program ecologist.

Species Identification and Naming Conventions

The separation between individuals clearly recognizable as "tall" or shiny Oregon grape *(Berberis aquifoliwn)* and those clearly identifiable as "creeping" Oregon grape *(B. repens)* is not clear in much of the material, so they have been lumped into just Oregon grape. Most plants appeared to fit *B. aquifolium* best, though there is considerable variation from plant to plant. Cascade Oregon grape *(B. nervosa)* was in a few plots and was recorded as such.

Big huckleberry *(Vaccinium membranaceum)* and globe huckleberry *(V. globulare)* are morphologically similar species that occur in the study area and are easily confused (Steele *et al.* 1981). Globe huckleberry is more common in the Rocky Mountains and big huckleberry in the Cascade Range. Most of our material seems to better fit big huckleberry so we arbitrarily refer to all plants of this group as big huckleberry. Low huckleberry *{V. myrtillus)* appears at times to intergrade with both big and grouse huckleberry *(V. scoparium).* However, the difference in indicator value of the species is most significant when grouse huckleberry is the only or greatly predominant species. Species identification is normally readily apparent under these conditions.

Pfister *et al.* (1977) indicate most of the spruces in their area are a hybrid complex ofEngelmann and white spruce. The same pattern may be true in our area but we did not collect any cone scale data to prove or disprove possible hybridization. Our material keys easily to Engelmann spruce so we refer to all spruces in our data by that name.

Common names are used in the text for plant species. Plant associations and community types are referred to in the text and tables by capital letter codes. This code is also used for species in some tables because of space limitations. The code is formed by taking the first two letters of each scientific name of a species. For example, the code for *Pseudotsuga menziesii* is PSME. The code occupies less space, is better adapted to computer use and helps distinguish between species and associations in the text. All codes follow Garrison *et al.* (1976). All codes, common and scientific names are presented in appendix 1. Scientific names follow Hitchcock and Cronquist (1973). Common names follow either Garrison *et al.* (1976) or Hitchcock and Cronquist (1973).

In plant association and community type names a slash (/) separates different life forms (trees, shrubs, herbs) *e.g.* PSME/CARU, and a dash (-) indicates members of the same life form *e.g.* PIPO-PSME/ AGSP Most association or community type names are restricted to the major climax tree species and the most indicative shrub or herb for brevity. Some longer names (three species) have been used as needed to avoid confusion.

Association Descriptions and Summary Tables

A map showing plot distribution is provided for each of the plant associations. These distribution maps show locations of ecology classification plots and Potential Natural Vegetation (PNV) mapping plots. The PNV plots were collected for the purpose of modelling vegetation patterns on the Forest, one product of which is the map of Vegetation Zones shown in Figure 4. The PNV plot data was also used in the histogram charts and tables describing environmental characteristics of each plant association. The number of visible plots on distribution maps may not always equal the total number of plots described (n) due to constraints in mapping and digitizing techniques.

Constancy is the percentage occurrence of a species in the plots used to describe a particular association. This is abbreviated as "CON" in many tables The term "mean" indicates the arithmetic average of foliar cover of a species. We consistently use it as "relative mean cover" instead of "absolute mean cover". Relative or "characteristic" cover is the arithmetic average of cover values relative to the number of plots that species occurs in. For example, if a species was found in only five of the ten plots representative of an association the cover value would be that for the five plots it was found in rather than averaged across all ten plots. In this example the constancy would be 50%. A constancy of 100% indicates a species occurred in every plot representative of the association. Cover by species in vegetation layer (tree overstory, tree understory, shrubs, and herbs) was estimated independently. Cover for all species in a particular layer rarely approached 100% because areas without living vegetation were not part of the estimate. Cover was not taken as a proportion of all vegetation. Cover and constancy values calculated for each plant association (including appendix 1) were generated using only ecology classification plot data.

Productivity Information

Summary productivity estimates are given in appendix 2. Productivity estimates for each plant association are relative estimates of site potential A majority of the plots are from mixed species stands and most site productivity estimation techniques are not well suited to multiple species stands. Further, we tried to visit the oldest stands we could find and these types of stands are not well adapted to providing growth estimates. Many, if not all, site index tables poorly fit our stands. Others may prefer different tables and equations than the ones we employed so our data from all intensive plots are available as a computer file. This file includes individual tree measurements for each live tree measured, and snags, and logs by species The file is available from the Area II Ecology Program ecologist. A personal computer program (MS-DOS compatible) is also available that summarizes site index, GBA, and radial increment by species; and SDI, total basal area, snags and downed woody material per acre. These data are also available in a relational data base format.

The summary tables by type were generated using individual plot output from the above computer program as summarized and averaged in a relational data base. Because of different methods of calculating averages *(e.g.* normal means versus weighted means) some figures vary depending upon which computer program was used to summarize the data. The general patterns remain the same between types and species within a type. The data are most useful as relative indices and the absolute values less meaningful.

Management Interpretations

Management interpretations in association descriptions are based on field experience, literature, and interpretation of data. They are subject to modification as data and experience accumulate. This guide will be revised in the future, and user input will be a valuable addition. Management activities often make site identification more complex Site potential may be altered indefinitely or more commonly, interpretation of site potential is more difficult. Use care and judgement in applying interpretations suggested in this or other guides. Events that alter the soil usually have profound and long-lasting effects. Soil erosion, mixing, or displacement can degrade and change site potential. Development of frost prone areas through harvest practices is also an important consideration (Figure 6). Timber harvest or fire will often make a site temporarily drier and warmer because of increased insolation. Absence of these disturbances can have the opposite effect.

Tree species common in late serai or climax stands may be poor selections for planting in the harvested stand or after wildfire. Conversely, moist sites can become swamps because removal of the tree "pumps" can raise the water table Each series, plant association or community type description contains specific information on site characteristics and vegetation. Much of this

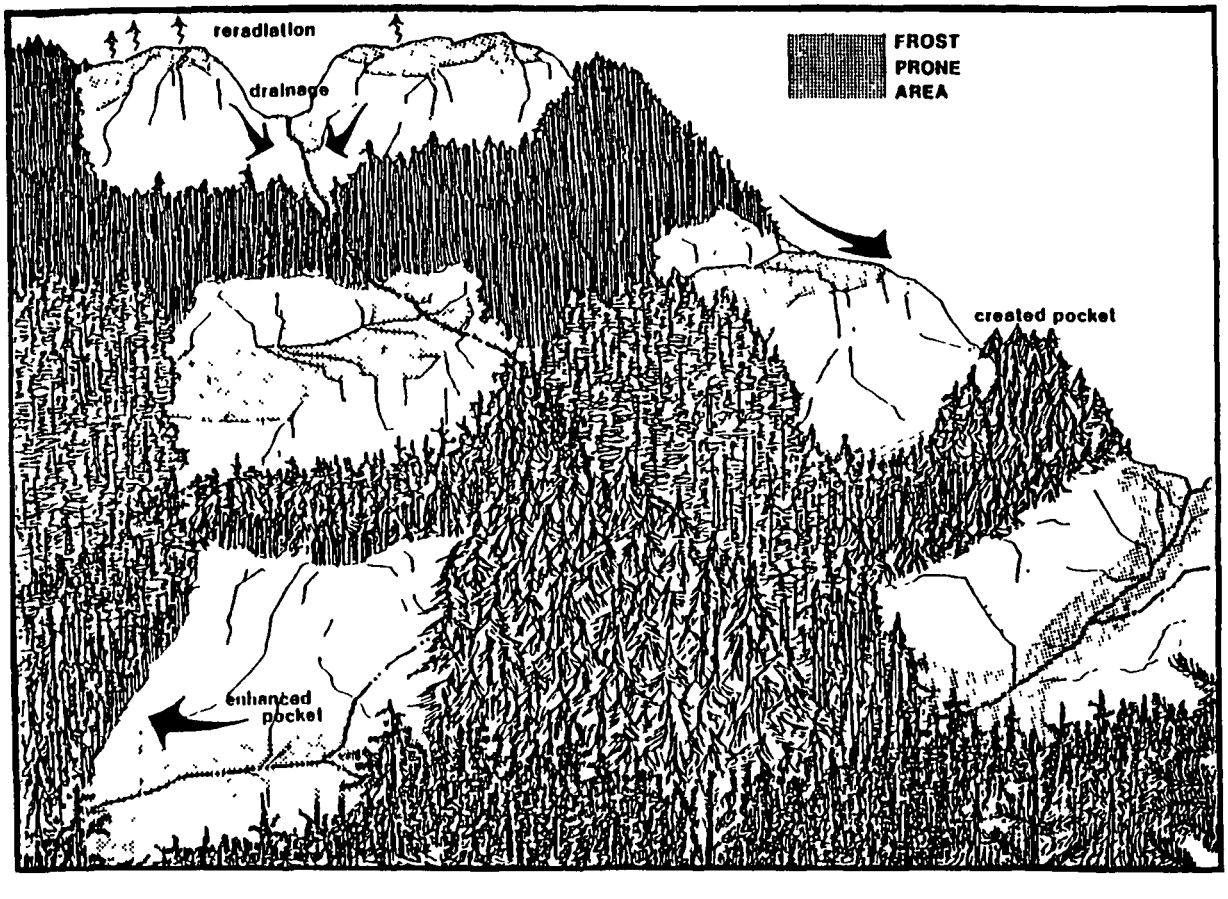


Figure 6. Development of frost prone areas in various topographic positions after clearcutting (Hemstrom *et al.* 1982)

information can be inferred from tables and appendices Accumulated field experience on sites and vegetation responses to treatments can be related to other locations and users by using the classification as a method of indexing information.

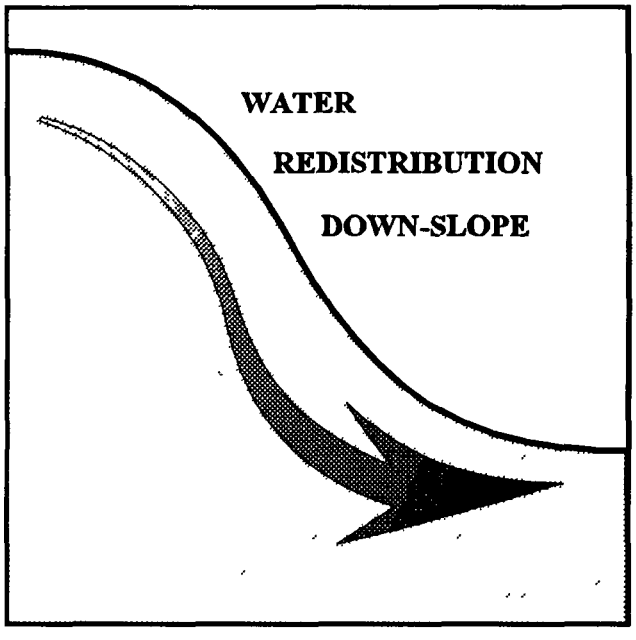


Figure 7. Water moves down-slope under the effect of gravity (Henderson *et al.* 1992).

Topographic Moisture

Topographic moisture is a concept used to describe and analyze the movement or redistribution of water by gravity through the soil and bedrock (Henderson *et al.* 1992). For any mountain slope, precipitation falls more or less evenly as snow or rain. Any unevenness of precipitation is due mostly to wind and the orographic effect of mountains. However, this effect is small relative to the redistribution of water once it is intercepted by the ecosystem. As precipitation is absorbed by litter or soil, it is immediately affected by the downward pull of gravity. The water in the soil that is free to move is therefore redistributed downward from ridgetops, steep slopes and convex surfaces to lower slopes, toeslopes and valley bottoms (Figure 7) The result of the redistribution of soil water by

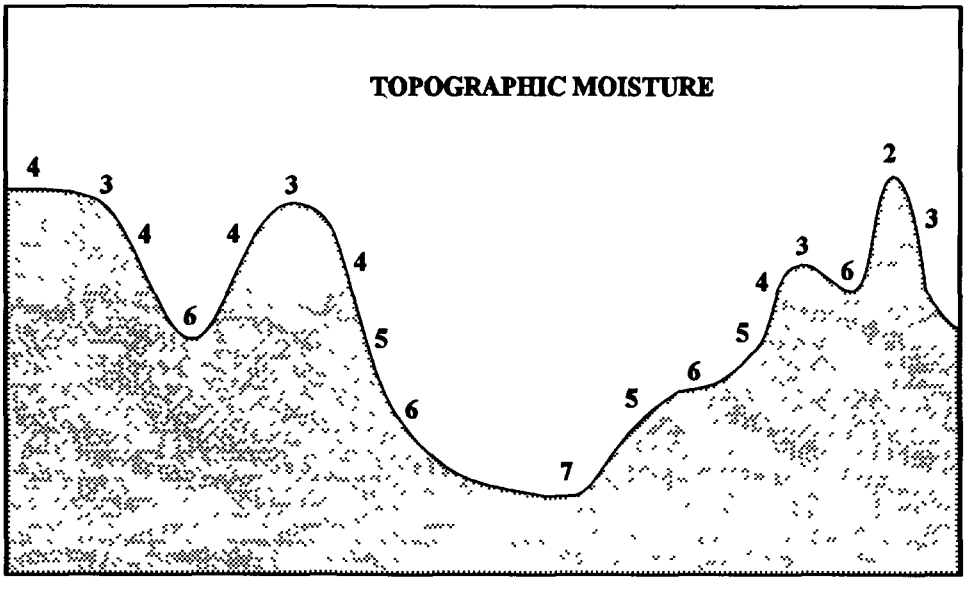


Figure 8. The topographic moisture scale relative to a schematic landscape (Henderson *et al.* 1992)

gravity is called "topographic moisture". We use a scale from one to nine to quantify the relative effects of this redistribution of soil water, where a "1" represents a very dry site where water immediately begins moving downhill. At the other extreme is code "9" which represents a body of open water. Code "5" represents a modal site where the effect of topography results in neither an accumulation nor deficit of soil water. Codes "3" and "4" are dry forest sites while codes "6" and "7" represent moist forest sites This coding system is illustrated in Figure 8. Use of the topographic moisture concept allows one to quantify yet another of the important variables *(e.g.,* aspect, slope, elevation) which influence vegetation distribution across a landscape. The relationships of the different tree series with elevation and topographic moisture is shown in Figure 9. The graph shown in Figure 9 was generated using only PNV plot data. No reconnaissance or intensive plots were coded for this variable.

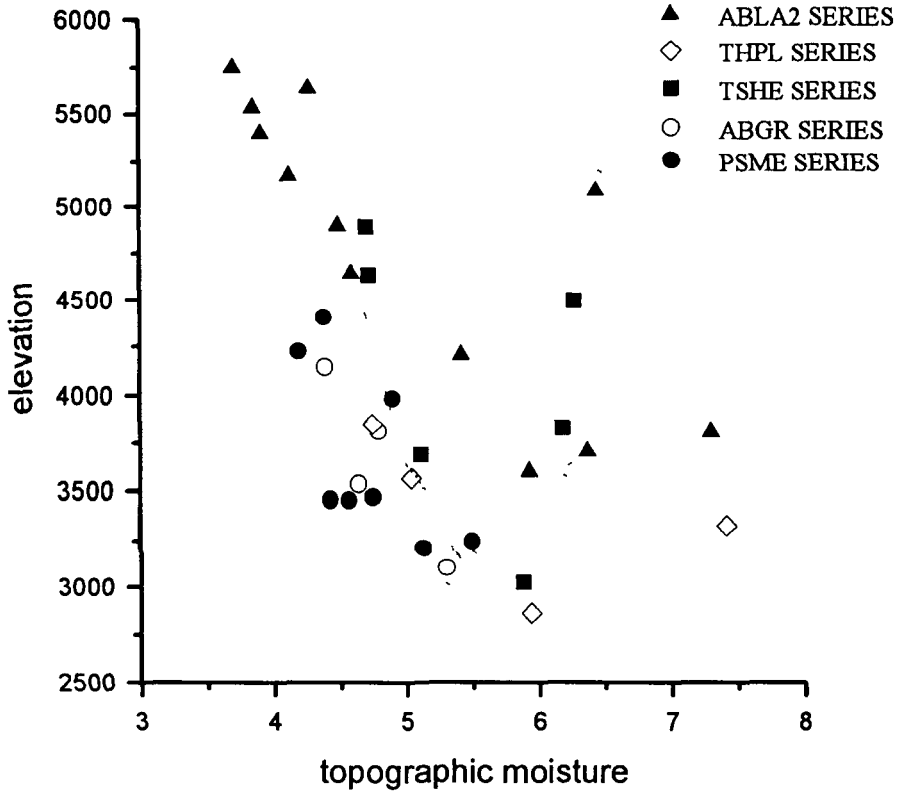
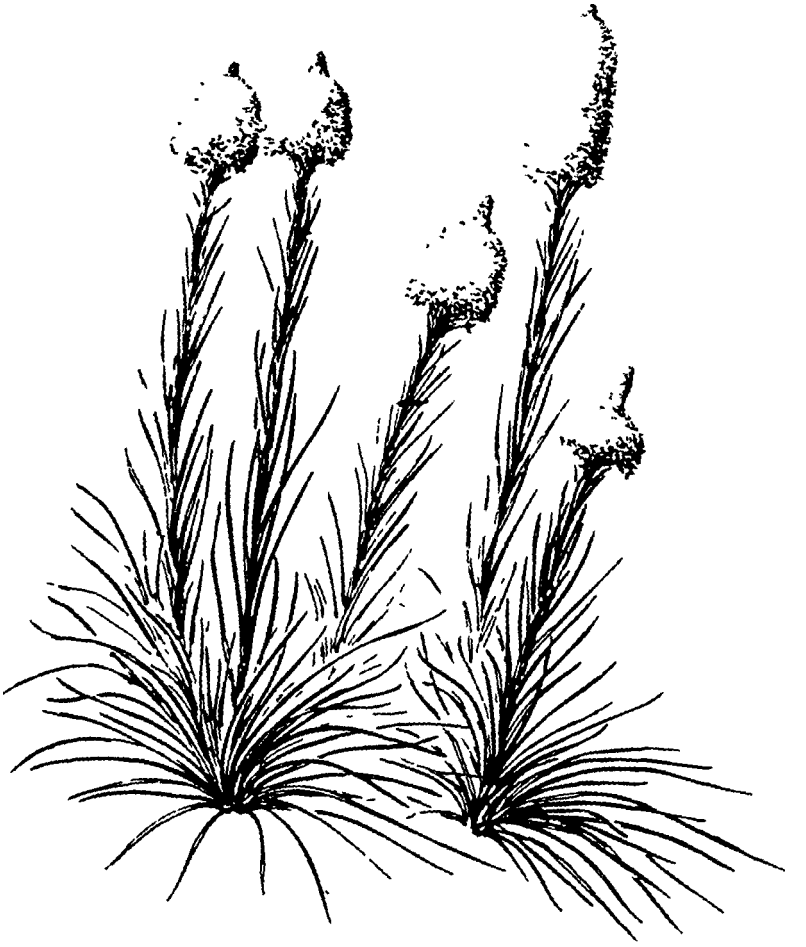


Figure 9. Ordination of plant associations on the Colville N. F. plotted by average elevation and topographic moisture value (based on Potential Natural Vegetation (PNV) plot data).



Using the Keys

The keys presented here are the beginning of the development of uniform keys and plant association descriptions for the forests in eastern Washington (Wenatchee, Okanogan and Colville National Forests). Ultimately, all classifications and vegetation keys for these forests will be combined into one uniform classification that will be consistent across various administrative boundaries.

The keys in this guide were developed using stands with as little disturbance and in as late a successional stage as could be found. As a result, the vegetation keys work best with undisturbed, late successional stands. In disturbed stands, or those under about 150 years in age, it may be necessary to utilize the alternate strategies for stand identification presented for disturbed, early serai or very dense or closed stands. The alternate strategies follow the primary keys.

Remember, the vegetation key is not the classification. It is simply a tool to assist in the identification of the plant community. Not all sites will necessarily key to a type. Some sites may not fit the classification because of data limitations, and complex biological systems are not easily reduced to a few simple classes. Use your best judgement.

Always use the steps below for any keys in this guide. It is important to follow them carefully. *Incorrect identification can lead to improper management interpretations.*

1. **Select a vegetatively uniform area** representative of the community in question to record data on the field form. Plot size for vegetation data should be either 375 square meters or 1/10 acre. The radius of a 375 square meter plot is approximately 11 meters or 36 feet; a 1/10 acre plot has a radius of approximately 11.3 meters, or 37 feet.

2. **Complete the field form** (Appendix 4) before trying to key the stand. Identify and list tree, shrub, and indicator herb species and estimate the cover of each. Cover is estimated to the nearest one percent up to 10 %, and to the nearest 5 % thereafter.

3. **Enter the keys,** and work through the keys step by step, making sure not to skip important choices. Follow the steps below:

   A. Use the Series Key to identify climax tree series from the data on the field form. When using the keys, read each lead as a question. For example, in the Series Key the statement "forests with ^ 10% canopy cover ofsubalpine fir" should be interpreted as, "Is the subalpine fir canopy cover greater or equal to 10% ?". If so, then read to the right, *i.e.*, to "SUBALPINE FIR SERIES". If not, read to the next lead immediately below. When the climax tree series has been identified, go to the Association Key for that series.

   B. Identify the plant association from the data on the field form. For example, the first entry in the key for subalpine fir plant associations reads "horsetail species ^ 5% cover". If this statement is true, then read to the right, *i.e.*, to the PIEN/EQUIS Association. If it is false, go down to the next lead, *i.e.*, to "Cascades azalea and/or rusty menziesia ^ 5%

cover; either singly or in combination".

C. Once a plant association has been identified, carefully read it's description to verify that the type, as identified, fits the narrative. If the type selected does not fit the narrative, review the key to determine if an error was made in the keying process. Further, review the coverage estimates from the field form and determine if, based on any coverage changes, a different association is possible. Often in using classification keys, other types would have been selected had coverage values of species been slightly different. Review those types and compare them with the original selection to determine the best fit. To help correctly identify the stand, make sure to review the cover and constancy values of plant species in Appendix 1.

4. **Resolve unanswered questions** about site identification. If the specific key you are using does not seem to fit:

A. Re-evaluate your choice of climax tree series. Remember, the ^ 10% cover value for tree series is based on stands over 150 years in age. In the majority of stands of this age, the climax tree species will have at least 10% canopy cover. In younger stands, it may be necessary to project the coverage of the potential climax tree species into the future to see if it then would meet the >. 10% cover criterion. The general intent of the Series Key is to determine the most shade tolerant and/or competitive tree with the capability to have at least 10% cover in the stand.

B. For disturbed, early serai or dense stands, use the methodologies outlined below to identify the stand.

DETERMINING PLANT ASSOCIATIONS FOR EARLY SERAL, DISTURBED OR OVERSTOCKED STANDS

1. **Series Identification-** Many forested stands in eastern Washington originated following large stand-replacement fires in the last 100 years. If the stands have well-developed overstories and understories (roughly 30-100 years), there are often enough climax indicator trees to determine the potential tree series. However, it may be necessary to substitute "present and reproducing successfully" for ">. 10% canopy cover" in the Series Key. This closely parallels previous conventions currently being used in keys for existing Area II vegetation classifications.

"Reproducing successfully" is defined as a species apparent ability to reproduce itself successfully under current conditions. It applies mainly to closed canopy conditions. The following conditions should be considered in the evaluation of reproduction success:

A. Trees per acre (an arbitrary starting point is 10 trees per acre- 20 or 30 is even better).

B. Tree health and vigor *(e.g.,* frost or drought intolerance or extreme age relative to size in some species).

C. Tree distribution (*e.g.,* species are not restricted to non-typical micro-sites and belong to more than one size or age-class in the understory).

Sometimes it is possible to use understory shrub and herb species to help determine the climax tree series. For example, the Douglas-fir Series is usually too dry to support either wild sarsaparilla *(Aralia nudicaulis)* or wild ginger *(Asarum caudatum),* so if a stand which is dominated by Douglas-fir also contains more than a trace of these species, the site should be keyed to one of the more moist tree series.

2. Association Identification- Recent disturbance, such as stand-replacement fire, timber harvest or extreme grazing pressure may make it impossible to identify a climax series or plant association using indicator plants. Likewise, early successional (generally less than 30 years old) and overstocked stands can be difficult. Indicator species are often absent in these stands and other approaches must be used:

A. In overstocked stands with a depauperate understory:

1. Lower cover values in the key by one class *(e.g.,* 10% becomes 5%, 5% becomes 2%).

or

2. Use relative rather than absolute canopy covers in the keys *(i.e.,* compare the amount of each species cover to the total cover in the sample plot).

B. Project the stand development forward in time, using knowledge of plant succession for the area; use the projected values in the series and association keys.

C. Look at similar sites in nearby areas that may be more open and/or less disturbed; determine their plant association and compare it to the stand in question.

KEY TO CLIMAX SERIES

Forests with >, 10% canopy cover of western hemlock . . . . . WESTERN HEMLOCK SERIES p. 189

Forests with >. 10% canopy cover of western redcedar . . . . . WESTERN REDCEDAR SERIES p. 231

Forests with >. 10% canopy cover of grand fir . . . . . GRAND FIR SERIES p. 87

Forests with >. 10% canopy cover ofsubalpine fir . . . . . SUBALPINE FIR SERIES p. 115

Forests with ^ 10% canopy cover of Douglas-fir . . . . . DOUGLAS-FIR SERIES p. 34

Forests dominated by lodgepole pine, western larch, quaking aspen
or western birch or whitebark pine with meager evidence of climax tree species . . . . . OTHER VEGETATION TYPES p. 262

OPTIONAL KEY TO CLIMAX SERIES
(disturbed or overstocked early serai stands)

Western hemlock present and reproducing successfully . . . . . WESTERN HEMLOCK SERIES p. 189

Western redcedar present and reproducing successfully . . . . . WESTERN REDCEDAR SERIES p. 231

Grand fir present and reproducing successfully . . . . . GRAND FIR SERIES p. 87

Subalpine fir or Engelmann spruce present and reproducing successfully . . . . . SUBALPINE FIR SERIES p. 115

Douglas-fir or ponderosa pine present and reproducing successfully . . . . . DOUGLAS-FIR SERIES p. 34

Not as above; whitebark pine, lodgepole pine, quaking aspen or western birch dominant
. . . . . OTHER VEGETATION TYPES p. 262

DOUGLAS-FIR SERIES

DOUGLAS-FIR SERIES

Pseudostuga menziesii

PSME

DISTRIBUTION AND ENVIRONMENT

The Douglas-fir Series is found across the entire Colville N. F. (Figure 10), and occupies a wide range of elevations and aspects (Figure 11). Douglas-fir is the climax tree on habitats either too dry for or beyond the geographic ranges of western hemlock, western redcedar, grand fir, and subalpine fir. However, a distinct distribution pattern exists as one proceeds from west to east across the forest. West of the Kettle Mountains, the Douglas-fir Series is the most widespread tree series, and is found from below the Subalpine Fir Series to lower treeline on all aspects (Figure 12). East of the Kettle Mountain Crest, the Douglas-fir Series becomes increasingly restricted to relatively dry habitats on east to west aspects (Figure 12). This is due to the dominance of the grand fir, western hemlock or western redcedar series on the more moist northern aspects.

At low elevations, the Douglas-fir Series grades into non-forest communities or xeric ponderosa pine climax forests. Ponderosa pine stands lacking Douglas-fir in any form are uncommon on Colville N. F. lands, but are more prevalent at lower elevations along the Columbia River. Most ponderosa pine stands will key to the PIPO-PSME/AGSP Association. Clausnitzer and Zamora (1987) and Daubenmire and Daubenmire (1968) describe climax ponderosa pine forests in more detail. The

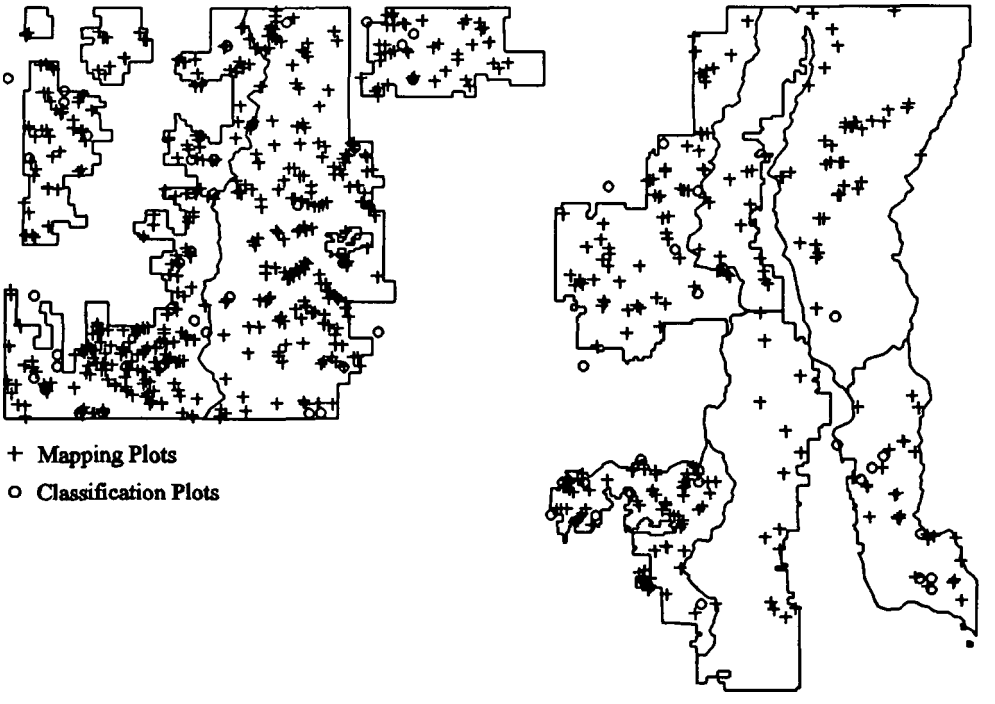


Figure 10. Plot locations for the Douglas-fir Series on the Colville N. F. (n=850).

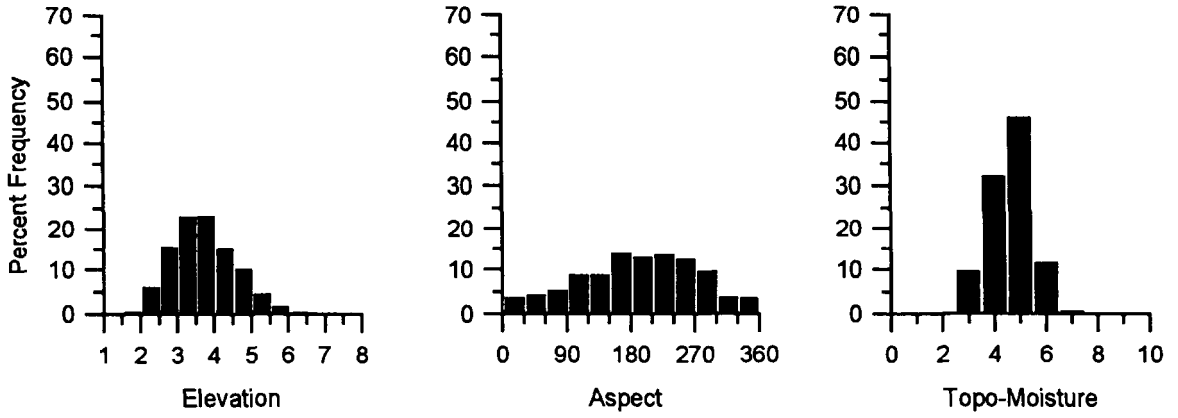


Figure 11. Frequency of Douglas-fir Series plots by elevation (1000 ft.), aspect, and topographic moisture.

Subalpine Fir Series typically forms the upper elevation bound west of the Kettle Mountain Crest. The Grand Fir Series is the common upper elevation bound east of the Kettle Mountains crest.

Seven associations and one community type are described for the'Douglas-fir Series. These include: the PSME/PHMA-LIBOL, PSME/PHMA, PSME/VACA, PSME/SYAL, PSME/SYOR, PSME/CARU, and PIPO-PSME/AGSP Associations and the PSME/VAME Community Type. Some Colville N.F. plots included in the PSME/VAME Community Type may better fit the ABLA2/VAME Association. Some relatively stable early serai stages in the ABLA2/VAME Association are dominated by Douglas-fir and big huckleberry, and early serai stands key with difficulty to the ABLA2/VAME Association. Additional field observations also indicate that the PSME/ARUV Association of Williams and Lillybridge (1983) for the Okanogan N.F. can be found on the Colville N.F., but is an incidental type with a very limited distribution. A description is included for this association under "Other Vegetation Types".

Douglas-fir may occur as a serai species on all but the coldest and wettest forest habitats throughout the Colville N. F. Douglas-fir is often a dominant or co-dominant species in stands of the Western Hemlock, Grand Fir, or Western Redcedar Series. Douglas-fir occurs within all other series described for the Forest.

VEGETATION

Mature forests of the Douglas-fir Series vary from dry, open woodlands to productive, closed forest stands. Ponderosa pine, western larch, and lodgepole pine occur as serai species. Douglas-fir Series' habitats are generally the most xeric found on the Forest, and appear to have greater moisture losses at 12 and 20 in. (30 and 50 cm) depths than habitats in other series. Because the Douglas-fir Series

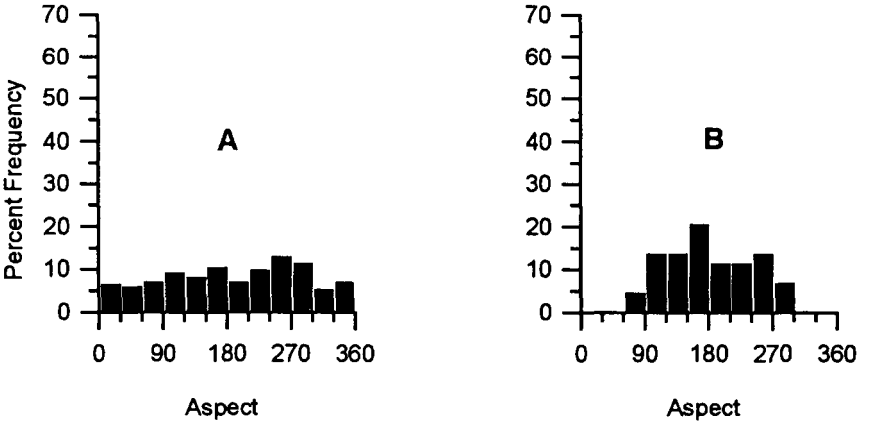


Figure 12. Frequency of Douglas-fir plots by aspect from Republic (A) and Sullivan Lake (B) Ranger Districts.

is the most xeric series found on the Colville N.F., it is easily distinguished from the more moist series by the absence ofmesic site indicators (Table 6). Mesic site indicators, if present, are restricted to moist microsites. The presence of more than trace or accidental amounts of these species indicates environments more moist than that normally encompassed by the Douglas-fir Series. Douglas-fir is the only regenerating tree species widely found in mature stands within the Series. Ponderosa pine regeneration commonly occurs only at the warm end of the Series in the PIPO-PSME/AGSP Association.

The undergrowth of mature stands in this Series is largely shrub dominated with the exception of PSME/CARU or early successional sites. The undergrowth of the driest habitats is dominated by pinegrass swards or bluebunch wheatgrass. Any shrubs in these habitats tend to be prostrate and well hidden by grass. Serviceberry, common snowberry, yarrow, heartleaf arnica, strawberry spp., and pinegrass are the only species present in more than half of the stands. Ninebark, common snowberry, mountain snowberry, oceanspray, and big huckleberry are medium to tall shrubs that can be locally abundant. Pinegrass and the ubiquitous strawberry spp. are the only widespread herbs. Pinegrass is present in at least trace amounts in nearly every stand.

Total species richness and estimated richness are the highest of any single tree series on the Forest (Table 7). However, average species heterogeneity, or N3, is the lowest of all the tree series. This indicates that as a whole, the Douglas-fir Series encompasses a wide array of environments but that most sites are dominated by only a few species. In addition, average richness per plot ranks second only to the Subalpine Fir Series as the lowest on the Forest. These statistics reinforce the interpretation of a wide variety of habitat conditions within the Series, but with strong dominance by only a few species in any one stand. This strong expression of dominance is due, in part, to the segment of the total forested environment of the Colville N.F. that is covered by the Douglas-fir Series. This environment is too dry by definition for many of the other conifer species that the more

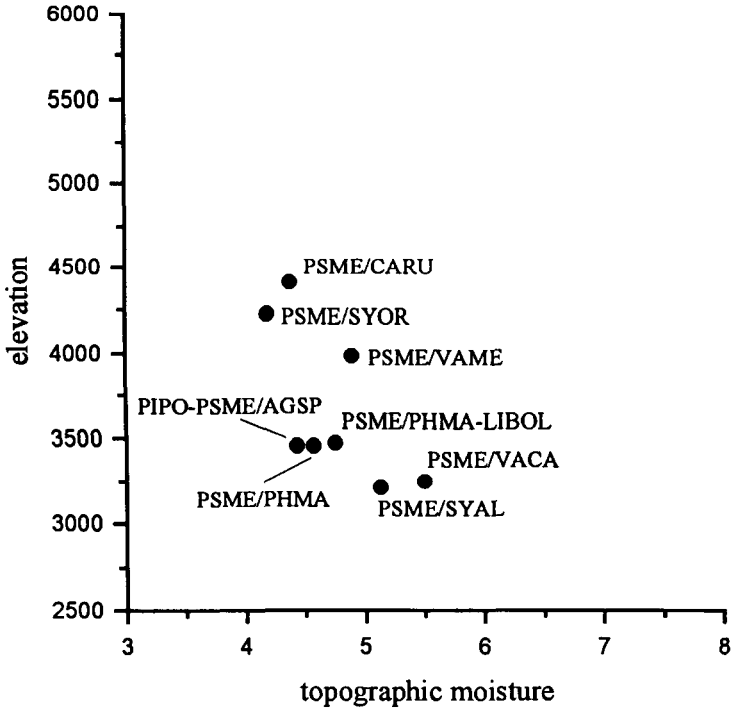


Figure 13. Ordination of Douglas-fir plant associations by elevation and topographic moisture.

mesic series can support. This leads to strong dominance in the overstory, at least, by relatively few tree species.

Four hundred and eighty-nine (489) Douglas-fir trees were sampled on the Colville N.F. (Table 8). Only two trees were over 300 years old (at breast height) when sampled. One was from a PSME/ PHMA Association and the other from an unclassified paper birch *(Betula papyri/era)* stand. Only one tree had an age between 250 and 300 years while 20 were between the ages of 200 and 250 years. Trees over 200 years old were found over a wide range of climax tree series and plant associations.

Western larch is often associated with Douglas-fir but always functions in a early serai role on whatever site it occupies. Three hundred and eighty-five (385) western larch were sampled (Table 8). One was 570 years old, another tree on a different site was 460 years old, with three more trees between 300 and 400 years. Five larch were between 250 and 300 years of age with 31 between 200 and 250 years. Western larch over 200 years old were distributed over a range of tree series and plant associations. Individual tree ages from the same stand may vary by 100 or more years apparently due to repeated fire events.

Western larch is so intolerant of shade as a seedling and sapling that it can successfully regenerate

Table 6. Codes and common names of moist site indicators. More than trace or accidental amounts of any of these species indicates a series other than the Douglas-fir Series.

Code	Common Name	Code	Common Name
TREES			
ABGR	grand fir	PIEN	Engelmann spruce
ABLA2	subalpine fir	THPL	western redcedar
BEPA	paper birch	TSHE	western hemlock
SHRUBS			
COCA	bunchberry dogwood	RUPE	five-leaved bramble
COST	red-osier dogwood	TABR	Pacific yew
MEFE	rusty menziesia	XETE	beargrass
RHAL	Cascades azalea		
HERBS			
ACRU	banebeny	EQUIS	horsetail spp.
ARNU3	wild sarsaparilla	GYDR	oak-fern
ASCA3	wild ginger	LUHI	smooth woodrush
CACA	bluejoint reedgrass	SETR	arrowleaf groundsel
CIAL	circea	TIUN	coolwort foamflower
CLUN	queencup beadlily	TRCA3	false bugbane
DIHO	Hooker fairybells	VASI	Sitka valerian

only after a disturbance such as fire that removes much or all of the forest canopy. Extensive areas of western larch dominated stands of approximately the same age almost invariably have a few scattered older and larger individuals that were the parents of the remainder of the stand. This pattern of a few larch surviving even intense fires can be observed on the White Mountain Fire of 1988. With the heavy seeding of domestic grasses over much of that fire area it is too soon to tell how well western larch will establish and compete.

FIRE ECOLOGY

The predominance of young Douglas-fir trees and stands on the Colville N.F. indicates that fire has been a common event. Reported fire-return intervals for the Douglas-fir Series range from 10 (Hall 1976), 7-11 (Wischnofske and Anderson 1983), and 10-24 years (Finch 1984). Though mature Douglas-fir are relatively fire-resistant, saplings are very susceptible to ground fire due to thin bark, thin bud scales and resin blisters (Smith and Fischer 1995). Amo (1988) reports that it takes approximately 40 years for fire-resistant bark to develop on Douglas-fir trees, with 6" DBH trees

Table 7. Diversity components of the Douglas-fir Series.

Richness[1]	259	
Number of associations	7	
	Mean	S.E.[2]
Expected richness[3]	319.6	11.5
Expected N2[4]	10.3	0.6
Average richness per plot	23.9	0.6
Average N2 per plot	6.6	0.2

[1] Total number of vascular plant species in the Douglas-fir Series data.
[2] Standard error of the estimate.
[3] Jackknife estimate of richness given a sample size of 163 plots

having moderate fire-resistance. Mature Douglas-fir trees exhibit high fire-resistance to low- and moderate-severity fires due to a thick layer of insulative, corky bark. However, the presence of flammable resin streaks on the lower bole of many trees often negates this protection. The probability of fire injury increases with the accumulation of heavy fuels at the base of Douglas-fir trees, including debris from dwarf-mistletoe brooms (Smith and Fischer 1995). Douglas-fir are more susceptible to crown scorch from summer fires than from late-season fires because buds are more vulnerable during summer. Western larch is better able to survive fire of a given intensity because of its thick insulating bark, open non-flammable crown, and deciduous habit. Western larch ages from the Colville N.F. confirm its greater fire resistance.

Low intensity ground fires (underbums) have significantly influenced the development of many stands. Fire-scarred trees were common in classification plots, especially on ponderosa pine and western larch, and frequent underbums favor these two species. Without underbuming they are replaced by the more shade tolerant but less fire resistant Douglas-fir, and potentially some grand fir on wet microsites. Fire effects in the drier Douglas-fir associations with understory dominants like snowberry, pinegrass, and bluebunch wheatgrass have evolved with frequent low-intensity fires which kept these forests open and park-like, with ponderosa pine as a serai dominant (Agee 1994). This is especially characteristic of the PIPO-PSME/AGSP, PSME/CARU, and PSME/SYOR Associations.

Occasional longer fire-free periods seem to be associated with an increase of Douglas-fir on these sites (Keane *et al.* 1990). With fire-return intervals of less than 20 years, computer simulations (Keane *et al.* 1990) suggest that the Douglas-fir component was essentially eliminated or kept to a minimum in stands due to it's low fire-tolerance when young, but that Douglas-fir becomes a co-dominant with ponderosa pine and western larch with longer fire-return intervals. Thus, many stands today likely have a much higher component of Douglas-fir than historical (prior to modem fire suppression) stands.

Table 8. Distribution of sampled Douglas-fir and western larch trees among forest types.

	Tree Species	
Forest Type	Douglas-fir	Western larch
Douglas-fir Series	212	64
Grand Fir Series	50	28
Subalpine Fir Series	80	133
Western Hemlock Series	57	91
Western Redcedar Series	85	54
Paper Birch stand	5	
Lodgepole Pine stands		15
Total Trees Sampled	489	385

Douglas-fir associations that contain dense shrub layers typically exhibit a moderate-intensity fire regime, resulting from a mix of low-intensity and high-intensity fires (Agee 1994). Douglas-fir associations such as PSME/PHMA, PSME/PHMA-LIBOL, PSME/VAME, and PSME/SYAL all may have dense shrub layers which provide ladder fuels for fires to reach tree crowns. Most Douglas-fir stands in reality probably show a mix of different fire-return intervals and intensities. Although stand-replacement fires were significant ecological factors of the past, the potential for catastrophic fire has increased because of increased ground and ladder fuels as dense Douglas-fir stands develop in the absence ofunderbums. Understory fuels tend to increase both horizontally and vertically in many Douglas-fir stands when low-intensity fire has been excluded. Thus, by altering natural fire regimes and subsequently, plant community composition and/or structure, there now exists a higher potential for stand-replacement fires in much of the Douglas-fir Series than existed historically (prior to modem fire suppression). Diversity in stand structure and composition has also increased.

INSECTS AND DISEASE

Associations located on the drier aspects, particularly on the convex south to southwest aspects at low elevations, were historically dominated by serai ponderosa pine. Fire suppression has allowed Douglas-fir to expand on these drier sites, which pose the greatest risk for insect and disease problems (Flanagan and Hadfield 1995). Douglas-fir dwarf mistletoe arguably has more impact in eastern Washington forests than any other insect or disease (Flanagan and Hadfield 1995). Douglas-fir is killed more readily by dwarf mistletoe than any other conifer. This disease has the greatest impact on dry sites in the Douglas-fir series, because the upward spread of dwarf-mistletoe exceeds the growth rate of the host. As previously mentioned, fuel ladders become more significant as Douglas-fir dwarf mistletoe cascades downward in the crown. Reducing incidence of dwarf mistletoe

is an effective method of reducing other disease risks. If a low-level of dwarf mistletoe is acceptable or desirable, distribution of this disease should be restricted to islands of infestation rather than a uniform distribution.

Dry Douglas-fir plant associations are also most at risk of western spruce budworm outbreaks, meaning an outbreak is most likely to begin on those sites (Flanagan and Hadfield 1995). These sites historically (before modem fire suppression) were dominated by serai ponderosa pine. However, the most impact from these outbreaks is usually incurred on more mesic sites within both the Douglas-fir and Grand Fir Series. The Republic Ranger District was probably far less susceptible to budworm outbreaks before fire suppression and selective harvest of serai species such as ponderosa pine. Other areas on the Colville N.F. are becoming more susceptible to budworm, such as the southern Colville Ranger District east ofChewelah.

Douglas-fir tussock moth outbreaks historically began on the driest Douglas-fir sites (Williams *et al.* 1980). Outbreaks quickly spread through host types, including subalpine fir. Mortality is higher in a tussock moth outbreak than a budworm outbreak due to more extensive defoliation of crowns. Some entomologists feel that outbreaks occur in rather predictable cycles; others feel that stand conditions, climate, and the presence of a naturally occurring lethal virus determine outbreak frequency. When they occur, Douglas-fir beetle outbreaks are usually small, local events associated with fire injury, defoliation, drought, root disease, dwarf mistletoe and windthrow.

Douglas-fir is host to a variety of fungal pathogens. Laminated root rot is the most damaging root disease of Douglas-fir, and incidence is highest in both the Douglas-fir and Grand Fir Series (Flanagan and Hadfield 1995). Laminated root rot spreads almost exclusively via root to root contact, so todays disease centers are also the historic centers. The increase in the abundance of susceptible hosts this century allows the disease to spread more readily. Douglas-fir is also very susceptible to and is severely damaged by armillaria root disease. However, incidence is perhaps highest in the Grand Fir Series. Infection rates by armillaria root rot are relatively high in undisturbed Douglas-fir stands and is much higher than in undisturbed stands of the Western Hemlock, Western Redcedar, or Grand Fir Series. Host susceptibility is reduced on more productive habitats. Relatively low productivity sites have much higher overall mortality but lower overall incidence of the pathogen (McDonald *et al.* 1987a). *Schweinitzii* root and butt rot is common in remnant Douglas-fir, and incidence is probably highest in the wetter grand fir sites (Flanagan and Hadfield 1995). Douglas-fir beetle outbreaks are usually small, local events associated with fire injury, defoliation, drought, root disease, and dwarf mistletoe.

MANAGEMENT IMPLICATIONS

Summer soil drought is severe on many Douglas-fir sites. Western hemlock, western redcedar, subalpine fir, and grand fir are unable to successfully occupy habitats within the Douglas-fir Series due mainly to this drought stress. Many herbs and shrubs within the Series are rhizomatous and respond quickly to disturbance. This vegetative reproduction strategy gives species such as pinegrass, northwestern sedge, common snowberry, big huckleberry, and shiny-leaf spirea a competitive advantage over species that rely entirely on seed.

The most widespread types in the series are the PSME/PHMA and PSME/PHMA-LIBOL Associations. These are divisions of a more broadly defined PSME/PHMA Habitat Type of Daubenmire and Daubenmire (1968). The PSME/PHMA type (in the broad sense) is important for the numerous studies done concerning reforestation problems. Recent work by Harvey *et al.* (1987) is especially significant for the insight provided on the essential role of soil wood and soil organic matter in the distribution of tree roots. They report tree roots are almost entirely concentrated in soil wood and other types of organic matter. Mineral soil contained only 4% of the roots while soil wood and organic matter contained 96% of the roots. Soil wood and organic materials made up only 18% of the total available soil. Their results on root distributions and the essential role of organic matter seem equally applicable to the PSME/PHMA-LIBOL and PSME/PHMA types. Clearly, activities that reduce soil organic matter and soil wood reduce site capacity to support trees. Clearcutting combined with burning or scarification often results in extensive and persistent shrubfields that resist reforestation efforts for years. Apparently, the accumulation of sufficient organic matter and soil wood is essential for tree establishment, growth and survival. Shrubfields may be an essential part of the sere, functioning to restore organic matter and nutrients before forest restoration.

Regeneration of Douglas-fir on burned sites is generally best where it grows as a serai species, and is comparably poorer on climax Douglas-fir sites (Smith and Fischer 1995). Organic seedbeds less than 2" thick and mineral soil are most favorable for seedling establishment. On dry south- and west-facing slopes, tree regeneration is improved by shading. Nitrogen is the only nutrient in the Pacific Northwest which has been shown to be limiting to growth of Douglas-fir (Bums and Honkala 1990). Douglas-fir saplings respond satisfactorily to release from competing brush or overstory trees if they have not been suppressed too severely or too long. Trees that have developed in a closed stand, however, are poorly adapted to radical release, such as that occasioned by very heavy thinning (Bums and Honkala 1990). Also, sudden and drastic release of young Douglas-fir may cause a sharp temporary reduction in height growth (Staebler 1956). Douglas-fir represents an important species which is grown for Christmas trees.

COMPARISONS

The Douglas-fir Series has been well described by ecologists in the Pacific Northwest, including eastern Washington and northern Idaho (Daubenmire and Daubenmire 1968), northern Idaho (Cooper *etal.* 1991), Montana (Pfister *et al.* 1977), central Idaho (Steele *et al.* 1981), and northeast Oregon (Johnson and Clausnitzer 1992, Johnson and Simon 1987). In addition, Clausnitzer and Zamora (1987) describe Douglas-fir types on the nearby Colville Indian Reservation. Zamora (1983) also described three Douglas-fir habitat types on the Spokane Indian Reservation. Douglas-fir forms a major forest zone along the entire east slope of the Cascade Range in Washington, and has been well documented by Lillybridge *et al.* (1995). All of the above classifications describe one or more Douglas-fir plant associations which are very similar to the types described for the Colville N.F. Seven "subzones" of Douglas-fir have been described for the southern interior of British Columbia immediately north of the Colville N.F. (Meidinger and Pojar 1991). Coastal populations of Douglas-fir are usually serai components of some of the drier western hemlock and redcedar plant communities from Vancouver Island, B.C., south to northern California. Some small areas of climax Douglas-fir have been described for western Washington by Henderson *et al.* (1989). These sites appear to be

limited to relatively dry areas which are under the influence of a rainshadow-effect caused by the Olympic Mountains.

KEY TO PLANT ASSOCIATIONS IN THE DOUGLAS-FIR SERIES

Before using the key, the field form in Appendix 4 should be completed. Refer to the "USING THE KEYS" section in the introduction for more specific information on using the key, particularly if the stand in question does not key properly.

Ninebark and/or oceanspray >. 5%

Twinflower and/or western larch ^ 1% ..... PSME/PHMA-LIBOL Association p. 61

Twinflower and/or western larch < ! % ..... PSME/PHMA Association p. 55

Dwarf huckleberry >. 5% ..... PSME/VACA Association p. 76

Big huckleberry and/or low huckleberry ^5% ..... PSME/VAME Community Type p. 82

Common snowberry ^ 5% ..... PSME/SYAL Association p. 66

Mountain snowberry ^5% ..... PSME/SYOR Association p. 71

Pinegrass or heartleaf arnica >.5% .... PSME/CARU Association p. 49

Bluebunch wheatgrass ^5% ..... PIPO-PSME/AGSP Association p. 44

PIPO-PSME/AGSP ASSOCIATION CDG3 11

Pinus ponderosa-Pseudotsuga menziesii/Agropyron spicatum
ponderosa pine-Douglas-fir/bluebunch wheatgrass

DISTRIBUTION AND ENVIRONMENT

The PIPO-PSME/AGSP Association is a minor type on the Colville N.F. (Figure 14) and is the hottest and driest plant association described. It is more common and forms more contiguous stands at elevations below that typically found on the Forest. On the forest proper, it generally occurs as smaller, non-contiguous islands of vegetation on well-drained, coarse-textured soils on steep southeast to west aspects (Figure 15) with convex microrelief. Elevations range from 2,160 to 5,860 ft., though most sites are below 4,000 ft. (Figure 15). The type as described here and in the Okanogan N.F. Guide (Williams and Lillybridge 1983) is based on a limited number of plots and is broadly defined. Current data are too limited for further subdivision although considerable variation is recognized. Okanogan N.F. plots are used to augment the data.

The regolith is glacial till or outwash and is often comprised of water sorted, sandy deposits. Soil textures are usually sandy loam to sand. Gravel is common. The type grades into non-forest grasslands and undescribed ponderosa pine climax forests on drier habitats. The type grades into the PSME/SYORU and PSME/CARU Associations on more moist habitats.

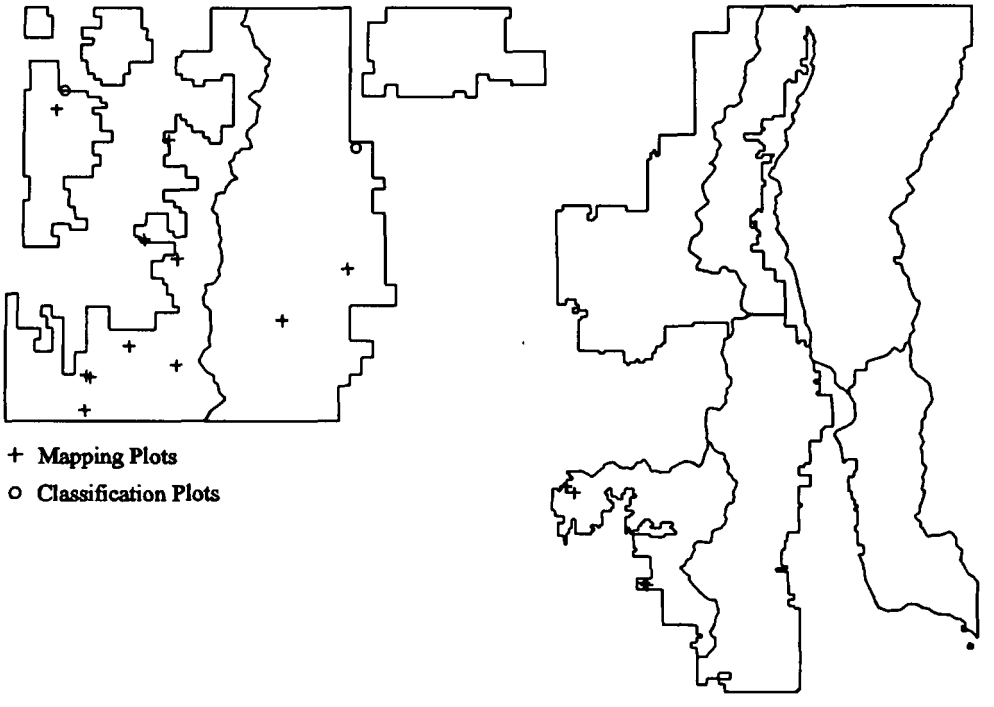


Figure 14. Plot locations for the PIPO-PSME/AGSP Association (n=19).

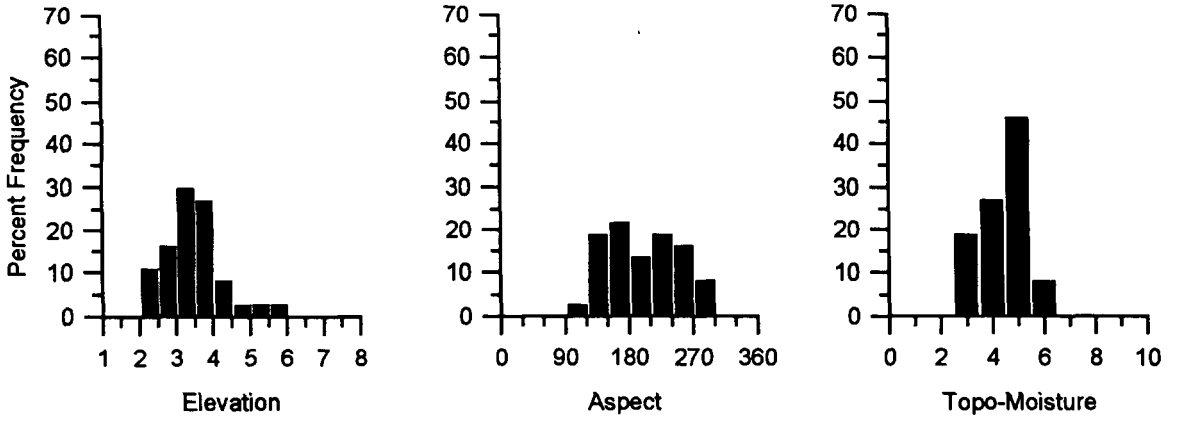


Figure 15. Frequency ofPIPO-PSME/AGSP plots by elevation (1000 ft.), aspect, and topographic moisture.

VEGETATION

These sites are characterized by open woodlands with a bunchgrass-dominated undergrowth. Ponderosa pine or Douglas-fir are the only tree species that occur. Therefore, serai and climax stands have essentially the same tree species composition because strictly serai tree species are lacking. These stands are open and rarely have a closed canopy. Ponderosa pine can reproduce successfully because the open canopy does not produce sufficient shade to exclude it. Most stands have been logged because of land ownership, ease of access and high value on large ponderosa pine.

Bunchgrasses dominate the undergrowth. Shrubs are generally absent or inconspicuous. Bearberry and the semi-shrubby Wyeth buckwheat may be present but usually with sparse cover. Ninebark indicates sites that best fit the PSME/PHMA Association. Bitterbrush is absent

Table 9. Common plants of the PIPO-PSME/AGSP Association (n=5).

		CON	COVER
TREE QVERSTQRY LAYER			
PIPO	ponderosa pine	100	29
PSME	Douglas-fir	80	8
TREE IJNDERSTORY LAYER			
PIPO	ponderosa pine	80	4
PSME	Douglas-fir	80	2
HERBS			
ACMI	yarrow	100	3
AGSP	bluebunch wheatgrass	80	33
LUSE	silky lupine	80	13
BASA	arrowleafbalsamroot	80	12
FEID	Idaho fescue	80	7
KOCR	Junegrass	80	2
CARU	pinegrass	60	7
ANRO	rosy pussytoes	60	3
ANLU	woodrush pussytoes	60	3
BRTE	cheatgrass	60	2
CARO	Ross sedge	60	1
AGIN	awnless b.b. wheatgrass	20	35

Table 10. Environmental and structural characteristics of the PIPO-PSME/AGSP Association.

	Mean	S.D.	Min	Max
Environment[1]				
Elevation	3457	772	2160	5860
Aspect[2]	165	46		
Slope	41	16	6	82
Topographic Moisture	4.43	0.90	3.0	6.0
Soil Surface[3]				
Exposed soil	18	16	3	35
Gravel	20	26	1	38
Rock	4	5	0	10
Bedrock	0	0	0	0
Moss	1	2	0	3
Lichen	1	2	0	3
Litter	40		40	40
Diversity[4]				
Richness	20.8	3.7	14	29
N2	6.1	1.5	4	8

' Values for environmental variables were generated using both classification plot and mapping plot data (n=37).
[2] The mean and standard deviation values for aspect are calculated using statistical formulae for circular data (Batschlet 1981).
[3] Soil surface characteristics in percent cover.
" Richness and heterogeneity, N;, are expressed as average number of species per plot.

from most of the Forest but may have been planted in some areas.

Bluebunch wheatgrass (both awned and awnless subspecies), Idaho fescue, prairie Junegrass, Ross sedge and arrowleaf balsamroot are the most characteristic herbs. Pinegrass indicates somewhat cooler and more moist conditions. Heartleaf arnica and northwestern sedge in combination with pinegrass indicate sites that better fit the PSME/CARU Association. Both average richness and average heterogeneity (N2) are below the Series average and are second only to the PSME/CARU Association as the lowest in the Series on the Colville N.F. (Table 10). These low values reflect the relatively harsh conditions characteristic of these habitats.

MANAGEMENT **IMPLICATIONS**

Wildlife/Range- These are important winter range sites for many species of wildlife, including deer and elk. These sites remain relatively warm and snow-free most of the winter. Browse production is generally low, but warm exposures encourage frequent use. Many non-migratory avian species

Figure 16. Photo of the PIPO-PSME/AGSP Association.

make extensive use of these stands in winter as well. The type is valuable for livestock forage. High cheatgrass cover and an abundance of other annuals combined with reduced bunchgrass cover indicates past overgrazing. Silky lupine and arrowleaf balsamroot may increase under grazing pressure. Management of livestock should be keyed mainly to the sensitivity of bluebunch wheatgrass. This is true even with significant amounts of Idaho fescue because; 1) Idaho fescue is not as sensitive to abusive grazing as bluebunch wheatgrass, and 2) Idaho fescue is often grazed by cattle before they start on bluebunch wheatgrass. The high quality of Idaho fescue as forage should be considered in management. Both bluebunch wheatgrass and Idaho fescue are most sensitive to heavy defoliation at approximately the same growth stage: from flowering to seed ripening (Mueggler and Stewart 1980). The calendar dates of the sensitive growth stages of these two important forage grasses coincide reasonably well, which simplifies management (Mueggler and Stewart 1980).

Grazing also decreases fine fuels and increases tree regeneration (Amo and Gruell 1986). Gruell *et al.* (1986) recommend restriction of grazing for at least one year after burming in order to develop sufficient fire fuel to carry a fire. According to Heidman (1988), successful regeneration requires the elimination of all grazing for several years after planting. Heavy grazing may aid tree establishment by reducing grass competition if not accompanied by an increase in knapweed. Coarse soils are easily displaced on steep slopes. Heavy grazing reduces cover of bluebunch wheatgrass and Idaho fescue.

Arrowleaf balsamroot, yarrow, silky lupine and cheatgrass either increase or become more conspicuous under grazing and diffuse knapweed may increase markedly.

Silviculture- Timber productivity is low due to open stands and slow growth rates. Poor regeneration success is a farther problem. Reforestation is difficult to assure within 10 years because of drought and heat stress. Natural regeneration may take as long as 20-40 years (Pfister *et al.* 1977). Stocking should be open to favor more rapid tree growth and reduce the possibility of stagnation. These habitats are sufficiently harsh to prevent closed canopies except on local microsites. Site preparation by broadcast burning recycles nutrients and helps to control the severe competition for moisture typical of these sites (Ryker and Losensky 1983). Because soils tend to be thin and rocky, disturbance should be minimized to reduce the risks of erosion. Preventing the introduction or spread of noxious weeds such as diffuse knapweed are a management concern on disturbed sites.

Mature trees often have fire scars. Fire scar patterns suggest a natural fire interval of 5-30 years. Fire helps maintain the large, open grown, ponderosa pine characteristic of the association. Prescribed fire may be used to enhance forage, maintain healthy, open stands, reduce fuels and encourage regeneration (Smith and Fischer 1995). These conditions discourage the spread of dwarf mistletoe and enhances ponderosa pine growth, which in turn discourages mountain pine beetle infestation. Periodic underburning or some method of stocking level control is needed to grow large trees on these sites. Underburning can also be used to encourage ponderosa pine regeneration and remove Douglas-fir. After saplings are over 12' tall, some can withstand fire. Regular underburning then can be used for thinning, to remove farther reproduction, and to reduce accumulated woody fuel and duff (Smith and Fischer 1995). Opportunities for prescribed burning occur before greenup and in late spring.

COMPARISONS

Lillybridge *et al.* (1995) describe several dry PIPO and PSME associations for the Wenatchee N.F. which would collectively belong in this type. The PSME/AGSP Association described for the Wenatchee N.F. seems most similar to the Colville type. The PIPO-PSME/AGSP Association is very similar to the PIPO-PSME/AGIN Association described for the Okanogan N.F. (Williams and Lillybridge 1983). The subspecies of bluebunch wheatgrass changes in dominance from west to east. The awnless subspecies (var. *inerme)* is more common in Okanogan County and adjacent Ferry County than is the awned subspecies (var. *spicatum).* Braumandl and Curran (1992), Brayshaw (1965), Lloyd *et al.* (1990) and McLean (1970) all describe several xeric PIPO and PSME associations for southern British Columbia. However, the majority of these associations have tree, shrub or herb layers which differ from those described for the Colville N.F. PIPO-PSME/AGSP Association. Steele *et al.* (1981) describe a PSME/AGSP Association for central Idaho that resembles some of our stands as does the PSME/AGSP Association of Cooper *et al.* (1991) in northern Idaho. Clausnitzer and Zamora (1987) have a PSME/FEED Association that is similar but their type contains more Idaho fescue than the PIPO-PSME/AGSP type. Many researchers describe one or more associations where ponderosa pine is climax and Douglas-fir absent or uncommon. Though some of these stands may resemble Colville N.F. stands in appearance, they differ greatly in composition.

PSME/CARU ASSOCIATION CDG1 31
Pseudotsuga menziesii/Calamagrostis rubescens
Douglas-fir/pinegrass

DISTRIBUTION AND ENVIRONMENT

The PSME/CARU Association is a widespread type on the western-half of the Forest on the Kettle Falls and Republic Ranger Districts (Figure 17). It is also common on the southern-half of the Colville Ranger District. It is uncommon elsewhere on the Forest. It represents relatively cool and dry environments on lower to upper slope positions. It is found on a variety of elevations and aspects. East to west aspects at upper elevations are most common (Figure 18). Elevations range from 1,920 to 6,300 ft., and average 4,406 ft. (Table 12). Though somewhat geographically limited on the Colville N.F., this type has an environmentally broad distribution where it is found. The PSME/CARU Association often represents the upper-elevational limits of the Douglas-fir Series on southern aspects.

The regolith is glacial till or outwash generally comprised of granitic parent material. Soil textures are silt to gravelly loams and sands. Coarse fragments usually comprise less than 50% of the profile. The PSME/CARU Association often grades into the PSME/PHMA or PSME/PHMA-LBOL Associations on warmer sites and into the ABLA2/CARU Association on colder sites. The

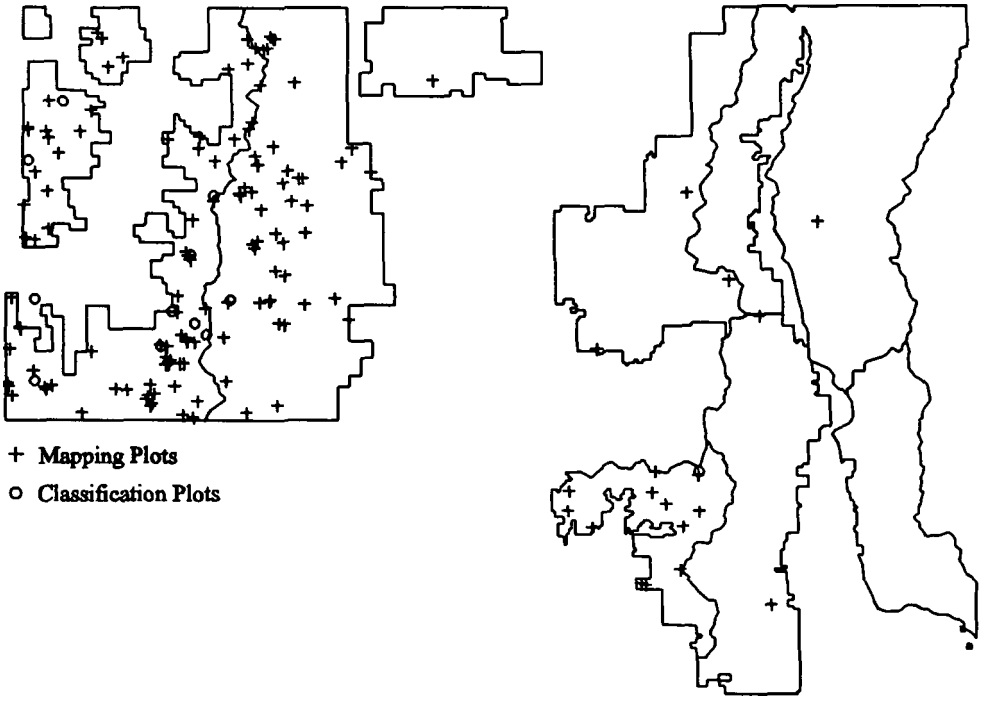


Figure 17. Plot locations for the PSME/CARU Association (n=161).

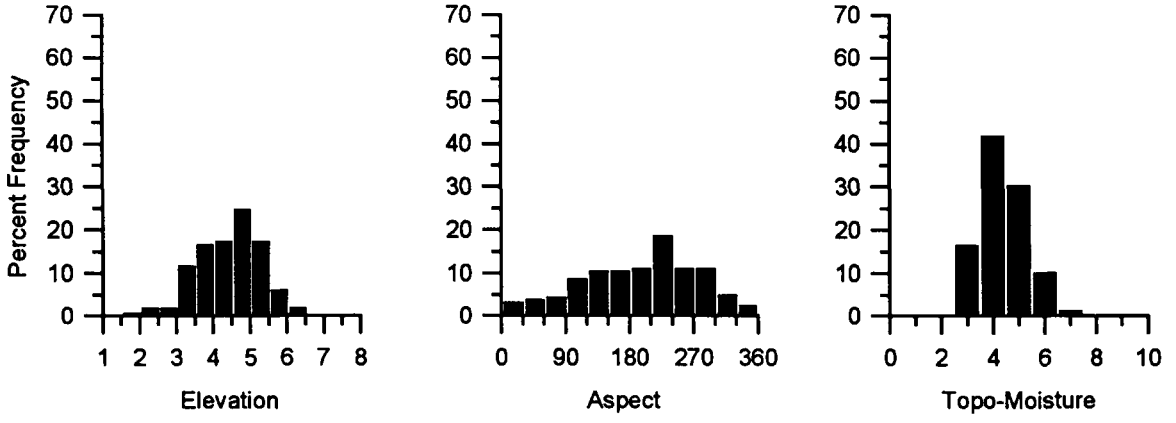


Figure 18. Frequency ofPSME/CARU plots by elevation (1000 ft.), aspect, and topographic moisture.

PSME/SYOR Association occasionally adjoins it on more wind prone locations. Frosty, more moist habitats are usually occupied by the PSME/VACA Association.

VEGETATION

Douglas-fir and pinegrass typically dominate these habitats. Stands with vegetative commposition reflective of late serai conditions are more common in the PSME/CARU type than any other type. Even relatively young stands may develop species compositions similar to climax or late serai conditions. Stands with only Douglas-fir in the tree layer are not unusual. The apt description ofDaubenmire and Daubenmire (1968) "A brilliant green sward, the uniformity of which is enhanced by the notable lack of inflorescences and the uniform spacing of grass tillers..." under a canopy of Douglas-fir captures the characteristic appearance of mature stands.

Table 11. Common plants of the PSME/CARU Association (n=42).

	CON	COVER
TREE OVERSTORY LAYER		
PSME Douglas-fir	98	29
LAOC western larch	62	17
PIPO ponderosa pine	52	18
TREE IJNDERSTORY LAYER		
PSME Douglas-fir	95	8
SHRUBS AND SIJBSHRIJBS		
PAMY pachistima	52	3
ARUV bearberry	52	3
HEBES		
CARU pinegrass	100	46
FRAGA strawberry spp.	74	3
ARCO heartleaf arnica	62	4
ACMI yarrow	60	2

Ponderosa pine is an important serai species in the lower, warmer stands under 4,000 ft. (1220 m) elevation and may dominate these sites, but is much less common at higher elevations. Western larch and/or lodgepole

Table 12. Environmental and structural characteristics of the PSME/CARU Association.

	Mean	S.D.	Min	Max
Environment[1]				
Elevation	4406	852	1920	6300
Aspect[2]	209	70		
Slope	33	15	1	66
Topographic Moisture	4.38	0.92	3.0	7.0
Soil Surface[3]				
Exposed soil	16	18	1	50
Gravel	16	16	1	38
Rock	6	10	0	38
Bedrock	0	1	0	5
Moss	1	1	0	2
Lichen	1	1	0	2
Litter	34	27	0	80
Diversity[4]				
Richness	18.6	6.4	8	35
N2	4.5	1.6	1	11

[1] Values for environmental variables were generated using both classification plot and mapping plot data (n=162).
[2] The mean and standard deviation values for aspect are calculated using statistical formulae for circular data (Batschlet 1981).
[3] Soil surface characteristics in percent cover.
[4] Richness and heterogeneity, N2, are expressed as average number of species per plot.

pine may dominate stands originating from stand-replacement fire. Lodgepole pine may be an early and long-lasting serai species on the cooler, high elevation sites on gentle terrain. Very old individuals of fire-resistant ponderosa pine and western larch are common in this type.

Pinegrass is the major herb species and characteristically forms a dense sward in the understory. Shrubs are minor stand components except in early serai stages. Snowbrush ceanothus may be abundant for the first few decades after fires. Pachistima, spiraea or snowberry may be locally common in some stands. Bearberry suggests rockier sites than normal and some sites with high bearberry cover and little pinegrass may better fit the harsh PSME/ARUV Association described for the Okanogan N.F. (Williams and Lillybridge 1983).

The average richness and average heterogeneity (N3) are among the lowest of all associations for the ColvilleN.F. (Table 12). The low heterogeneity index indicates strong dominance by relatively few species. This agrees with visual impressions of mature stands where only Douglas-fir and pinegrass appear to be present. These low values reflect the relatively harsh conditions indicated by the type. The PSME/ARUV type (Williams and Lillybridge 1983) has lower values still, so the cautionary notes

Figure 19. Photo of the PSME/CARU Association.

about bearberry mentioned above need to be kept in *mind.*

MANAGEMENT IMPLICATIONS

Wildlife/Range- Big game and domestic cattle may make heavy seasonal use of these sites. Mature stands provide moderate forage for wild and domestic ungulates. Early serai stages may have a tall shrub component (ceanothus, Scouler willow) useful as browse and cover. Serai stands that contain Ceanothus, Scouler willow, and aspen are very important to deer and elk. In some areas, these sites are important for elk calving. Old-growth stands are important nesting sites for Stellarsjay, western tanager, and pine ciskin. Pileated woodpecker activity is also commonly observed in older stands.

Livestock often make use of these sites. Herbage production can be relatively high but tends to decrease as soil coarse fragments or tree overstory increases. Pinegrass is grazed well by cattle, and is not avoided in our stands to the extent it is in the Blue Mountains of Oregon. It often shows appreciable use even in areas with palatable seeded species. Pinegrass is relatively resistant to trampling damage.

Silviculture- Timber productivity is relatively low compared to other associations in the Douglas-fir Series (appendix 2). Considerations for management include competition from rhizomatous species, pocket gophers, wildlife and cattle damage to seedlings, and soil drought. Rummel (1951) points out that forage production and tree regeneration are incompatible goals on these sites. The best growth potential is usually seen with ponderosa pine located in the drier extremes of this type. Erosion control is rarely needed because of the characteristically abundant pinegrass. Coarse soils may be displaced by heavy equipment on steep slopes.

Herbaceous competition with young trees can be severe, especially on clearcuts. Prompt regeneration after harvest is essential to decrease pinegrass competition. With overstory removal, pinegrass may develop a thick sod which may require a special treatment to establish conifers. Moderate scarification combined with burning can also stimulate pinegrass. Regeneration is usually better in shelterwood cuts of 10-30 trees/acre than in clearcuts (Steele and Geier-Hayes 1993). Shelterwoods provide shade essential for successful reforestation. Shelter is particularly important on south and west aspects. Clearcutting and shelterwood systems will favor the serai species, while partial cutting will lead to eventual dominance by Douglas-fir (Pfister *et al.* 1977). Douglas-fir regeneration is enhanced if large woody debris remains on the site or if shrub cover develops to shelter the seedlings. Scarification can decrease early shrub and grass competition, but may increase erosion potential and pocket gopher activity (Smith and Fischer 1995).

Vegetation in this association recovers quickly from fire, especially species such as ponderosa pine, pinegrass, ceanothus and Scouler willow. Underburning can help maintain an open forest with a productive sward of pinegrass. Slash from thinning operations can be burned without "excessive damage" to reserved trees (Weaver 1968) but drier (1989) cautions that spring fires may cause higher mortality than fall fires because they cause greater damage to the fine roots of the trees. Site preparation by burning has mixed-effects on tree regeneration but appears to enhance subsequent growth substantially. Several studies report that site preparation by fire enhances sapling growth and development and sites tend to have fewer pocket gophers than scarified sites. Broadcast burning enhances natural regeneration of ponderosa pine (Weaver 1968) if a seed source is available within 100 ft. and if 80-90% of mineral soil is exposed (Steele and Geier-Hayes 1993). Burning may set back competing grass species for 1-2 years, providing a short window for seedling establishment. However, severe fire behavior can lead to profuse germination of ceanothus, which could retard tree regeneration. If ceanothus seeds are in the soil, it is possible that fires may create a dominant ceanothus shrub layer for decades (Smith and Fischer 1995). Very hot fires designed to reduce pinegrass vigor may also cause long-term soil damage by reducing soil organic matter and nutrients.

COMPARISONS

The PSME/CARU Association is widespread throughout the Columbia River Basin. Variants described for northern Idaho (Cooper *etal.* 1991, Daubenmire and Daubenmire 1968), central Idaho (Steele *etal.* 1981), Montana (Pfister *etal.* 1977), southern British Columbia (Braumandl and Curran 1992, Lloyd *et al.* 1990, Mclean 1970), northeastern Washington (Clausnitzer and Zamora 1987, Daubenmire and Daubenmire 1968, Williams and Lillybridge 1983, Zamora 1983) and northeastern Oregon (Johnson and Clausnitzer 1992, Johnson and Simon 1987) are some of those available.

Lillybridge *et al.* (1995) also describe similar types for the eastern Cascade Mountains in central Washington.

The Bearberry Phase of the PSME/CARU Habitat Type ofDaubenmire and Daubenmire (1968) is more comparable to our PSME/VACA Association and not PSME/CARU. Sites with bearberry but lacking dwarf huckleberry are considered as a warm dry extension of the PSME/VACA Habitat Type by some authors (Steele and Geier-Hayes 1987). We are uncertain if the same interpretation is always true in our area. Bearberry may occupy very rocky sites dissimilar to PSME/VACA habitats; such rocky sites better fit the PSME/ARUV Association described for the adjacent Okanogan N.F. (Williams and Lillybridge 1983) than the currently described PSME/CARU Association. Some sites similar to the PSME/ARUV Association may be found west of the Columbia River in Ferry and Okanogan Counties *(see* Other/Vegetation Types).

Calamagrostis rubescens
pinegrass

PSME/PHMA ASSOCIATION CDS7 15
Pseudotsuga menziesii/Physocarpus malvaceus
Douglas-fir/ninebark

DISTRIBUTION AND ENVIRONMENT

The PSME/PHMA Association is the most widely occurring plant association in the Douglas-fir Series, and is found across the entire forest (Figure 20). It occupies warm, xeric habitats on lower to upper slope positions, primarily on east to west aspects (Figure 21). West of the Columbia River it can be found on northern aspects. However, east of the river it becomes increasingly restricted to steep, rocky, east- to west-facing slopes, particularly near the eastern forest boundary. Elevations range from 1,400 to 5,200 ft. (Table 14).

The regolith is gravelly and rocky colluvium. Soil textures are gravelly to cobbly silts and loams. Ash dominated profiles are uncommon. Discemable ash layers often indicate areas transitional to other associations such as the ABGR/PHMA type. Field notes describe many soils as "loose, non-coherent". These soils are well-to excessively-well drained. Summer soil temperatures at 20 in. (50 cm) normally range between 50 and 54 °F (10 to 12 °C). Soil Ph data are limited but range between 6.5 and 7.5. Rock outcrops and ledges are common. Near lower treeline the type may occur on relatively gentle slopes and north aspects.

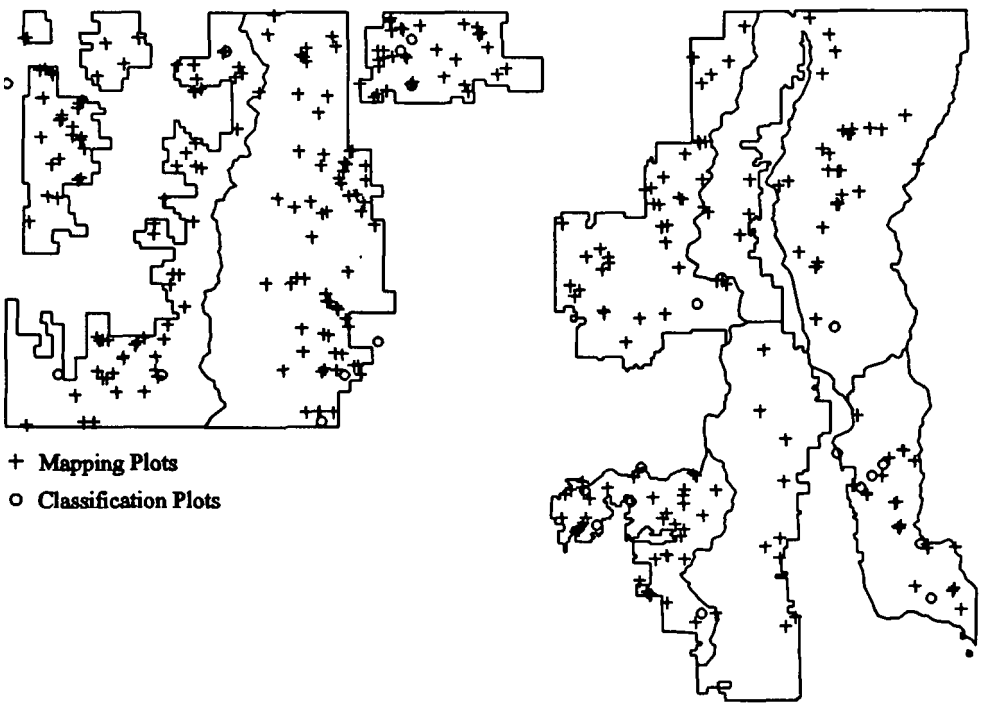


Figure 20. Plot locations for the PSME/PHMA Association (n=353).

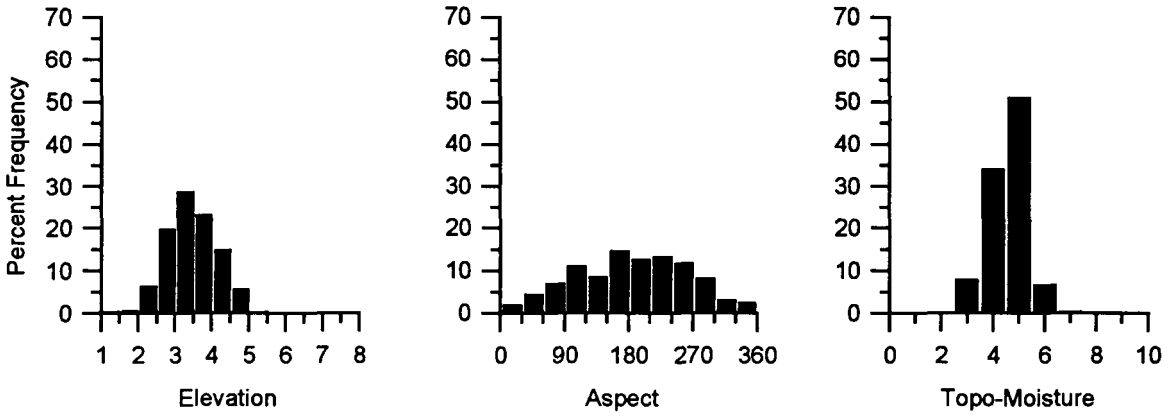


Figure 21. Frequency of PSME/PHMA plots by elevation (1000 ft.), aspect, and topographic moisture.

The PSME/PHMA Association grades into the PSME/PHMA-LIBOL Association on slightly more moist habitats. The latter type often occurs in more sheltered portions of the same slope or on areas of concave micro-relief while the PSME/PHMA Association is on convex or more exposed portions of the site. The PSME/PHMA type grades into either the PIPO-PSME/AGSP Association or a ninebark shrubland on drier habitats. It grades into the PSME/VACA or PSME/CARU Associations on cooler habitats. It is often found in a mosaic with PSME/CARU types, where CARU is growing on finer textured and/or deeper soils and PHMA on coarser, more well-drained soils.

Table 13. Common plants of the PSME/PHMA Association (n=33).

		CON	COVER
IEEE.	OVERSTORY LAYER		
PSME	Douglas-fir	97	47
PIPO	ponderosa pine	58	11
TREE	UNDERSTORY LAYER		
PSME	Douglas-fir	79	4
	SHRUBS AND SUBSHRUBS		
PHMA	ninebark	91	29
SPBEL	shiny-leaf spirea	91	6
AMAL	serviceberry	85	7
BEAQ	Oregon grape	79	5
SYAL	common snowberry	76	8
HODI	oceanspray	70	6
ROGY	baldhip rose	70	5
PAMY	pachistima	55	2
HERB5			
CARU	pinegrass	88	11
FRAGA	strawberry spp.	76	4
ARCO	heartleaf arnica	73	9
DITR	wartberry fairybells	73	3
SMRA	feather solomonplume	73	3

VEGETATION

Douglas-fir is the most common tree species in these stands. Ponderosa pine is the major serai species in this association, though only rarely is it the stand dominant. Individual large ponderosa pine trees may occur above the main canopy of Douglas-fir

Table 14. Environmental and structural characteristics of the PSME/PHMA Association.

	Mean	S.D.	Min	Max
Environment[1]				
Elevation	3455	655	1400	5200
Aspect[2]	190	66		
Slope	37	19	1	96
Topographic moisture	4.57	0.74	3.0	7.0
Soil Surface[3]				
Exposed soil	22	17	0	70
Gravel	34	20	1	62
Rock	23	26	0	88
Bedrock	0	0	0	0
Moss	2	1	0	3
Lichen	1	2	0	4
Litter	61	18	25	80
Diversity[4]				
Richness	24.6	3.2	10	35
N2	6.5	2.3	3.0	11.5

[1] Values for environmental variables were generated using both classification plot and mapping plot data (n=354).
[2] The mean and standard deviation values for aspect are calculated using statistical formulae for circular data (Batschlet 1981).
[3] Soil surface characteristics in percent cover.
[4] Richness and heterogeneity, N3, are expressed as average number of species per plot.

in some stands as they are more resistant to fire-related mortality and can survive one or more fires. Lodgepole pine is abundant only on habitats transitional to the PSME/VACA Association.

Abundant medium to tall shrubs dominate the undergrowth. Ninebark is characteristically the major shrub but oceanspray is an alternative indicator of the type. Ninebark is a Rocky Mountain species that nears its western distribution (except for disjunct populations) not far from the western boundary of the ColvilleN.F. Oceanspray extends into the Cascade Range and south into California. Douglas maple, serviceberry, Oregon grape, pachistima, mockorange, shiny-leaf spirea and common and mountain snowberries may be abundant and conspicuous shrubs in individual stands depending on local seed source, stand age, and disturbance history. Herbs are normally much less conspicuous than shrubs but pinegrass can be abundant. Average species richness and heterogeneity (N2) are close to the average for the Series (Table 14).

There several extensive stands near Scatter Creek and Swan Lake on the Republic Ranger District that occur on steep, boulder covered slopes which may key here. These stands range from open woodland to closed forest conditions but are characterized by a unique undergrowth including

Figure 22. Photo of the PSME/PHMA Association.

mountain snowberry, ocean-spray, common snowberry, ninebark, serviceberry, shrubby penstemon, and bluebunch wheatgrass. Pod-fem *(Aspidotis densd)*, a common serpentine indicator, may also be present. These stands typically occur below 3,000 ft. (910 m), though existing ecology plot data are insufficient to describe these stands.

MANAGEMENT IMPLICATIONS

Wildlife/Range- These stands provide important forage and cover for a wide variety of wildlife species. PSME/PHMA sites remain snow-free later in the fall and become snow-free earlier in the spring than many other forested plant communities on the Forest. In mature stands, wildlife use of this type is primarily for cover, since forage production is low. However, early serai stages of this association can be very productive for both food and cover requirements of big game. Bighorn sheep may use these areas for forage and cover areas, and grouse like to use these sites also. Severe fires every 30-60 years will maintain shrub cover on these sites, which elk and deer use as winter forage. Wild turkeys may forage and roost in large remnant ponderosa pine while flying squirrels are also known to use old, hollow pines. The type can also be important habitat for pileated woodpeckers, mountain chickadee's and nuthatches. Several common shrubs such as serviceberry, Douglas maple,

redstem ceanothus and baldhip rose are considered good deer browse. The tall shrub layer also provides excellent hiding cover.

Livestock grazing is not important, except perhaps in very early successional stages with a high abundance of grasses. However, significant damage from livestock grazing can occur from excessive use as shaded rest areas adjacent to sites having greater herbage production. Strawberry spp. are disturbance-indicating species that flourish under heavy grazing on these sites.

Silviculture- PSME/PHMA stands have major reforestation difficulties following traditional logging and reforestation practices (e.g. clearcutting, burning, scarification). These reforestation problems are primarily due to drought and heat stress, steep slopes, and shrub and grass competition. Plant species are fire-resistant and post-fire recovery of the understory occurs relatively quickly in most situations. Many plants in this association are rhizomatous and competition is intense. Sites with heavy coverage ofpinegrass indicate potential regeneration problems due to competition. Natural regeneration (mainly Douglas-fir) in PSME/PHMA. stands in Montana often required more than 20 years following logging practices common in the 1960's and early 1970's (Amo *et al.* 1985). Artificial regeneration in the same time frame was successful about half the time and then mainly after scarification or terracing. Similar studies from central Idaho agree with these findings (Steele and Geier-Hayes 1989). Timely regeneration following clearcutting is very difficult to assure regardless of the techniques employed. Clearcuts may resist reforestation efforts for decades, especially if followed by a broadcast bum. Only ponderosa pine and Douglas-fir are suggested for management. The presence of Douglas maple, smooth brome or sweetroot in a stand may indicate better than average tree productivity.

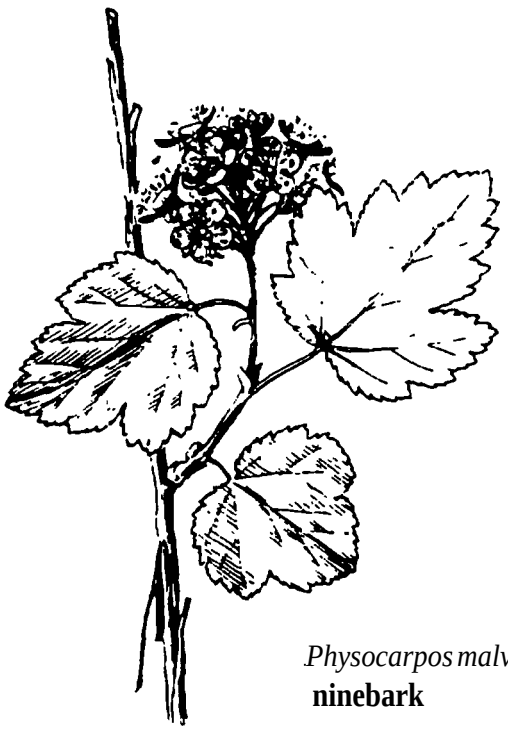
Soil wood and organic matter have a crucial role in nutrient cycling in a broadly defined PSME/ PHMA type (Harvey *et al.* 1987). They report that tree roots are almost entirely concentrated in soil wood and other organic matter. Activities that reduce soil organic matter and soil wood also reduce capacity to support trees (refer to the Douglas-fir Series description for more information). Burning is commonly practiced on PSME/PHMA sites ostensibly with one goal: to reduce shrub competition with young trees. However, long-term studies of shrub dynamics on such sites indicate that burning encourages more shrub cover and slows reforestation compared to unbumed sites. This is especially true of fall burning (h-win and Peek 1979, Morgan and Neuenschwander 1988). Wildfire or broadcast burning often results in complete site occupancy by shrubs for extended periods of time. Appendix 1 provides some information on expected response of selected species to fire.

In view of the above considerations, natural regeneration under a shelterwood with little or no site preparation or fuels treatment appears to be the most cost effective reforestation method. The shelterwood should remain until the stand is adequately reforested before removal. This may require decades before trees are re-established. The alternative is a high rate of reforestation failures. No known techniques will assure reforestation in five years. Loose soils and steep slopes indicate that erosion can be a serious problem. Natural soil movement rates are high and heavy equipment on steep slopes and vegetation destruction may lead to accelerated erosion. On sites which are on the dry extreme for this type where ponderosa pine may dominate, underbuming can be used in combination with partial or group selection cutting to maintain productivity and species composition as well as an open stand structure. A natural fire regime, consisting of frequent, non-lethal fires,

perpetuates dominance by serai species. A combination of selection cutting with underbuming can help perpetuate the pre-settlement stand structure. However, serai species may be difficult to replace or maintain after stand-replacing fire or clearcutting has removed seed sources. Dwarf mistletoe is commonly observed on larch and Douglas-fir trees in this association. Infections seem to be more pronounced on the drier sites within the type.

COMPAMSONS

Plant associations with Douglas-fir as the major tree species and ninebark as the primary shrub have been widely reported for the Rocky Mountains. Similar associations have been described for northern Idaho (Cooper *et al.* 1991, Daubenmire and Daubenmire 1968), eastern Washington (Clausnitzer and Zamora 1987, Daubenmire and Daubenmire 1968, Williams and Lillybridge 1983, Zamora 1983), northeastern Oregon (Hall 1973, Johnson and Clausnitzer 1992, Johnson and Simon 1987), Montana (Pfister *etal.* 1977), and central Idaho (Steele *etal.* 1981). Braumandl and Curran (1992) describe a Douglas-fir-Ponderosa Pine/Ninebark Site Association for the southern Kettle River Valley in British Columbia. However, the association is found at lower elevations on warmer and drier sites than those that support the PSME/PHMA Association described for the Colville N.F.



Physocarpos malvaceus
ninebark

PSME/PHMA-LIBOL ASSOCIATION CDS7 16
Pseudotsuga menziesii/Physocarpus malvaceus-Linnaea borealis var. *longiflora*
Douglas-fir/ninebark-twinflower

DISTRIBUTION AND ENVIRONMENT

The PSME/PHMA-LIBOL Association is one of the most common plant associations in the Douglas-fir Series. It is found across the entire forest but is best represented west of the Pend Orielle River (Figure 23). It occupies warm, xeric habitats primarily on lower and mid-slope positions on a variety of aspects (Figure 24). At elevations nearer the lower forest margin it may be on sheltered north slopes, draws and swales while at higher elevations it is usually found on southeast to west-facing aspects. Elevations range from 2,000 to 5,000 ft. (Table 16).

The regolith is largely colluvium mixed with glacial till. Volcanic ash may be mixed in the upper horizon in some soils but most profiles do not have the ash layer characteristic of many other associations on the Forest. Soil textures are almost always gravelly to very gravelly silts or loams. Soil parent materials are variable including granitic, basaltic and metamorphic rock types. Soil pH ranged between 6.5 and 7.5. Soil temperatures at 20 in. (50 cm) ranged between 48 and 52 °F (9 to 11 °C). Some soils had compacted or very hard horizons deeper in the profile but compaction was not a common characteristic in natural stands.

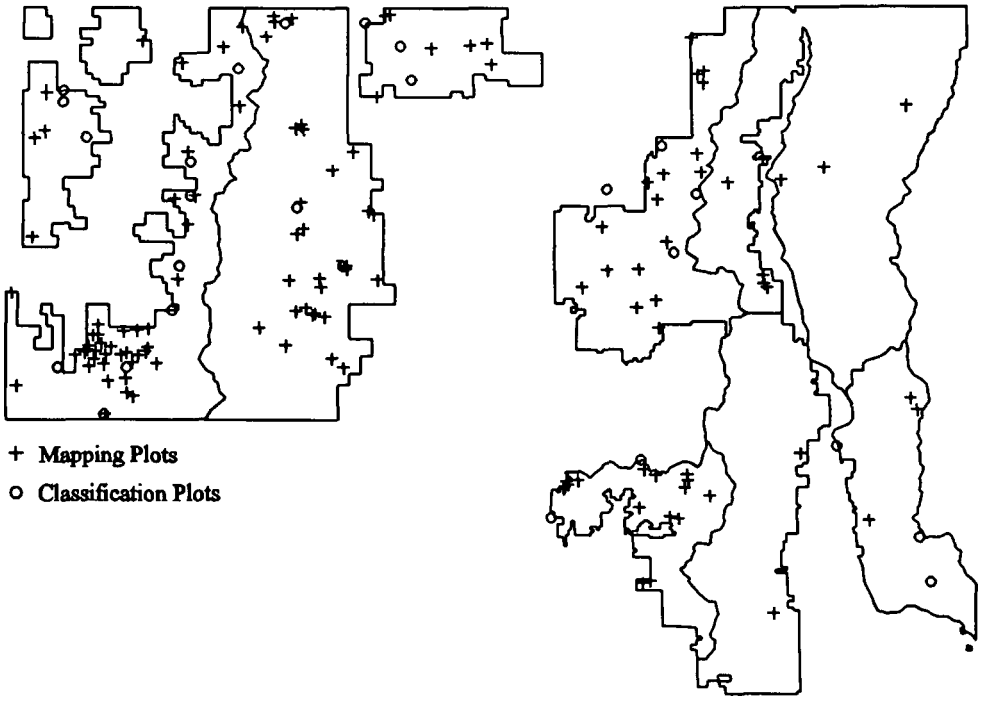


Figure 23. Plot locations for the PSME/PHMA-LIBOL Association (n=164).

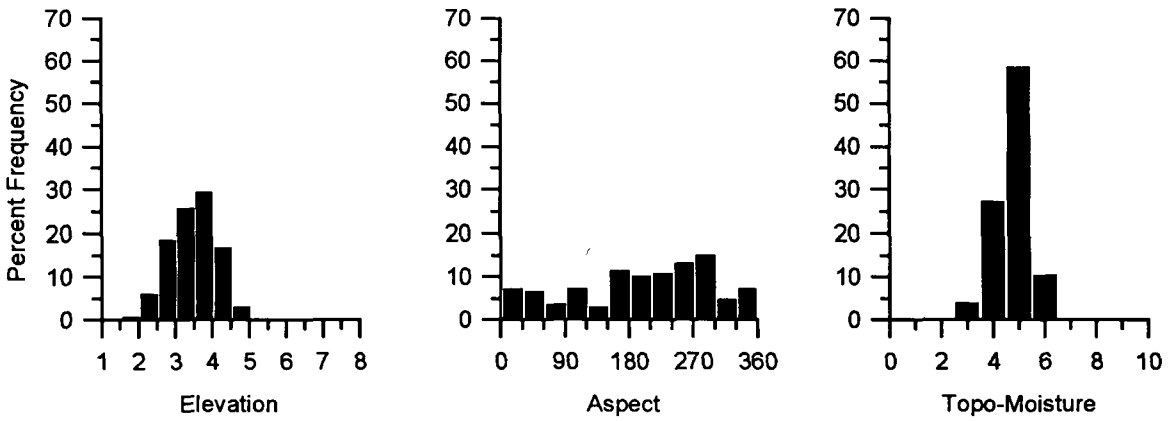


Figure 24. Frequency ofPSME/PHMA-LffiOL plots by elevation (1000 ft.), aspect, and topographic moisture.

The PSME/PHMA-LIBOL type is very similar to the PSME/PHMA Association which occurs on what appear to be slightly more xeric habitats. The PSME/PHMA-LIBOL type is also closely related to the ABGR/PHMA Association and distinguishing between the types in early serai stands is often difficult. The PSME/PHMA-LBOL Association grades into the PSME /VACA Association on colder, frostier sites. The presence of dwarf huckleberry and bearberry indicates habitats transitional between the two associations.

Table 1-5. Common plants of the PSME/PHMA-LIBOL Association (n=51).

		CON	COVER
TREE OVERSTORY LAYER			
PSME	Douglas-fir	100	43
LAOC	western larch	92	8
TRFF UNDERSTORY LAYER			
PSME	Douglas-fir	82	7
SHRUBS AND SUBSHRUBS			
PHMA	ninebark	98	23
SPBEL	shiny-leaf spirea	88	9
AMAL	serviceberry	86	3
SYAL	common snowberry	75	5
BEAQ	Oregon grape	69	4
PAMY	pachisdma	67	3
ROGY	baldhip rose	63	5
ARUV	bearberry	57	5
LIBOL	twinflower	51	5
HERB5			
CARU	pinegrass	98	22
FRAGA	strawberry spp.	92	4
ARCO	hearueaf arnica	75	6
SMRA	feather solomonplume	69	2
DITR	wartberry fairybells	57	3

VEGETATION

Very old stands are rare in these fire prone sites. Douglas-fir dominates late serai and mature stands. Western larch and ponderosa pine are common long-lived serai tree species. After a disturbance such as fire, the typical overstory is a mixture of Douglas-fir and western larch. Douglas-fir is normally dominant. Ponderosa pine is less common

Table 16. Environmental and structural characteristics of the PSME/PHMA-LIBOL Association.

	Mean	S.D.	Min	Max
Environment'				
Elevation	3473	604	2000	5000
Aspect[2]	256	58	20	310
Slope	31	17	2	84
Topographic Moisture	4.75	0.69	3.0	6.0
Soil Surface[3]				
Exposed soil	41	23	0	70
Gravel	10	4	1	12
Rock	18	19	12	38
Bedrock	0	0	0	0
Moss	2	1	1	5
Lichen	0	0	0	0
Litter	69	21	35	85
Diversity[4]				
Richness	23.7	3.4	19	29
N2	6.1	1.7	4	10

' Values for environmental variables were generated using both classification plot and mapping plot data (n=167).
[2] The mean and standard deviation values for aspect are calculated using statistical formulae for circular data (Batschlet 1981).
[3] Soil surface characteristics in percent cover.
[4] Richness and heterogeneity, N2, are expressed as average number of species per plot.

in the sere as compared to the PSME/PHMA Association. Western larch and lodgepole pine are more important on the more moist sites within the type. Shrubs are common and ninebark is typically the most abundant species. Oceanspray may be locally abundant and is used as an alternate indicator species for these sites. Shiny-leaf spirea, pachistima, serviceberry, Douglas maple, Oregon grape, common snowberry and baldhip rose are other shrubs that may be abundant. South or west aspects in the Grand Fir, Western Redcedar and Western Hemlock Series may support shrub layers very similar to that of a PSME/PHMA-LIBOL type, particularly in early serai stages.

Pinegrass is the most common and abundant herb but other common species include wartberry fairybells, heartleaf arnica, strawberry and showy aster. Both average species richness and heterogeneity (N;) values are close to the Series' averages (Table 16). Average species richness is the highest of any association in the Douglas-fir Series indicating the relatively mild environment characteristic of the type.

Figure 25. Photo of the PSME/PHMA-LBOL Association.

MANAGEMENT IMPLICATIONS

Wildlife/Range- These stands provide important forage and cover for a wide variety of wildlife species. PSME/PHMA-LIBOL sites remain snow-free later in the fall and become snow-free earlier in the spring than many forested sites. In mature stands, wildlife use of this type is primarily for cover; forage production is low. However, early serai stages of this of the association can be very productive for both food and cover requirements of big game. Serviceberry, Douglas maple, redstem ceanothus and baldhip rose and other common shrubs are considered good deer browse. Bighorn sheep may use these areas for forage and cover areas, and ruffed grouse like to use these sites also. Severe fires every 30-60 years will maintain shrub cover on these sites, which elk and deer use as winter forage. When large, remnant ponderosa pine are present, wild turkeys may forage and roost, and flying squirrels are known to use the old, hollow pines. The type can also be important habitat for pileated woodpeckers, mountain chickadee's, and nuthatches.

Livestock grazing is not important, except perhaps in very early successional stages with a high abundance of grasses. However, significant damage from livestock grazing can occur from excessive use as shaded rest areas adjacent to sites having greater forage production. Strawberry spp. are disturbance-indicating species that flourish under heavy grazing.

Silviculture- The PSME/PHMA-LIBOL Association is easier (though still difficult) to regenerate than the PSME/PHMA type. Natural regeneration on similar stands in Montana required more than 10 years (Amo *et al.* 1985). This is about half the delay time for PSME/PHMA. Soil wood and organic matter have a crucial role in a broadly defined PSME/PHMA type (Harvey *et al.* 1987). Tree roots are almost entirely concentrated in soil wood and other types of organic matter. Activities that reduce soil organic matter and soil wood reduce site capacity to support trees (refer to the Douglas-fir Series description for more information). Additionally, steep slopes and rocky soils make planting difficult, and soils may be displaced by heavy equipment.

Shelterwood cuts with little or no site preparation are recommended to reduce reforestation difficulties. Clearcuts may resist reforestation efforts for decades, especially if broadcast burned. Burning is commonly practiced on PSME/PHMA-LIBOL sites ostensibly with one goal: the reduction of shrub competition with young trees. However, long-term studies of shrub dynamics on similar sites indicates broadcast bums encourage more shrub cover and retard reforestation when compared to unbumed units. This is especially true of fall bums (Irwin and Peek 1979, Morgan and Neuenschwander 1988). Appendix 1 provides some information on expected response of selected species to fire. Abundant Douglas maple, smooth brome or sweetroot may indicate habitats with better than average productivity. Dwarf mistletoe is commonly observed on larch and Douglas-fir trees in this association.

COMPARISONS

The PSME/PHMA-LIBOL Association is separated from the PSME/PHMA Association based the presence of western larch and/or twinflower. These species indicate a more moist extreme of the PSME/PHMA Association, and have a different successional pathway (Amo *et al.* 1985). Plant associations with Douglas-fir as the major tree species and ninebark as the primary shrub have been widely reported for the Rocky Mountains. Similar associations have been described for northern Idaho (Cooper *et al.* 1991, Daubenmire and Daubenmire 1968), eastern Washington (Clausnitzer and Zamora 1987, Daubenmire and Daubenmire 1968, Williams and Lillybridge 1983, Zamora 1983), northeastern Oregon (Hall 1973, Johnson and Simon 1987), Montana (Pfister *et al.* 1977), and central Idaho (Steele *et al.* 1981).

The PSME/ACGL-PHMA Association of northeastern Oregon (Johnson and Simon 1987) is similar. However, Douglas maple (ACGL or ACGLD) is much less common in the Colville N.F. data. The PAMY Phase of the PSME/PHMA Habitat Type described for the adjacent Colville Indian Reservation (Clausnitzer and Zamora 1987) also appears to be very similar. The SMST Phase of PSME/PHMA Habitat Type described for northern Idaho (Cooper *et al.* 1991) can be considered an extension of the Colville N.F. PSME/PHMA-LIBOL type. The Colville data contain little starry solomonplume so twinflower and western larch are used as key species. Braumandl and Curran (1992) describe a Douglas-fir-Ponderosa Pine/Ninebark Site Association for the Kettle River Valley in southern British Columbia. However, this association contains no western larch or twinflower and is found on warmer and drier sites than those that support the PSME/PHMA-LIBOL Association.

PSME/SYAL ASSOCIATION CDS6 33
Pseudotsuga menziesii/Symphoricarpos albus
Douglas-fir/common snowberry

DISTRIBUTION AND ENVIRONMENT

The PSME/SYAL Association is most common west of the Pend Orielle River (Figure 26) though is even more common in lower elevations outside of National Forest lands. This type typifies warm, moist but well-drained lower slope, bench or terrace topographic positions that receive run-on or percolation water. Most PSME/SYAL stands are along drainages, in swales, or on lower slopes where subsurface moisture may accumulate. Slopes are variable and sites tend to be located on southeast to southwest aspects (Figure 27). Elevations range from 2,200 to 4,800 ft. (Table 18), but the type extends to lower elevations. These sites represent xero-riparian communities in many locations.

The regolith is alluvium or glacial till and outwash. Soil textures are sandy loams to sands. Coarse fragment content is variable. The upper soil horizons are relatively coarse-textured and xeric. However, subsurface horizons may be relatively moist and it is not uncommon to find seepage along nearby roadcuts. Wetter habitats are typically spruce (PIEN/SYAL), quaking aspen (POTR/SYAL)

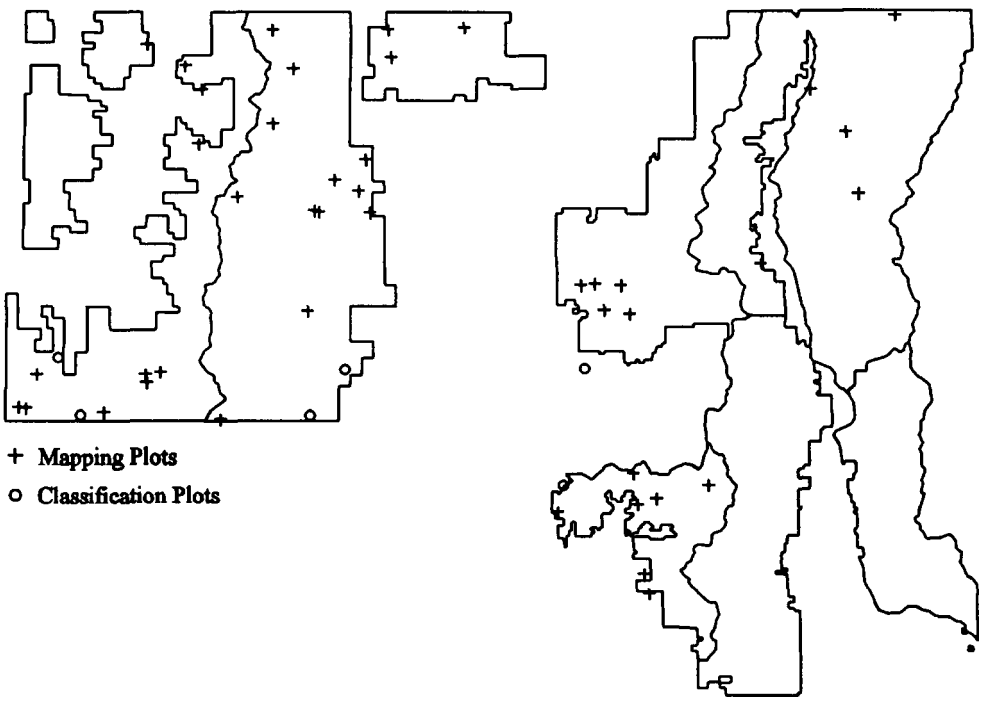


Figure 26. Plot locations for the PSME/SYAL Association (n=50).

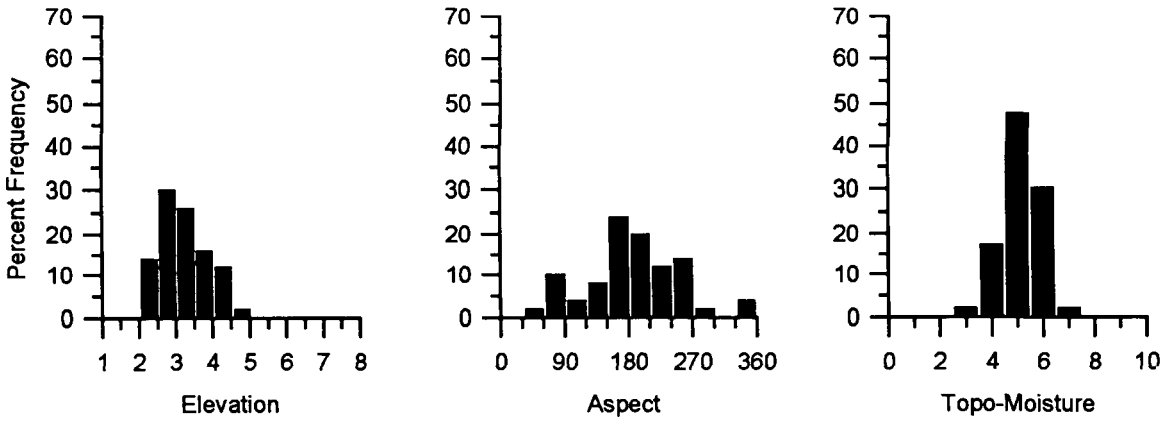


Figure 27. Frequency ofPSME/SYAL plots by elevation (1000 ft.), aspect, and topographic moisture.

or black cottonwood (POTR2/SYAL) riparian communities. These riparian associations are described in greater detail by Kovalchik (1993). PSME/SYAL grades into the PSME/PHMA-LIBOL, PSME/ PHMA or PSME/SYOR Associations on drier habitats.

VEGETATION

Douglas-fir, ponderosa pine, or a mixture of both species dominates the overstory of early to mid-seral stands. Western larch and lodgepole pine are occasional serai stand components. Quaking aspen may be a minor sub-canopy component in some stands. Douglas-fir is the most shade tolerant species present and is expected to dominate late serai or climax conditions. Currently, Douglas-fir dominates the tree reproduction layer due to changes in the fire regime. Ponderosa pine reproduction may dominate early succession, and would usually be found under an open, ponderosa-pine dominated canopy. Ponderosa pine typically dominates the warmer extensions of this type, and will seldom be totally excluded by Douglas-fir on these sites.

Table 17. Common plants of the'.PSME/SYAL Association (n=13).

		CON	COVER
TREE OVERSTORY LAYER			
PIPO	ponderosa pine	85	35
PSME	Douglas-fir	85	26
LAOC	western larch	8	40
TREE UNDERSTORY LAYER			
PSME	Douglas-fir	69	4
SHRUBS AND SUBSHRUBS			
SYAL	common snowberry	100	43
AMAL	serviceberry	69	4
BEAQ	Oregon grape	54	3
HERBS			
CARU	pinegrass	85	14
OSCH	sweetroot	62	2
FRAGA	strawberry spp.	62	2
ARCO	heartleaf arnica	54	5
ACMI	yarrow	54	2

Table 18. Environmental and structural characteristics of the PSME/SYAL Association.

	Mean	S.D.	Min	Max
Environment[1]				
Elevation	3212	646	2200	4800
Aspect[2]	186	54		
Slope	34	16	6	70
Topographic Moisture	5.13	0.81	3.0	7.0
Soil Surface[3]				
Exposed soil	23	13	10	50
Gravel	17	12	12	38
Rock	18	19	1	38
Bedrock	0	0	0	0
Moss	0	0	0	0
Lichen	0	0	0	0
Litter				
Diversity[4]				
Richness	22.4	7.7	7	35
N2	6.6	2.9	4	13

[1] Values for environmental variables were generated using both classification plot and mapping plot data (n=50).
[2] The mean and standard deviation values for aspect are calculated using statistical formulae for circular data (Batschlet 1981).
[3] Soil surface characteristics in percent cover.
[4] Richness and heterogeneity, N3, are expressed as average number of species per plot.

A dense 2 ft. (0.6 m) high shrub layer in association with abundant grasses characterizes the undergrowth. Common snowberry is the dominant and characteristic shrub. Bristly nootka rose, wood's rose, Oregon grape, shiny-leaf spirea and serviceberry are locally abundant shrubs. Pinegrass is the most common grass and is often very abundant. Sweetroot, yarrow, heartleaf arnica and strawberry spp. are the only herbs present with a degree of constancy. Arrowleaf balsamroot indicates sites at the dry end of the type. Average species richness and heterogeneity (N3) are close to the Series' averages (Table 18).

MANAGEMENT IMPLICATIONS

Wildlife/Range- Animal use can be high. Deer, elk, cattle, grouse, and passerines all utilize this habitat seasonally. These stands are important for forage, cover and proximity to water. Serai shrub species may provide important browse for elk and deer and provide good thermal and hiding cover when the shrub layer is dense. Ruffed grouse may use the drier types with ponderosa pine year-round. Turkeys may roost in large pines and feed on pine seeds. Livestock find low to moderate

Figure 28. Photo of the PSME/SYAL Association.

amounts of herbage in this type (appendix 2). However, sites may be heavily utilized as resting/shade areas due to gentle ten-am and proximity to water. Cattle often congregate seeking shade and water, in which case damage from overuse may occur. Common snowberry is sensitive to trampling and soil compaction.

Silviculture- Site indexes are good for sites on gentle slopes (< 30%) but decline as slopes increase (appendix 2). Productivity data from Okanogan N. F. plots are used to characterize site productivity and all these plots are from slopes less than 30%. The modal sites tend to be very productive for the Douglas-fir Series, and timber productivity is moderate to high (appendix 2), though stocking control may be a problem. As with other Douglas-fir/tall shrub associations, competition from rhizomatous understory vegetation (common snowberry, shiny-leaf spirea, pinegrass, etc.) and animal use are important factors to consider in management (Johnson and Clausnitzer 1992). Natural reforestation potential is good but too much delay in tree establishment results in a dense shrub and grass stand highly competitive with young trees. Ponderosa pine regenerates well on the drier sites while Douglas-fir regenerates better on more moist sites within the type.

Pre-harvest species composition of shrub and herb layers, type and timing of treatment, combined with species responses in appendix 1 can be used to estimate vegetation responses to alternative

treatments Ponderosa pine, snowberry, and pinegrass will respond favorably to increased sunlight, though this may also allow pinegrass to form a dense sward which may retard conifer regeneration (Steele *et al.* 1981) These shrubs and herbs respond vigorously to overstory removal and may hinder regeneration in clearcuts Most species are fire-resistant, and recurrent fire will promote ponderosa pine and pinegrass in this type Underburning can be used to maintain open conditions, increase forage production and enhance the nutritional value of forage Shrubs may take two years or more to regain dominance after underburning (Weaver 1968) Mechanical thinning could be used in conjunction with low-severity underbums to open up stands where fuel ladders are extensive or surface fuels are heavy (Smith and Fischer 1995) Elytroderma needle cast frequently infests ponderosa pine on PSME/SYAL sites on the neighboring Okanogan N F Slopes steeper than 30% or the presence of mountain snowberry indicates conditions where PSME/SYOR timber management interpretations are more applicable

COMPARISONS

Similar types have been described for northern Idaho (Cooper *et al.* 1991, Daubenmire and Daubenmire 1968), eastern Washington (Clausnitzer and Zamora 1987, Lillybridge *et al.* 1995, Zamora 1983), Montana (Pfister *et al.* 1977), British Columbia (Brayshaw 1965), central Idaho (Steele *et al.* 1981) and northeastern Oregon (Johnson and Clausnitzer 1992, Johnson and Simon 1987) There are floristic differences between areas but all types are used to indicate similar environments The PSME/SYAL/AGSP Association described by Lillybridge *et al.* (1995) is similar to some of the Colville N F stands In Montana, the bluebunch wheatgrass phase of Pfister *et al.* (1977) seems to better fit the PSME/SYOR Association than the PSME/SYAL type described for the Colville N F

Symphoricarpos a/bus
common snowberry

PSME/SYOR ASSOCIATION CDS6 32
Pseudotsuga menziesii/Symphoricarpos oreophilus
Douglas-fir/mountain snowberry

DISTRIBUTION AND ENVIRONMENT

The PSME/SYOR Association is a minor type on the Colville N.F., and is primarily found west of the Kettle Mountain Crest on the Republic Ranger District (Figure 29). This association typically occurs on dry, windswept habitats with coarse textured soils. Sites are generally on upper-slope or ridgetop positions on southeast to southwest aspects (Figure 30). Elevations range from 2,550 to 5,280 ft. and average 4,224 ft. (Table 20). The PSME/SYOR Association represents one of the driest and harshest environments within the Douglas-fir Series.

The regolith is glacial till, outwash or colluvium. Soil textures are gravelly silts to loams. Coarse fragments often make up 50% or more of the soil profile. These are well- to excessively well-drained soils. Summer soil temperatures at 20 in. (50 cm) average 46 °F (8 °C) which are the coldest for the Douglas-fir Series on the Colville N.F. The PSME/SYOR Association often occurs next to shrublands with mountain snowberry or, less commonly, mountain big sagebrush. It grades into the PSME/CARU or ABLA2/CARU Associations on less xeric or somewhat cooler sites. Stands dominated by mountain snowberry are essentially wooded mountain shrublands. They frequently

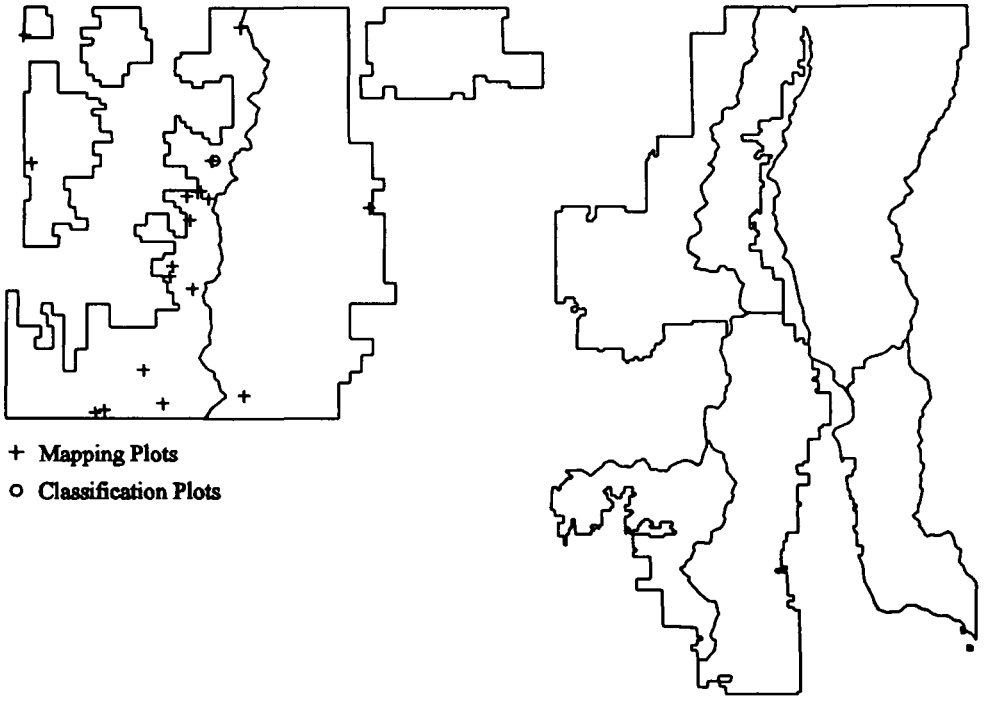


Figure 29. Plot locations for the PSME/SYOR Association (n=22).

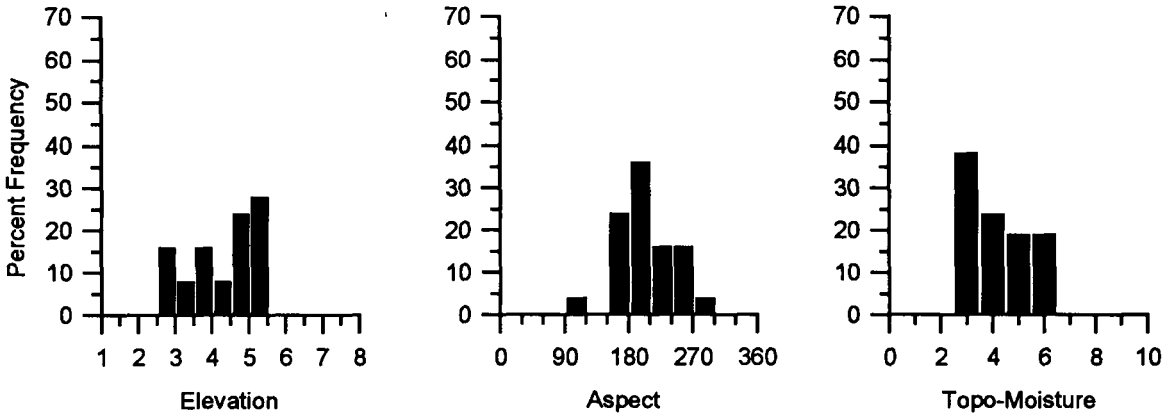


Figure 30. Frequency ofPSME/SYOR plots by elevation (1000 ft.), aspect, and topographic moisture.

adjoin non-forested communities including grasslands and shrublands and represent a transition zone between forested and non-forested conditions within the Douglas-fir Series.

There are several extensive stands near Scatter Creek and Swan Lake on the Republic Ranger District that occur on steep, boulder covered slopes which may key here. These stands range from open woodland to closed forest conditions but are characterized by a unique undergrowth including mountain snowbeny, ocean-spray, common snowberry, ninebark, serviceberry, shrubby penstemon, and bluebunch wheatgrass. Pod-fem *{Aspidotis densd)*, a common serpentine indicator, may also be present. These stands typically occur below 3,000 ft. (910 m) which contrasts sharply with typical PSME/SYOR. Existing ecology plot data are insufficient to describe these stands.

Table 19. Common plants of the PSME/SYOR Association (n=9).

		CON	COVER
TREE OVERSTORY LAYER			
PSME	Douglas-fir	100	36
PIPO	ponderosa pine	67	16
TREE UNDERSTORY LAYER			
PSME	Douglas-fir	89	3
SHRUBS AND SIJBSHRUBS			
SYOR	mountain snowberry	100	11
AMAL	serviceberry	56	4
HERBS			
CARU	pinegrass	89	29
ACMI	yarrow	89	2
FRAGA	strawberry spp.	67	5
COPA	little flower collinsia	67	2
SMRA	feather solomonplume	67	1
LUSE	silky lupine	56	5
ANAN	tall pussytoes	56	3

VEGETATION

The PSME/SYOR Association represents semi-open forests of large trees with an open, grassy undergrowth and scattered shrub patches. They rarely form a closed forest situation. The physiognomy closely resembles the more open PSME/CARU

Table 20. Environmental and structural characteristics of the PSME/SYOR Association.

	Mean	S.D.	Min	Max
Environment'				
Elevation	4224	916	2550	5280
Aspect[2]	205	33		
Slope	42	16	10	63
Topographic Moisture	4.19	1.17	3.0	6.0
SoilSurface[3]				
Exposed soil	26	14	5	35
Gravel	12		12	12
Rock	9	16	0	38
Bedrock	0	0	0	0
Moss	2	1	1	5
Lichen	0	0	0	0
Litter	38	4	35	40
Diversity[4]				
Richness	25.1	9.0	13	36
N2	6.1	1.9	4	9

' Values for environmental variables were generated using both classification plot and mapping plot data (n=25).
[2] The mean and standard deviation values for aspect are calculated using statistical formulae for circular data (Batschletl981).
[3] Soil surface characteristics in percent cover.
[4] Richness and heterogeneity, N3, are expressed as average number of species per plot.

stands except for the shrub layer. Douglas-fir mixed with ponderosa pine dominates the open overstory canopy. Western larch is present in some stands. Douglas-fir dominates late serai and climax stands as both western larch and ponderosa pine are strictly serai. Douglas-fir is typically the only tree regeneration present.

Abundant pinegrass mixed with scattered mountain snowberry is the characteristic undergrowth. Mountain snowberry is a caespitose, non-rhizomatous species and rarely approaches the density characteristic of common snowberry in the PSME/SYAL Association. Rose spp. or shiny leaf spirea are the only other shrubs likely to occur. Pinegrass is the most common herbaceous species and may form a dense sward. Lupine spp., yarrow, strawberry spp. and tall pussytoes are some of the other common herbaceous species. A diverse mixture of other grass species is also present.

Average species richness is above the Series average while average heterogeneity (N^) is slightly below the Series' average (Table 20). Transition vegetation types such as PSME/SYOR often have fairly diverse floras because of both the open canopies and adjacent vegetation. The open canopies provide a wide range ofmicroclimatic conditions from near open conditions to closed-forest shade

Figure 31. Photo of the PSME/SYOR Association.

which tends to provide conditions suitable for a number of species. The transition areas receive propagules from both open, non-forested vegetation as well as adjacent closed-forest vegetation, which again tends to promote increased diversity. However, habitat conditions are relatively harsh, which limits the number of dominant species, hence the relatively lower heterogeneity index.

MANAGEMENT IMPLICATIONS

Wildlife/Range-These sites represent important transition areas between forest and non-forest communities, and enhance landscape and species diversity. Wildlife use is high, since these stands represent important forage and cover areas for a variety of wildlife species. Deer, elk, cattle, blue grouse, and passerines all utilize this habitat seasonally. Blue grouse especially favor the large Douglas-firs found on the windswept ridges. Shrub species may provide important browse for elk and deer, as well as provide good thermal and hiding cover when the shrub layer is dense. These habitats become snow-free early in the spring because of the warm, exposed slopes combined with snow removal by wind. As such, they provide important habitat for a variety of wildlife including winter range for large ungulates.

Grazing has been heavy on most sites and loss of perennial grass cover and a concomitant increase in weedy *arnica* spp., asters and annual forbs follow excessive grazing. Tree canopy reduction will increase herbage production, while heavy grazing tends to eliminate the more palatable herbs. Moderate to heavy livestock use is common because of the proximity of the type to grass or shrublands. These sites also represent good shade and rest areas, increasing domestic livestock use and impacts.

Silviculture- Douglas-fir and ponderosa pine site indices are moderate and stocking rates are moderately low (appendix 2). Natural regeneration is sparse and reforestation is difficult because of droughty soils and competition from herbs and shrubs. Succession to trees after deforestation is especially slow. Planting is usually needed to assure regeneration, but even then survival is often poor, and trees should be planted before the shrubs and herbs can respond to release. Shading may be required because of high insolation rates and shelterwoods appear to have the highest probability of reforestation success. Planting may not be required under a shelterwood, but tree establishment will be slow regardless of the techniques used.

Windthrow and winter desiccation are prevalent. Clearcuts next to natural shrublands and grasslands are very difficult to regenerate and have high potential for rodent damage. Clearcuts essentially extend the mountain shrublands and grasslands into formerly forested areas and tree establishment may require decades. Due to these factors, management activities need to be limited and planned very carefully. Uneven-aged silvicultural systems show promise on these habitats. Uneven-aged management combined with prescribed fire and extended rotations should be effective in helping to maintain or enhance open stand structures. Natural stocking in mature stands is often low enough that spread of disease and parasites such as mistletoe are slow. *Elytroderma* infections are common on ponderosa pine on the Okanogan N. F. Similar infection levels may occur on the Colville N. F., especially on the Republic Ranger District.

COMPARISONS

PSME/SYOR types have been described for western Wyoming (Reed 1969, 1976), Montana (Pfister *et al.* 1977), central Idaho (Steele *et al.* 1981), and northeastern Oregon (Johnson and Clausnitzer 1992, Johnson and Simon 1987). These communities often have less pinegrass and contain some species not present on the Colville N.F. The PSME/SYOR types described for central and northcentral Washington (Lillybridge *et al.* 1995, Williams and Lillybridge 1983, respectively) are similar to the Colville N.F. type. Mountain snowberry is also used to identify phases of other associations in central Idaho which suggests that it's indicator role is different in that area (Steele *et al.* 1981). Most of the above studies describe PSME/SYOR as a minor type with a restricted distribution similar to the situation found on the Colville N.F.

PSME/VACA ASSOCIATION CDS8 13
Pseudotsuga memiesii/Vaccmium caespitosum
Douglas-fir/dwarf huckleberry

DISTRIBUTION AND ENVIRONMENT

The PSME/VACA Association is a minor type on the Colville N.F., best developed west of the Kettle Mountain Crest (Figure 32). It is similar to the ABGR/VACA Association, but occurs on drier sites which are generally outside the range of grand fir. It occupies gentle, moist, well-drained glacial outwash terraces, benches, and toeslopes on predominantly southeast to west aspects (Figure 33). Elevations range from 2,300 to 4,420 ft. (Table 22) and sites tend to accumulate cold air at night. This association represents warm day and cool- to frosty-night habitats within the Douglas-fir Series.

The regolith is glacial till, outwash (often of granitic origin), or colluvium with a thin surface layer of volcanic ash. Subsoils are often glacially compacted tills which may limit root penetration. Soil textures are sandy, gravelly to cobbly silts, sands and loams. Average soil temperature at 20 in. (50 cm) is 48 °F (9 °C) which ranks on the cool side for the Series. Soil Ph varied between 6.3 to 7.0. Subsoils are occasionally mottled. PSME/VACA is the most frost prone type in the Douglas-fir Series. It grades into either the ABGR/VACA or ABLA2/VACA Association on cooler, more moist habitats and into the PSME/PHMA, PSME/PHMA-LIBOL or PSME/CARU Associations on less

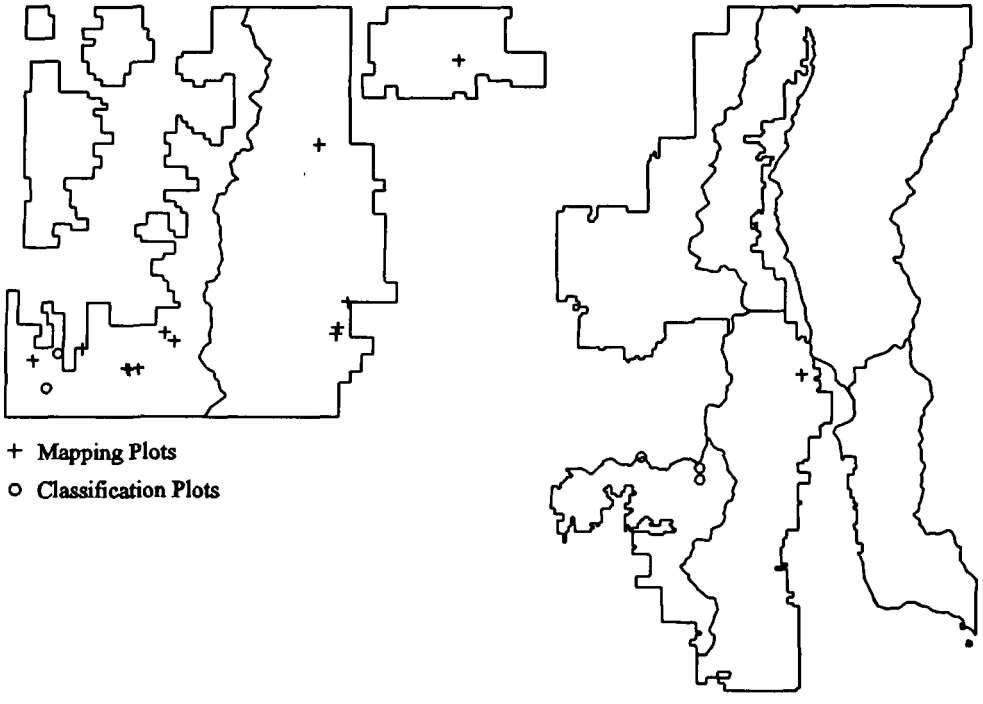


Figure 32. Plot locations for the PSME/VACA Association (n=22).

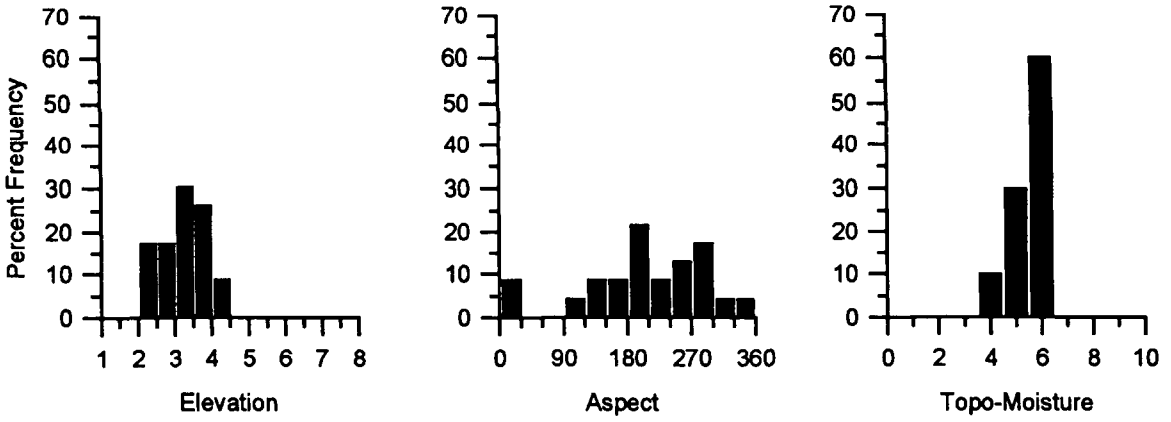


Figure 33. Frequency ofPSME/VACA plots by elevation (1000 ft.), aspect, and topographic moisture.

frosty habitats. Gentle slopes and glacial outwash terraces and terrace sideslopes may key to PSME/ARUV but most seem best viewed as a warm-dry extension of the PSME/VACA Association.

VEGETATION

A diverse mixture of lodgepole pine, western larch, ponderosa pine, and Douglas-fir dominates early to mid-seral stands (Table 21). Large western larch are often survivors from previous stands and may be considerably older and larger than the current canopy trees. Douglas-fir is often absent or only a minor component of early serai stands. These stands are often dominated by lodgepole pine, especially if sites have experienced repeated moderate- and high-intensity fires in the past. Ponderosa pine is near its frost limits in this type. Small amounts ofEngelmann spruce may be present on restricted, moist microsites. Douglas-fir dominates the regeneration. Lodgepole pine and even

Table 21. Common plants of the PSME/VACA Association (n=12).

		CON	COVER
IREE-OVERSTORY LAYER			
PSME	Douglas-fir	92	24
PICO	lodgepole pine	83	19
LAOC	western larch	75	12
TT?T^T7 IJNDRRSTORY LAYER			
PSME	Douglas-fir	100	11
SHRUBS AND SUBSHRUBS			
ARUV	bearberry	100	7
VACA	dwarf huckleberry	100	5
SPBEL	shiny-leaf spirea	92	11
AMAL	serviceberry	92	2
LIBOL	twinflower	83	14
SYAL	common snowberry	75	5
PAMY	pachistima	75	2
SHCA	russet buffaloberry	67	9
LOUT2	Utah honeysuckle	67	5
CHUM	w. prince's pine	67	4
BEAQ	Oregon grape	67	1
HERB^			
CARU	pinegrass	100	27
FRAGA	strawberry spp.	92	4
VIAD	Hook violet	67	2
SMRA	feather solomonplume	58	3
ARCO	heartleaf arnica	50	6

Table 22. Environmental and structural characteristics of the PSME/VACA Association.

	Mean	S.D.	Min	Max
Environment[1]				
Elevation	3249	556	2300	4420
Aspect[2]	227	56		
Slope	19	19	1	58
Topographic Moisture	5.50	0.68	4.0	6.0
Soil Surface[3]				
Exposed soil	14	11	5	35
Gravel	21	13	12	38
Rock	1		0	2
Bedrock	0	0	0	0
Moss	2		2	2
Lichen	2		2	2
Litter	50		50	50
Diversity[4]				
Richness	24.8	5.5	17	35
N2	9.3	1.9	7	12

[1] Values for environmental variables were generated using both classification plot and mapping plot data (n=23).
[2] The mean and standard deviation values for aspect are calculated using statistical formulae for circular data (Batschlet 1981).
[3] Soil surface characteristics in percent cover.
[4] Richness and heterogeneity, N3, are expressed as average number of species per plot.

ponderosa pine regeneration may occur under open western larch or lodgepole pine canopies.

The undergrowth is a diverse mixture of low shrubs and sub-shrubs set in a pinegrass matrix. Abundant pinegrass cover is common in the PSME/VACA Association and may complicate identification by concealing diagnostic low or prostrate shrubs such as dwarf huckleberry and bearberry. The shrub layer is usually prostrate and hidden by the grasses. Mature stands often appear very open because of the lack of tall shrubs. Bearberry, twinflower, shiny-leaf spirea, dwarf or grouse huckleberry, serviceberry, and common snowberry are all common and abundant shrubs or sub-shrubs. Dwarf huckleberry indicates frost pockets with warm days and cold nights (cold air drainage). Russet buffaloberry may be abundant early in the sere. Bearberry and dwarf huckleberry consistently indicate coarse textured glacial outwash terraces and slopes. Bearberry and, to a lesser extent dwarf huckleberry, also suggest compacted or very stony subsoils that limit root penetration.

Pinegrass is the dominant and characteristic herb. The undergrowth can be dominated by pinegrass in earlier successional stages. Few other herbaceous species are common except strawberry spp., yarrow, and Hook violet. Average species richness is only slightly higher that the Series' average

Figure 34. Photo of the PSME/VACA Association.

(Table 22). However, average heterogeneity (N^) is well above the Series' average which reflects the often diverse overstory and the large number of abundant low shrubs and subshrubs typically present. Many of these sites were homesteaded and these old homesteads are commonly dominated by lodgepole pine or a variety of weedy grasses and forbs including many introduced species. Highly disturbed stands on glacial outwash in the Little Pend Oreille Wildlife Recreation Area key to the PSME/VACA Association but are at much lower elevations than normal for the association.

MANAGEMENT IMPLICATIONS

Wildlife/Range- Baldhip rose, Oregon grape, bearberry, and snowberry provide fruit used by bear, grouse, non-game birds, and small mammals, as well as browse for wild ungulates. Dense pole-size stands dominated by lodgepole pine may be valuable for wildlife cover. Good herbaceous production, proximity to water and gentle slopes make this association attractive to livestock. Heavy grazing was noted in several stands. Bearberry and twinflower increase (or at least become more evident) as grazing pressure increases. Strawberry increases with disturbance such as grazing while dwarf huckleberry can be eliminated by excessive grazing. Areas used for shade and rest areas by cattle have little herbaceous cover, and may suffer from overuse.

Silviculture- Frost potential is high, therefore slope position, topography and air drainage patterns must be considered in management activities. Frost is a result of cold air drainage and ponding but PSME/VACA sites are apparently less frosty than the similar ABLA2/VACA Association. Western larch thrives on these habitats and natural regeneration may be prolific if soils are not compacted and severe frost pockets are avoided. Ashy soils are easily compacted when moist or displaced by heavy equipment. Lodgepole pine is the most tolerant species to frost and compacted soils.

Pinegrass cover greater than 20% may hinder conifer regeneration and extend the time necessary to achieve foil stocking under most conditions. Pinegrass may form a dense sward after harvest and may be designated as the reason for reforestation failure. However, close examination of several of these sites indicates that the reforestation failures were due more to soil compaction and frost. Soil compaction resulted from harvest/slash disposal operations with heavy equipment. The dense grass layer may have compounded the problem but was less damaging than soil compaction or frost. However, abundant pinegrass may help control excessive lodgepole pine reproduction where lodgepole pine appears to be the most suitable species. Severe fire and/or scarification of the site should lead to increases in pinegrass. Gentle slopes and abundant pinegrass reduce the need for erosion control.

Frost and effectively shallow soils appear to limit tree growth. Natural regeneration potential is good after shelterwood or seedtree harvests if frost pockets are avoided and pinegrass cover is less than 20%. Fire suppression will favor Douglas-fir. Clearcuts tend to favor lodgepole pine if present, though full stocking may require 20 years or more. Shrubs and herbs increase after clearcutting so regeneration should be accomplished promptly or competition may delay establishment and growth. In addition, some clearcutting patterns may increase the pooling of cold air which allows lodgepole pine to dominate where other species may have been previously established. However, in the coldest sites, Douglas-fir and ponderosa pine (if present) seedlings may benefit from a cover crop of lodgepole pine, which helps moderate the microenvironment in these sites (Smith and Fischer 1995).

Dwarf huckleberry is sensitive to damage by equipment and easily eliminated by mechanical equipment or trampling due to brittle stems while bearberry and pinegrass are relatively resistant to mechanical damage and will persist. Gentle slopes or benches with pinegrass make good locations for campgrounds and similar uses. However, huckleberries will soon be eliminated in high traffic areas.

COMPARISONS

The PSME/VACA Association is a subdivision of the PSME/VACCI Association described for the Okanogan N.F. (Williams and Lillybridge 1983) and of earlier drafts of the Colville N.F. guide. The PSME/VACA type has also been described for Montana (Pfister *et al.* 1977), central Idaho (Steele *etal.* 1981), central Washington (Lillybridge *etal.* 1995) and northern Idaho (Cooper *etal.* 1991). Montana variants differ by having more abundant ponderosa pine, dwarf huckleberry, elk sedge and beargrass and a relative lack of western larch (Pfister *et al.* 1977). It is apparently a minor type in Idaho (Cooper^ *al.* 1991, Steele *et al.* 1981). Clausnitzer and Zamora(1987) and Daubenmire and Daubenmire (1968) both describe an ARUV Phase ofaPSME/CARU Association that resembles,

in part, the PSME/VACA Association. Much of this type though represents warmer upland sites than that described for the PSME/VACA type.

Vaccinium caespitosum

dwarf huckleberry