Table 46. Environmental and structural characteristics of the ABLA2/RHAL-XETE Association.

	Mean	S.D.	Min	Max
Environment[1]				
Elevation	5536	372	4850	6520
Aspect[2]	90	71		
Slope	37	15	2	70
Topographic Moisture	3.85	0.84	3.0	6.0
Soil Surface[3]				
Exposed soil	20	5	15	25
Gravel	12	0	12	12
Rock	6	13	0	38
Bedrock	0	0	0	0
Moss	25	22	0	65
Lichen	1	2	0	5
Litter	31	17	10	60
Diversity[4]				
Richness	15.3	5.5	7	28
N2	5.6	1.5	4	9

' Values for environmental variables were generated using both classification plot and mapping plot data (n=45).
[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, N3, are expressed as average number of species per plot.

rusty menziesia. Beargrass is included as an important component in the ABLA2/RHAL-XETE type because of its persistence in the oldest stands, relatively limited geographic range (in this study area) and successional importance. Stands lacking beargrass will key to the ABLA2/RHAL Association.

Herbs are normally inconspicuous and are low in cover and constancy. Smooth woodrush occurs in some stands and indicates lingering snowpacks. Both richness and heterogeneity (N3) are well below Series averages (Table 46), but are consistent with other truly subalpine habitats. The low values indicate an environment with some severe limitations. Heterogeneity is slightly higher than that for ABLA2/RHAL, reflecting the importance of beargrass, while average richness for the two types is about equal.

MANAGEMENT IMPLICATIONS

Wildlife/Range- Bear, grouse, and many avian species use the berries of shrub species such as big huckleberry, serviceberry, and mountain ash. Beargrass is a desirable forage species for deer. The

Figure 74. Photo of the ABLA2/RHAL-XETE Association.

beargrass flowering heads are often cropped-off by the ungulates. The seeds are a favorite food of chipmunks and other rodents. Elk and deer use these sites for summer forage and cover. This is especially true for sites in early and mid-seral stages (Simpson 1990). Early serai species such as *Carex* spp. and pinegrass can be important spring forage for bears. These stands may also represent important thermal areas for deer and elk. Some of these stands are in late serai or old-growth stages and provide valuable habitat for old-growth dependent species. Mature stands on the Sullivan Lake Ranger District are important winter range for woodland caribou. The principal forage is epidendric lichens often draping the older trees. While managing for caribou habitat, severe bums should be minimized to protect *Vaccinium* spp. roots and to avoid dense lodgepole regeneration (Smith and Fischer 1995). These old-growth stands are important winter habitat for martin (Koehler and Homocker 1977). Herbage production for livestock is very low in most stands. Little use is made of ABLA2/RHAL-XETE stands by livestock.

Silviculture- Cold temperatures and heavy snow accumulations limit growth rates on these sites. Subalpine fir and Engelmann spruce are adapted to all sites and would be appropriate species for natural or artificial regeneration. Lodgepole pine is adapted to most sites and may be useful where other species fail. Western larch and Douglas-fir are suited only to the warmest habitats in the type and not recommended for wide scale regeneration. Engelmann spruce seedlings are suggested for wet or very frosty sites.

Water tables may be close to the soil surface on toe slopes or benches, and overstory removal on these sites may raise water tables to the surface, creating boggy conditions that are difficult to reforest. In addition, ashy soils can be compacted when wet. Selective harvest favors subalpine fir, but predisposes stands to blowdown. Clearcutting is suggested, except for high water table sites, even though this may increase snowpacks. Reforestation is less reliable than in the ABLA2/RHAL Association because of the additional competition from beargrass. These sites are good choices for natural regeneration and there is a high probability of success on most sites (Cooper *et al.* 1991). They may require 10 or more years for full stocking following mechanical scarification or broadcast burning. Artificial regeneration (with 1960's and 1970's techniques) was often successful, but was often redundant because of ample natural regeneration (Fiedler 1982).

Cascade azalea and rusty menziesia decrease in abundance in response to scarification and/or burning. Cool fire will stimulate beargrass, mountain ash and Utah honeysuckle. Very hot or repeated bums favor beargrass over the other species. Mechanical scarification is detrimental to huckleberries and beargrass. Beargrass is highly resistant to trampling damage and will exhibit little evidence of damage while most other shrubs suffer extensive damage under the same level of use.

Silvicultural treatments should consider the high wildlife values, especially for late serai or old-growth stands. There is relatively little old-growth on the Colville N.F. due to the extensive fire history of the area. Remaining late serai or old-growth stands likely represent very important habitat to species requiring late serai stand structures. Management plans need to address these important considerations. Managers also need to address the relative importance of these stands in watershed management, due to the high levels of precipitation (and subsequent runoff) which these sites receive.

COMPARISONS

Daubenmire and Daubenmire (1968) describe a broadly defined ABLA2/MEFE Association that occasionally contains Cascade azalea. These data would fit within their type. Pfister *et al.* (1977) in Montana describe a ABLA2/MEFE Association but their data does not contain Cascades azalea. They also describe rusty menziesia phases of other associations in the Subalpine Fir Series, so apparently view rusty menziesia's indicator value differently. Steele *et al.* (1981) also describe a ABLA2/MEFE Association for central Idaho as do Johnson and Clausnitzer (1992) and Johnson and Simon (1987) for northeast Oregon. Their types also do not contain Cascades azalea and have little or no beargrass. Cooper *et al.* (1991) describe a widespread ABLA2/MEFE Association that they divide into four phases. The ABLA2/RHAL-XETE Association appears to best fit their XETE Phase. This phase often has Cascade azalea and part of the range of their phase adjoins northeast Washington. Braumandl and Curran (1992) describe several Subalpine Fir/White-Flowered Rhododendron Site Associations for the southern interior of British Columbia, though none contain beargrass. The authors note that in the extreme southern portions of the Selkirk Mountains there are sites similar to the ABLA2/RHAL-XETE where substantial amounts of beargrass grow but have yet to be described.

ABLA2/TRCA3 ASSOCIATION CEF4 22
Abies lasiocarpa/Trautvetteria carohniensis
subalpine fir/false bugbane

DISTRIBUTION AND ENVIRONMENT

The Subalpine Fir/False Bugbane Association is a minor but distinctive high-elevation meso-riparian plant community. It can be found on all ranger districts, but is most common along the Kettle Mountain Crest and the southern portions of the Colville and Newport Ranger Districts (Figure 75). It generally occupies cold, moist-to-wet, upper-elevation sites near streams or on sub-irrigated slopes. Aspects are usually west to east (Figure 76). Plot elevations are located between 4,450 and 5,600 ft. (Table 48).

The regolith is volcanic ash mixed with glacial till, colluvium or glacial outwash, with the glacial till often comprised of metamorphic or basaltic rocks. Soils are poorly drained. Mottling and rust pockets was found in many soil pits, indicating high water tables for at least part of the year. Compacted layers in some soil profiles may indicate perched water tables. The ABLA2/COCA Association often adjoins this type on stream terraces. The ABLA2/CLUN or ABLA2/VAME Associations may occur on nearby sideslopes. The ABLA2/RHAL Association may adjoin this type on higher elevational sites. The ABLA2/TRCA3 Association may be confused with the PIEN/EQUIS.

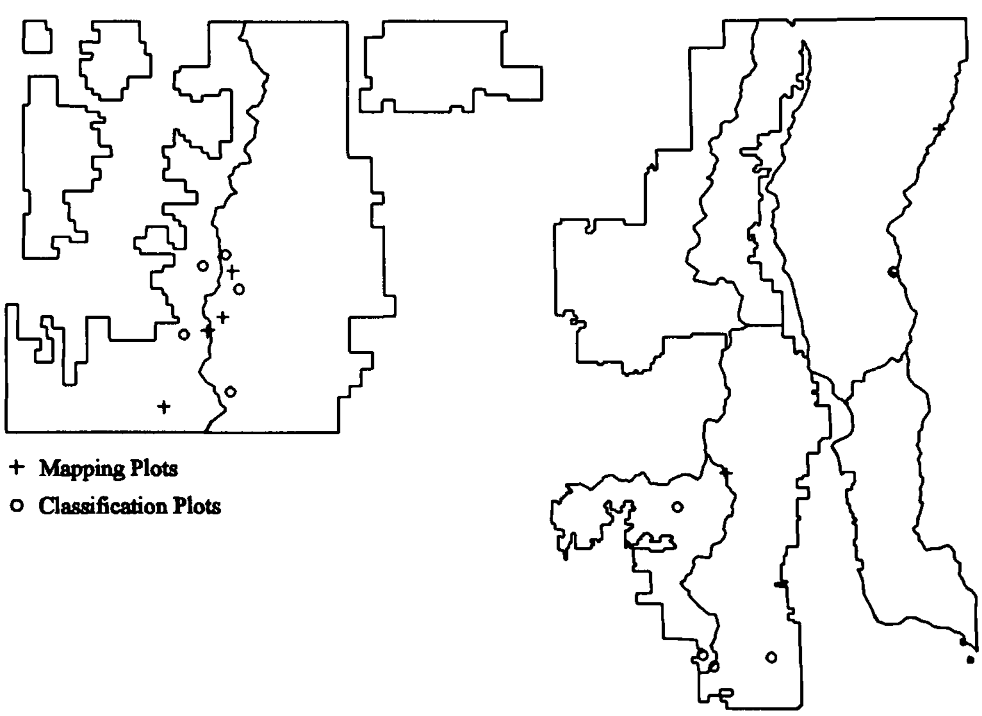


Figure 75. Plot locations for the ABLA2/TRCA3 Association (n=19).

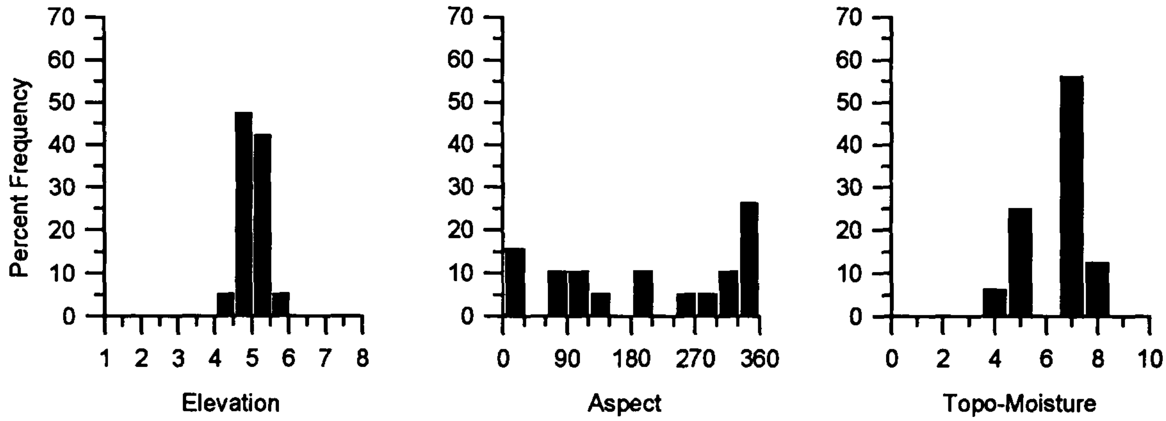


Figure 76. Frequency of ABLA2/TRCA3 plots by elevation (1000 ft.), aspect, and topographic moisture.

However, it tends to occur at higher elevations and on higher slope positions than the PEEN/EQUIS Association.

Table 47. Common plants of the ABLA2/TRCA3 Association (n=8).

		CON	COVER
IEEE OVERSTORY LAYER			
ABLA2	subalpine fir	88	23
PIEN	Engelmann spruce	88	15
PSME	Douglas-fir	88	7
LAOC	western larch	75	21
PICO	lodgepole pine	50	16
ABGR	grand fir	50	14
TT?d3 UNDERSTORY LAYER			
ABLA2	subalpine fir	88	3
PIEN	Engelmann spruce	63	1
SHRUBS AND SUBSHRUBS			
PYSE	sidebells pyrola	100	2
LOUT2	Utah honeysuckle	75	3
VAME	big huckleberry	63	19
RILA	prickly currant	63	4
PAMY	pachistima	63	2
SPBEL	shiny-leaf spirea	50	2
HERE^			
TRCA3	false bugbane	100	15
VIOR2	round-leaved violet	88	4
CLUN	queencup beadlily	75	7
THOC	western meadowrue	75	4

VEGETATION

Subalpine fir and Engelmann spruce will dominate late serai and climax stands. Grand fir may persist in small numbers in some stands. However, all stands sampled for this type are less than 100 years old so exact overstory composition in late serai stages is unknown. Engelmann spruce is common but is less abundant in these data than expected for such a moist and cool environment. Subalpine fir dominates the regeneration tree layer, especially in the oldest stands within the data. Engelmann spruce regeneration is typically present along with scattered grand fir.

Subalpine fir, grand fir, Douglas-fir, western larch or lodgepole pine dominate early serai stands depending on stand age, history and

Table 48. Environmental and structural characteristics of the ABLA2/TRCA3 Association.

	Mean	S.D.	Min	Max
Environment[1]				
Elevation	5031	355	4450	5600
Aspect[2]	355	48		
Slope	24	13	1	56
Topographic Moisture	6.43	1.21	4.0	8.0
Soil Surface[3]				
Exposed soil	45	19	25	70
Gravel	12	0	12	12
Rock	13	20	0	38
Bedrock	0	0	0	0
Moss	6	9	0	20
Lichen	0	1	0	1
Litter	55	30	15	80
Diversity[4]				
Richness	25.3	5.6	21	31
N2	9.7	2.6	4	11

[1] Values for environmental variables were generated using both classification plot and mapping plot data (n=19).
[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, N^, are expressed as average number of species per plot.

pattern of disturbance. Repeated fires favor pine when the interval between major conflagrations is less than 200 years. Less intense fires or longer intervals are more favorable to western larch or, to a lesser extent, Douglas-fir.

Shrub and herb layers are floristically rich and variable in both the numbers and amount of species. Big huckleberry and swamp current are the most common and abundant shrubs. A wide variety of other shrubs may be abundant as well. Sitka alder is a minor component of closed canopy stands but forms dense thickets if stands are burned or logged. False bugbane is characteristic and diagnostic and dominates the herb layer. Coolwort foamflower, round-leaved violet, lady-fern, queencup beadlily, and western meadowrue are common. Both richness and heterogeneity (N3) are higher than the Series average (Table 48), and any single stand in this type is likely to have close to 25 vascular plant species. The relatively high species richness and heterogeneity is a common characteristic of the cool and moist, but not cold, habitats within the Series.

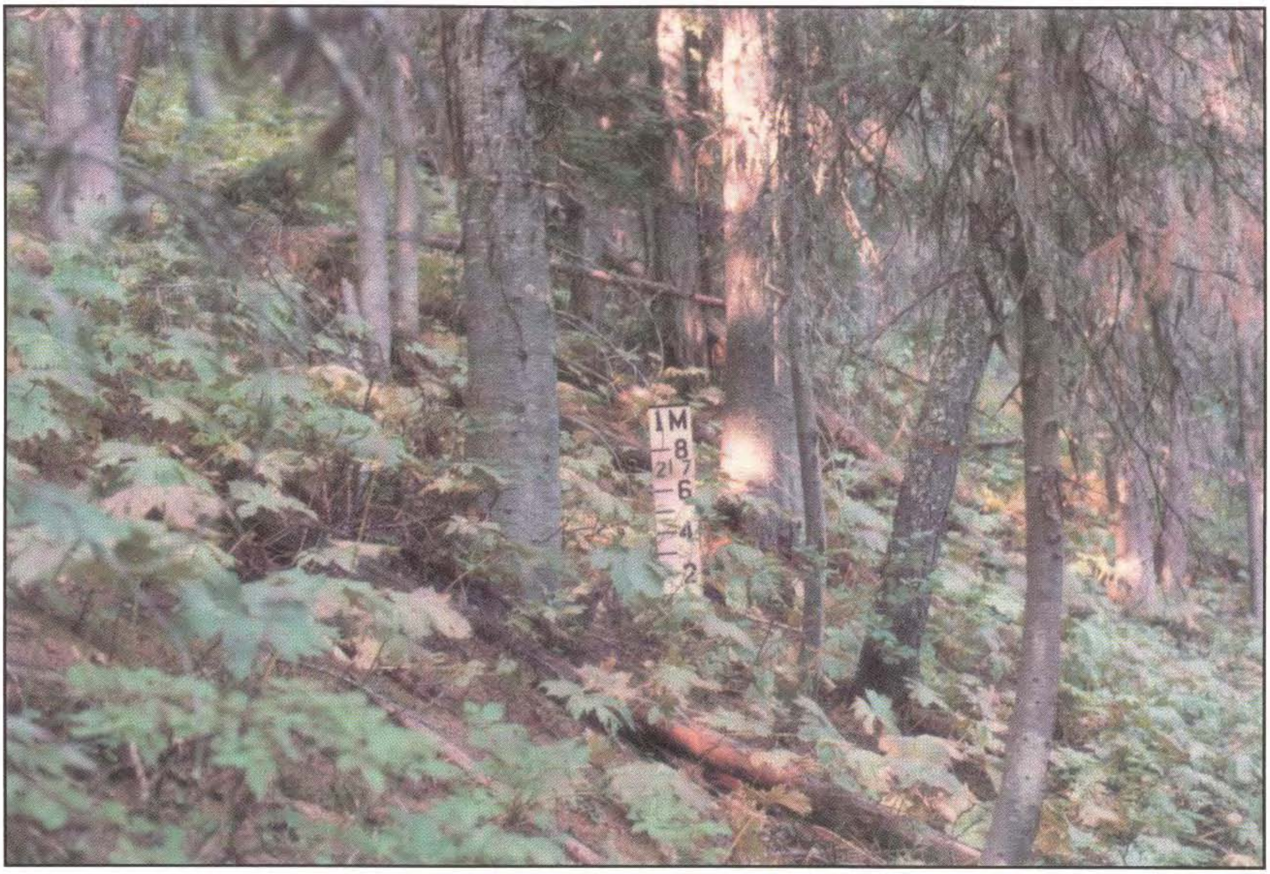


Figure 77. Photo of the ABLA2/TRCA3 Association.

MANAGEMENT IMPLICATIONS

Wildlife/Range- The type provides valuable riparian habitat for wildlife. Deer and elk use the type for cover and forage. Forage may be moderate to high depending upon serai stage and amount of shrub coverage. Wet spots make good elk wallows. Gentle slopes and close proximity to water make many of these sites susceptible to overgrazing. Livestock are attracted to these sites due to abundant herbs and water which usually remains throughout summer, though false bugbane may be toxic to livestock. Soils are very susceptible to disturbance from cattle. Continued overgrazing may chum soils and destroy herb and tree regeneration layers (Cooper *et al.* 1991). Livestock use should be monitored closely.

Silviculture- Management opportunities are limited due to high water tables and the close proximity to water courses. Tree productivity is the highest within the Series but stands are generally limited in acreage and are seldom large enough to be managed independently. Most stands are in small, moist stringers or pockets within larger management units. Removal of trees may raise the already high water table, creating sites with standing water. Soils are also subject to compaction and flooding. The dense Sitka alder thickets and saturated soils that develop following wildfire or timber harvest may inhibit conifer regeneration. Cold air accumulation causes additional concern for management. Frost pocket potential is high so careful attention should be paid to local topography and air drainage patterns to avoid concentrating cold air.

Partial-cutting can lead to high amounts ofwindthrow on these sites, which can be negated to a certain extent by clearcutting. However, shrub-dominated communities, especially those dominated by Sitka alder, often develop after clearcutting due to rising water tables. Conifer regeneration can be inhibited for long periods of time. Where this association occurs on uplands, sub-surface irrigation will also limit timber management alternatives and road building activities. Any use of heavy equipment should be delayed until late summer or fall when the soils are less saturated and less prone to damage from compaction (Cooper *et al.* 1991). Site development such as roads or trails should be avoided. Potential for natural regeneration with western larch is good especially when understory development of shrubs and herbs is sparse and water tables are not so high as to make the sites boggy. The moist nature of these sites limit the number of days when prescribed natural fires can burn and when management ignited fires can be conducted effectively and safely. Also, when the opportunity arises for effective prescribed bums on these sites, other fire suppression needs may be claiming forest resources in other locations (Smith and Fischer 1995).

Trails in these wet sites have been shown to be in poorer condition than surrounding drier upland sites such as ABLA2/VAME, ABLA2/VASC or ABLA2/RHAL. The lush vegetation development makes these sites interesting and attractive to those interested in wildflowers and taxonomy. However, the wet nature of the sites makes them very poor choices for recreation developments. Most of these forbs are sensitive to trampling and are easily damaged by foot traffic.

COMPARISONS

The ABLA2/TRCA3 Association is a subdivision of the broadly defined ABLA2/LIBOL Association of Williams and Lillybridge (1983). Johnson and Clausnitzer (1992) and Kovalchik (1993) describe nearly identical ABLA2/TRCA3 plant associations for northeast Oregon and northeast Washington, respectively. These data would fit within the broadly defined ABLA2/PAMY Association of Daubennure and Daubenmire (1968). One plot from that classification would key to this type. The ABLA2/STAM Habitat Type- LICA *[Ligusticum canbyi)* Phase of Cooper *et al.* (1991) and of Steele *et al.* (1981) in Idaho includes data that appear to fit this type. Most of the plots in the ABLA2/ GYDR Association of Clausnitzer and Zamora (1987) also appear to fit this type. Colville N.F. data have much less oak-fem. but these sites appear to be similar except for some floristic differences. Both types appear to indicate a similar habitat.

ABLA2/VACA ASSOCIATION CES4 22
Abies lasiocarpd/Vaccinium caespitosum
subalpine fir/dwarf huckleberry

DISTRIBUTION AND ENVIRONMENT

The ABLA2/VACA Association is most common west of the Columbia and Kettle Rivers on the Kettle Falls and Republic Ranger Districts (Figure 78). It is also locally abundant near the Little Pend Oreille Lakes on the Colville Ranger District. This type represents xero-riparian sites located on gentle, well-drained glacial outwash terraces and benches along lower slopes and in large stream bottoms. Sites generally have seasonally high water tables due to compacted subsoils and experience warm-day, frosty-night temperature regimes. This type is usually found at moderate elevations between 3,000 and 4,000 ft. on east to west aspects (Figure 79). Many stands in the type have been affected by grazing, homesteading, recreation developments or roads because of the favorable topography.

The regolith is volcanic ash deposited over glacial outwash or till. Nearly all sampled stands have compacted or very stony subsoils that limit root penetration. Upper soil horizons are typically mixed with ash and are well drained. Soil textures are silts to gravelly silt loams. Summer soil temperatures at 20 in. (50 cm) varied between 45 and 50 °F (7 and 10 °C). The ABLA2/VACA Association is

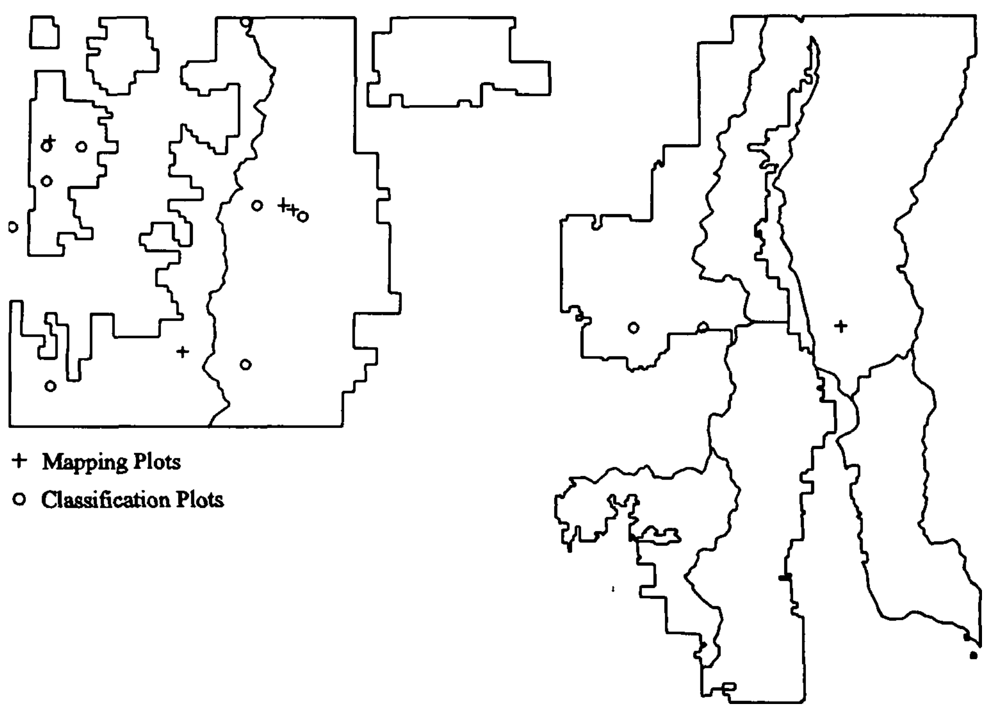


Figure 78. Plot locations for the ABLA2/VACA Association (n=20).

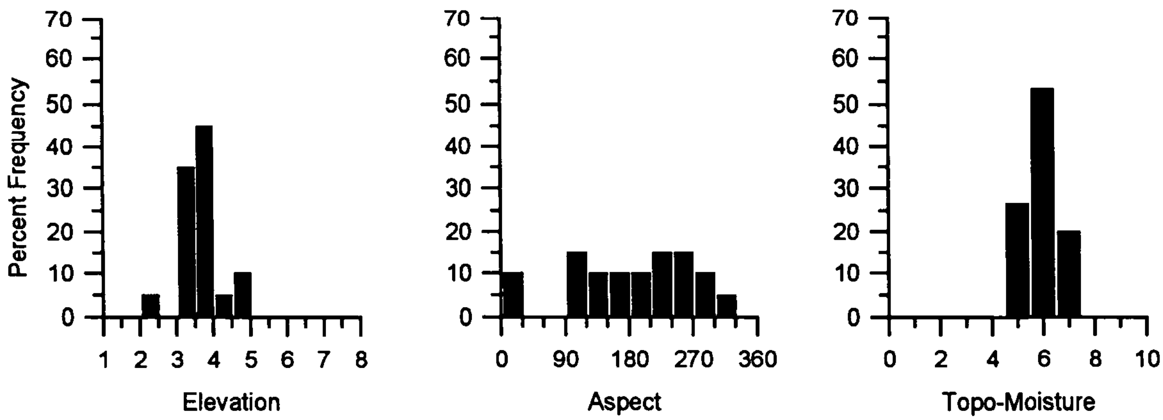


Figure 79. Frequency ofABLA2/VACA plots by elevation (1000 ft.), aspect, and topographic moisture.

closely related to the slightly less frosty ABGR/VACA Association. The PSME/ VACA Association occurs on still warmer sites. Stands that key to the ABGR/VACA or PSME/VACA Associations may actually belong to the ABLA2/VACA Association but lack, through disturbance, subalpine fir or Engelmann spruce. Careful examination of elevation range or geographic distribution may help make a proper assignment. Many stands in the PICO/ SHCA Community Type probably belong to this type, but lack of definitive indicators prevent their present assignment to a plant association.

Table 4S3. Common plants of the ABLA2/VACA Association (n=15).

		CON	COVER
IEEE.OVERSTORY LAYER			
LAOC	western larch	93	18
PSME	Douglas-fir	73	23
PICO	lodgepole pine	73	20
TRFF UNDERSTORY LAYER			
PSME	Douglas-fir	93	6
PIEN	Engelmann spruce	67	3
ABLA2	subalpine fir	60	6
SHRUB&AND SUBSHRUBS			
LIBOL	twinflower	93	19
PAMY	pachistima	93	5
ARUV	bearberry	87	9
AMAL	serviceberry	80	2
CHUM	western prince's pine	73	4
BEAQ	Oregon grape	73	2
VACA	dwarf huckleberry	67	6
LOUT2	Utah honeysuckle	67	3
SPBEL	shiny-leaf spirea	60	5
HERB^			
CARU	pinegrass	100	27
HIAL	white hawkweed	80	2
FRAGA	strawberry spp.	73	5
CACO	northwestern sedge	53	3

VEGETATION

Late serai or climax stands are absent from the data and successional patterns in this part of the sere are not fully understood. Theoretically, late serai or climax stands will be dominated by subalpine fir with some Engelmann spruce and a minor component of Douglas-fir.

Table 50. Environmental and structural characteristics of the ABLA2/VACA Association.

	Mean	S.D.	Min	Max
Environment[1]				
Elevation	3599	526	2480	4580
Aspect[2]	196	69		
Slope	18	12	1	38
Topographic Moisture	5.93	0.70	5.0	7.0
Soil Surface[3]				
Exposed soil	21	16	1	60
Gravel	17	13	1	38
Rock	8	19	0	62
Bedrock	0	0	0	0
Moss	1	1	0	4
Lichen	0	0	0	1
Litter	31	18	5	45
Diversity[4]				
Richness	28.0	6.2	17	38
N2	9.7	2.9	4.3	16.0

[1] Values for environmental variables were generated using both classification plot and mapping plot data (n=20).
[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.

Douglas-fir, western larch or lodgepole pine may dominate serai stands depending on stand age and history. A common stand structure is an open upper canopy of older, fire-resistant western larch or Douglas-fir over a subcanopy of younger Engelmann spruce, subalpine fir and/or lodgepole pine. The subcanopy cohort belong to a much younger age class that became established after a ground fire. Considerable differences in individual tree ages may exist within a stand due to the natural fire regime of this type.

Douglas-fir is the most common and often the most abundant tree species in the understory. Very open stands may also have western larch reproduction, but these are not expected to survive long enough to reach the upper canopy unless a disturbance removes most of the dominants. The abundant Douglas-fir (relative to subalpine fir and Engelmann spruce) indicates that long, disturbance free periods will be needed for Engelmann spruce and subalpine fir to become dominant (relatively rare in this type).

The undergrowth consists of a diverse mixture of low shrubs and subshrubs set in a pinegrass matrix. Few tall shrubs are present and those that are have a low abundance. Serviceberry and Utah honeysuckle are the only tall shrubs widely distributed in the type. The subshrubs and low shrubs are

Figure 80. Photo of the ABLA2/VACA Association.

often inconspicuous because of their stature and the abundant pinegrass. Twinflower, bearberry, Oregon grape, western prince's pine, pachistima, and a variety of huckleberry species are likely to be present in undisturbed stands. Dwarf huckleberry is the most common huckleberry. Grouse huckleberry, low huckleberry or big huckleberry are locally common. Pinegrass is present in every stand and usually abundant. Northwestern sedge may also be common.

Average species richness per plot in the ABLA2/VACA type is well above the average for the Series as a whole while the heterogeneity indices are about equal (Table 50). The high richness probably reflects the relative open canopy characteristic of the type which increases the range of microsite habitats available. The average heterogeneity values, despite the relatively rich flora available, probably reflect an environmental limitation associated with the unique environment of warm days-frosty nights. High grouse huckleberry cover indicates frostier than normal sites with a shorter growing season. Dwarf huckleberry indicates frost pockets with warm days and cold nights. Bearberry, and to a lesser extent, dwarf huckleberry suggest compacted or very stony subsoils that limit root penetration. Bearberry is also common on sandy soils or rocky outcrops. Most of these shrubs and herbs can resprout after fire.

Dwarf huckleberry is retained as the type name even though it is not present in every stand because:

a) studies in the northern Rocky Mountains on similar sites use dwarf huckleberry as the type indicator, and b) dwarf huckleberry combined with bearberry consistently indicates coarse textured glacial outwash terraces and slopes. Dwarf huckleberry is highly susceptible to mechanical injury while bearberry is much more resistant, making the latter a more consistent key species on disturbed sites.

MANAGEMENT IMPLICATIONS

Wildlife/Range- Deer and elk make moderate use of this type during the summer. *Vaccinium* spp. fruits are utilized by blue grouse and other wildlife species. Livestock grazing is common within the type. Twinflower and bearberry increase (or at least become more apparent) as pinegrass cover is reduced by grazing. Pinegrass provides moderately palatable forage for cattle. These sites are used for resting and shading areas by livestock as well.

Silviculture- This type has the lowest stand density index and lowest average basal area of any association within the Subalpine Fir Series (appendix 2). Since these stands are close to the lower elevation boundary for the Series, these low production indices point to some limiting site characteristics. Growth is slow on these sites due to frequent summer frosts combined with relatively warm daily maximum temperatures. Frost potential is high and slope position, topography and air drainage pattern must be considered in management planning. Frost is generally a result of cold air concentrations rather than radiation cooling. Both western larch and lodgepole pine are well adapted to these conditions and natural regeneration can be prolific if soils are not compacted and severe frost pockets are avoided. An ash horizon at the soil surface is usually present and especially subject to compaction. Lodgepole pine is the most tolerant tree species to frost and compacted soils. Pinegrass may hinder reforestation if pre-harvest cover is high.

Low-severity understory fires for thinning the overstory and preparing a patchy seedbed for regeneration can be used on these sites (Smith and Fischer 1995). In addition, prescribed fire can be used in conjunction with tree harvesting for site preparation and hazard reduction. On sites which may have seasonally high levels of soil moisture, management activities should be restricted to periods when soils are less vulnerable to compaction. Open stands of western larch and Douglas-fir over swards of pinegrass and gentle topography makes these sites desirable for campgrounds and similar types of uses. Dwarf huckleberry is easily eliminated by trampling but bearberry and pinegrass are relatively resistant to such activities. However, campers may prefer to locate themselves in areas that receive less frost than these sites.

COMPARISONS

The ABLA2/VACA Association is a part of the more broadly defined ABLA2/VACCI Association described for the Okanogan N.F. (Williams and Lillybridge 1983) and earlier drafts of the Colville N.F. guide. Similar ABLA2/VACA sites have been described in Montana (Pfister *et al.* 1977), central Idaho (Steele *et al.* 1981) and northern Idaho (Cooper *et al.* 1991). The Colville N.F. stands typically contain more Douglas-fir, Engelmann spruce, subalpine fir and western larch and generally less lodgepole pine than the stands described by Pfister *et al*. (1977). This may be due to the more severe continental climate (east of the Continental Divide) where the majority of their plots were sampled.

Vaccinium caespitosum
dwarf huckleberry

ABLA2/VAME COMMUNITY TYPE CESS 13
Abies lasiocarpci/Vaccinium membranaceum
subalpine *fir/big,* huckleberry

DISTRIBUTION AND ENVIRONMENT

The *ABLA2/VAME* Community Type is the most common subalpine fir plant community on the Colville N.F. It is found on all ranger districts, but is clearly most abundant west of the Columbia and Kettle Rivers in the Kettle Mountain Range (Figure 81). It occupies mid- to upper-slope positions on relatively cool and dry habitats at mid- to upper-elevations, and is located on a variety of aspects (Figure 82). Approximately 90% of the plots are above 4,000 ft. (Figure 82), with elevations ranging from 2,570 to 6,700 ft. (Table 52).

The regolith is volcanic ash mixed with glacial till or outwash. The tills are often ofmetamorphic or granitic origin (particularly along the Kettle Mountain Crest). Cobbles are common in the soils and most soils are well-drained to excessively well-drained. Most soil textures are gravelly silts to silts depending on the amount of volcanic ash mixed into the solum. The ABLA2/VAME type normally grades into the ABLA2/XETE, ABLA2/CARU or PSME/VAME Associations on drier habitats and into the ABLA2/COCA, ABLA2/LIBOL or the ABLA2/RHAL Associations on more moist habitats.

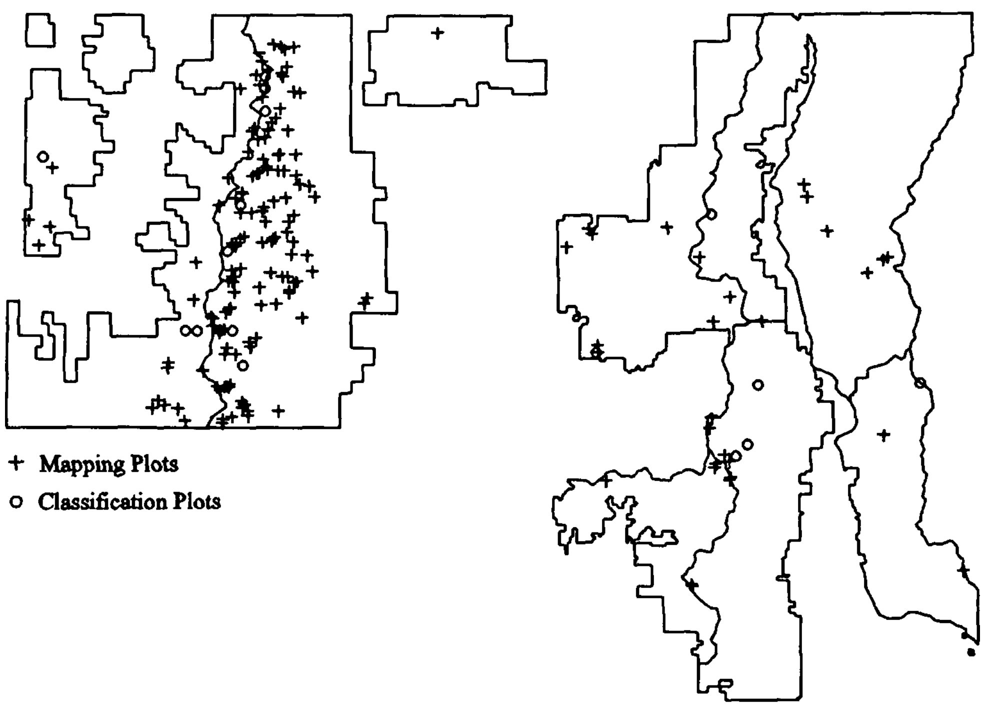


Figure 81. Plot locations for the ABLA2/VAME Community Type (n=191).

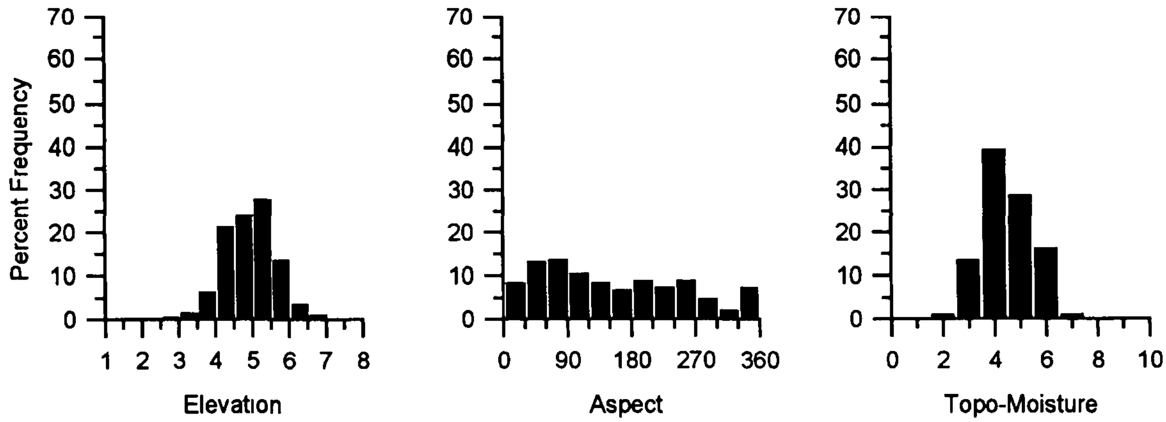


Figure 82. Frequency of ABLA2/VAME plots by elevation (1000 ft.), aspect, and topographic moisture.

VEGETATION

Mature stands are poorly represented in the data but apparently subalpine fir will dominate in the overstory and understory. Subalpine fir increases in prominence as stand ages exceed 100 years but this pattern is variable depending on amount and type of past disturbance. Subalpine fir dominates the regeneration layer, though Engelmann spruce is often present as reproduction but seldom very abundant. Scattered Douglas-fir reproduction may occur under open canopies but is also seldom abundant.

Western larch and Douglas-fir often occur as large serai remnants over a dense subcanopy of subalpine fir in early to mid-seral stands. Western larch or lodgepole pine commonly dominate early serai stands (<100 years old). Engelmann spruce is more common on northerly aspects while Douglas-fir is more common on southerly aspects.

Table 51. Common plants of the A]BLA2/VAME Community Type (n=24).

		CON	COVER
IEEE. OVERSTORY LAYER			
LAOC	western larch	96	19
PICO	lodgepole pine	79	22
ABLA2	subalpine fir	71	15
PSME	Douglas-fir	67	18
TWP UNDERSTQRYJAYER			
ABLA2	subalpine fir	79	11
SHRUBS AND SUBSHRUBS			
PAMY	pachistima	92	6
CHUM	western prince's pine	75	3
SPBEL	shiny-leaf spirea	63	6
LOUT2	Utah honeysuckle	63	3
VAMY	low huckleberry	58	10
VAME	big huckleberry	54	18
PYSE	sidebells pyrola	50	3
SHCA	russet buffaloberry	4	25
HEREIS			
CARU	pinegrass	79	25
VIOR2	round-leaved violet	79	3
HIAL	white hawkweed	75	2

Table 52. Environmental and structural characteristics of the ABLA2/VAME Community Type.

	Mean	S.D.	Min	Max
Environment'				
Elevation	4899	670	2570	6700
Aspect[2]	94	72		
Slope	28	15	1	66
Topographic Moisture	4.49	0.99	2.0	7.0
Soil Surface[3]				
Exposed soil	32	31	0	85
Gravel	20	25	1	38
Rock	17	19	0	38
Bedrock	0	0	0	0
Moss	5	8	0	30
Lichen	1	1	0	4
Litter	42	26	0	80
Diversity[4]				
Richness	23.5	5.9	13	32
N2	7.1	1.8	4	10

' Values for environmental variables were generated using both classification plot and mapping plot data (n=191)
[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.

The undergrowth is a diverse mixture of shrubs and herbs. Either big huckleberry and/or low huckleberry being the most abundant shrubs. Low huckleberry indicates somewhat cooler sites than does big huckleberry and grouse huckleberry indicates still yet cooler conditions. Grouse huckleberry is present on the coldest sites with the association. Other common shrubs and subshrubs include Pachistima, Utah honeysuckle, western princes's pine and shiny-leaf spirea. Herbs are variable in occurrence and abundance. Pinegrass is often abundant. Other common herbs include round-leaved violet, sweetroot and white hawkweed. Both species richness and heterogeneity are close to the Series average (Table 52).

Some sites in the Kettle Range that were severely burned in the 1929 Fire often closely resemble the ABLA2/VASC Association. However, these stands have low huckleberry instead of grouse huckleberry, have deeper soils and are at elevations lower than those typical of the ABLA2/VASC Association. However, due to problems identifying low and grouse huckleberry in the field, some high elevation ABLA2/VAME sites (based on presence of low huckleberry) may actually be ABLA2/VASC sites. We also suspect that many stands in the Kettle Mountains that key out to the PSME/VAME Community Type are actually ABLA2/VAME sites with little-to-none subalpine fir regeneration due to the extensive fire history in the area.

Figure 83. Photo of the ABLA2/VAME Community Type.

MANAGEMENT IMPLICATIONS

Wildlife/Range- Berry-producing shrubs such as big and low huckleberry, serviceberry, bearberry, Utah honeysuckle and baldhip rose all produce fruits which are important to a variety of wildlife. Berries are used by bear, grouse, non-game birds and humans. These sites provide good thermal and hiding cover for wildlife species. Herbage for livestock is moderately low and overgrazing further reduces pinegrass cover. Huckleberry species are easily damaged by trampling.

Silviculture- Stand density index is relatively high for the Subalpine Fir Series (appendix 2). Both western larch and Douglas-fir have good site index values and appear well adapted to these sites. Natural regeneration should be acceptable with properly applied seed tree harvests. Seed tree and shelterwood cuts are more favorable for regeneration than clearcuts. Douglas-fir and subalpine fir will regenerate better in small clearings that receive partial shade. Lodgepole pine is better suited for the colder sites, perhaps indicated by low amounts of grouse huckleberry or gentle terrain. It regenerates better in clearings that receive full sunlight. Douglas-fir regenerates well using shelterwood techniques.

Mechanical scarification may be used to reduce shrub competition and enhance Engelmann spruce regeneration, but substantial woody debris should be left to shelter seedlings. Natural regeneration after mechanical scarification required approximately 10 years while after broadcast burning required 15 years (Fiedler 1982). However, big huckleberry is easily damaged by scarification or heavy equipment. Big huckleberry and pinegrass should increase with canopy removal and may compete with regeneration seedlings, especially on the more moist sites. Management to enhance berry production may be an important consideration. Huckleberries will decrease with ground scarification and it's shallow rhizomes are very sensitive to trampling damage.

High pinegrass cover before harvest may indicate potential reforestation difficulties. These pinegrass-dominated habitats also tend to be on southerly or westerly aspects, increasing reforestation difficulty. Natural regeneration may decrease on sites after burning or piling woody debris, since woody debris is an important source of soil wood, acidifying the soil and nurturing ectomycorhizzal fungi (Harvey 1982). Wood also shelters tree seedlings (Smith and Fischer 1995). Very hot bums may severely damage the roots of big huckleberry, reducing the cover of this species for many years (Smith and Fischer 1995). However, low-severity bums can stimulate the growth of big huckleberry. In general, broadcast burning heavily favors lodgepole pine when present on sites, and favors shrubs over herbs, which may discourage pocket gopher expansion (Smith and Fischer 1995). Burning has been used beneficially to remove mistletoe-infested lodgepole pine (Chonka 1986) and inhibit spruce beetles by removing their food supply of cull logs or windthrows (Wright and Bailey 1982).

COMPARISONS

The ABLA2/VAME Community Type is part of the broadly defined ABLA2/VACCI Association (Williams and Lillybridge 1983). It is very similar to the ABLA2/VACCI Association reported for the Colville Indian Reservation (Clausnitzer and Zamora 1987). It is also similar to the ABLA2/VAME Association described for central Washington by Lillybridge *et al.* (1995), though that type contains very little low huckleberry. Big huckleberry was the dominant *Vaccinium* spp. in the preceding classifications. Similar types have also been described in central Idaho (Steele *et al.* 1981), Montana (Pfisterc/ *al.* 1977) and northeast Oregon (Johnson and Clausnitzer 1992). These types tend to have more grouse huckleberry and less lodgepole pine than the ABLA2/VAME type described for the Colville N.F. The ABLA2/VAME Association of Johnson and Simon (1987) for the Wallowa-Snake Province is similar to this type, and they also describe a stable successional stage dominated by lodgepole pine as a PICO/VAME Community Type. Braumandl and Curran (1992) describe Subalpine Fir/Grouseberry/Cladonia and Subalpine Fir/Falsebox/Grouseberry Site Associations. Portions of both of these types contain comparable environments and species compositions to the ABLA2/VAME Community Type.

ABLA2/VASC ASSOCIATION CES4 12
Abies lasiocarpa/Vaccinium scoparium
subalpine fir/grouse huckleberry

DISTRIBUTION AND ENVIRONMENT

The ABLA2/VASC Association is a minor type on the Colville N. F. It is more common to the west on the Okanogan N. F. Plot locations include upper elevation sites along the Kettle Mountain Crest and on prominent peaks such as Calispell Peak (Figure 84). The association typifies cold, high elevation sites on gentle or rolling benches and ridgetops. Locations are usually above 5,500 ft. (Figure 85), though elevations range from 3,680 to 6,720 ft. (Table 54). The type can extend well below the average elevation on sites with cold air accumulation. Aspects are variable. Severe frost is common on many of these sites.

Soils are cold, acid, shallow, droughty, well-drained and poorly developed. The regolith is comprised ofmetamorphic material such as gneiss and often mixed with volcanic ash. Soil textures are gravelly silts to very gravelly silts. The ABLA2/VASC Association grades into the ABLA2/RHAL Association on somewhat more moist habitats, particularly on steep northeast exposures. Drier, more exposed sites are often in whitebark pine associations. Warmer sites with abundant pinegrass are either the ABLA2/VAME or ABLA2/CARU types. Heavily burned stands in the ABLA2/

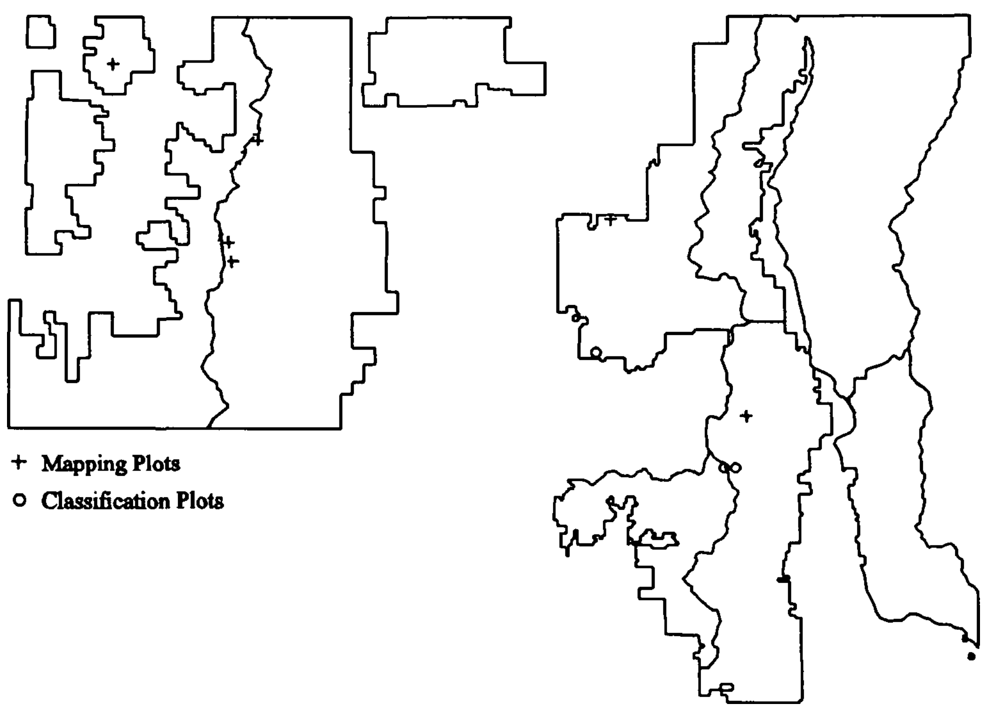


Figure 84. Plot locations for the ABLA2/VASC Association (n=12).

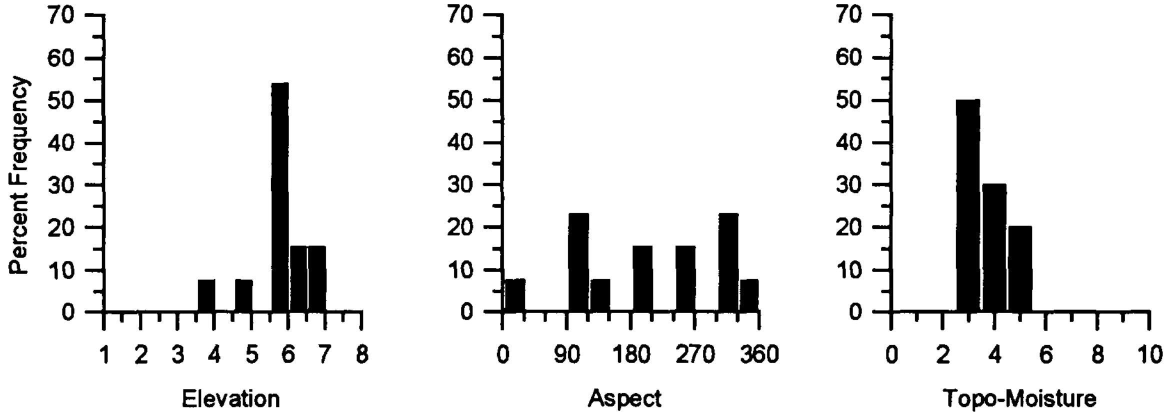


Figure 85. Frequency ofABLA2/VASC plots by elevation (1000 ft.), aspect, and topographic moisture.

VAME Community Type in the Kettle Mountains often closely resemble the ABLA2/VASC Association, apparently because of organic matter and nutrient depletion. Burned over ABLA2/VAME sites typically have only low huckleberry present and are at lower elevations and on generally deeper soils than those characteristic of the ABLA2/VASC Association.

VEGETATION

The data is limited in size and geographic extent. Late serai or climax stands are rare. Species composition and successional characteristics indicate that subalpine fir increases in importance as stands age. Engelmann spruce did not occur in the Colville N.F. data but has been sampled in the same type both in northern Idaho (Cooper *et al.* 1991) and on the Okanogan N.F. (Williams and Lillybridge 1983). Subalpine fir dominates the regeneration layer. Lodgepole pine is the most common tree species and dominates early to mid-seral stands. Sites are too harsh for Douglas-fir and western larch to do well although rare individuals may survive on favorable microsites. Whitebark pine may be found in the upper-elevational limits of

Table 53. Common plaints of the ABLA2/VASC Association (n=6).

		CON	COVER
IREE OVERSTORY LAVER			
ABLA2	subalpine fir	100	31
PICO	lodgepole pine	100	26
TRFFJIND^RSTQRY LAYER			
ABLA2	subalpine fir	100	14
SHRUBS AND SUBSHRUBS			
VASC	grouse huckleberry	67	25
PAMY	pachistima	67	6
CHUM	western prince's pine	67	2
VAMY	low huckleberry	50	10
SOSC2	mountain ash	50	2
HERE^			
VASI	Sitka valerian	83	3
LUPIN	lupine spp.	67	3
SENEC	groundsel spp.	67	2
HYMO	pinesap	50	2

Table 54. Environmental and structural characteristics of the ABLA2/VASC Association.

	Mean	S.D.	Min	Max
Environment[1]				
Elevation	5750	793	3680	6720
Aspect[2]	322	65		
Slope	25	15	1	45
Topographic Moisture	3.7	0.82	3.0	5.0
Soil Surface[3]				
Exposed soil	19	20	1	40
Gravel	20	25	2	38
Rock	17	19	0	38
Bedrock	0	0	0	0
Moss	8	3	5	10
Lichen	1	1	0	2
Litter	70	18	55	90
Diversity[4]				
Richness	11.0	3.0	9	17
N2	3.9	1.7	2.5	7.1

' Values for environmental variables were generated using both classification plot and mapping plot data (n=13).
[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, N;, are expressed as average number of species per plot.

these sites.

The depauperate undergrowth is dominated by a prostrate layer of grouse huckleberry. The leaf size of the huckleberry may occasionally exceed the limits described for grouse huckleberry and therefore is called low huckleberry. See the section on taxonomic problems in the introduction. Pachistima, western princess pine, Sitka valerian, and various lupine species are typically present but seldom abundant. Undergrowth is apparently naturally depauperate due to the harsh nature of the sites. The average species richness and heterogeneity (N;) indices are the lowest for the Series reinforcing the interpretation that these are the harshest sites described for the Subalpine Fir Series (Table 54).

MANAGEMENT IMPLICATIONS

Wildlife/Range- Grouse huckleberry fruits are edible, and provide important food for wildlife, especially species of grouse and bear. Dense lodgepole pine stands in this type are important components of Canadian lynx habitat because of the relative abundance ofsnowshoe hares. These stands are also considered important habitat for marten. These sites are reportedly good nesting

Figure 86. Photo of the ABLA2/VASC Association.

habitat for red crossbill, dark-eyed junco, mountain chickadee, and red-breasted nuthatch species (Steeled/a/. 1981). Forage potential for domestic livestock grazing is generally very low. Early successional stages may produce some grass and shrub forage. Use by livestock is generally low except for cover and bedding on these sites.

Silviculture- Cold temperatures, snowpack and potential late-summer drought are all concerns for timber management. Trees grow slowly in these harsh conditions. Site index tends to decrease with increasing elevation, especially above 6,500 ft. Frost may occur at any time of the year, either from re-radiation cooling or cold air ponding. Frost pockets often develop after overstory removal. Lodgepole pine is the most reliable species under an even-aged management scenario and will regenerate quite well in unshaded clearings. Clearcutting and burning is not an ecological substitute for the crown fires typical of the association. For example, post-fire snags give protection to seedlings from sun and frost. In consequence, burned areas often have excessive regeneration while some harvest units may have little or none. Harvested areas may have little or no regeneration if prescribed fire is used after harvest to treat slash. Fire in these situations destroys the seed stored in serotinous cones left on site. Any prescribed burning or site preparation by mechanical means must be completed within a short time after logging to avoid loss of stored seed. Most roots are concentrated in the upper 8 in. (20 cm) or less of soil suggesting low nutrient availability.

Disturbance or removal of the upper soil horizons will greatly reduce productivity. In addition, soil scarification may increase frost heaving. The shallow soils can be easily displaced by heavy equipment.

Stocking level control is needed to maintain reasonable growth rates for lodgepole pine regeneration. Unmanaged lodgepole pine stands often quickly stagnate so thinning before stagnation is necessary to insure good response. Grouse huckleberry is sensitive to mechanical or trampling damage so the type is a poor choice for campgrounds if the natural vegetation is to be maintained. Annual snowpacks on these sites may produce high quantities of water in certain watersheds.

COMPARISONS

Associations nearly identical to the ABLA2/VASC Association have been reported by many workers in the Pacific Northwest. Only the most applicable studies are cited. The association has been described in Montana (Pfister *et al.* 1977), northern Idaho (Cooper *et al.* 1991), central Idaho (Steele *etal.* 1981), central Washington (lillybridge *et al.* 1995) and eastern Washington and northern Idaho (Daubenmire and Daubenmire 1968). Most of these preceding classifications use LUHI as an additional indicator to identify the upper elevational environment for this type. Additional types have been reported in northcentral Washington (Clausnitzer and Zamora 1987, Williams and Lillybridge 1983), northeastern Oregon (Johnson and Clausnitzer 1992, Johnson and Simon 1987) and British Columbia (McLean 1970). Braumandl and Curran (1992) describe Lodgepole Pine-Engelmann Spruce/Pinegrass and Subalpine Fir/Grouseberry/Cladonia Site Associations for the southern interior of British Columbia. Both of these broader Site Associations include environments and species compositions which are similar to the ABLA2/VASC Association.

Vaccinium scoparium
grouse huckleberry

ABLA2/XETE ASSOCIATION CEF111
Abies lasiocarpa/Xerophyllum tenax
subalpine fir/beargrass

DISTRIBUTION/ENIRONMENT

The ABLA2/XETE Association is most common east of the Pend Oreille River on the Newport and Sullivan Lake Ranger Districts (Figure 87). The distribution ofbeargrass is closely correlated with the Inland Maritime weather pattern, and thus, is limited to the eastern-half of the Forest. It typically occupies upper-slope or ridgetop positions above 5,000 ft. on southeast to west aspects (Figure 88). Elevations range from 4,500 to 6,680 ft. and average aspect is 208 degrees (Table 56). Non-forest openings are found next to ABLA2/XETE stands. The type grades into the TSHE/XETE Association on warmer habitats and into the ABLA2/RHAL-XETE Association on cooler aspects or moister soils.

The regolith is volcanic ash deposited over glacial till or residual material. Granite or quartzite are the parent rock type for most tills. Soils are well drained. Soil textures are silts and gravelly silt loams. Soil pH measurements are as low as 4.3 in the upper horizons which indicates acidic, nutrient poor soils. Most soils are relatively cold with summer temperatures at 20 in. (50 cm) of 6 °C.

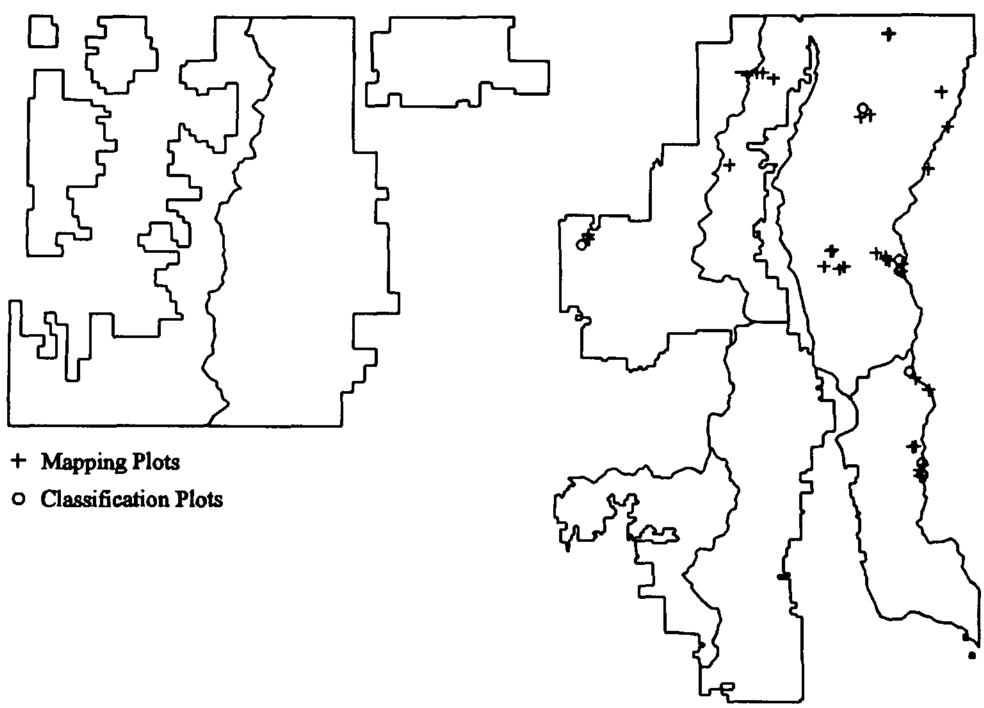


Figure 87. Plot locations for the ABLA2/XETE Association (n=47).

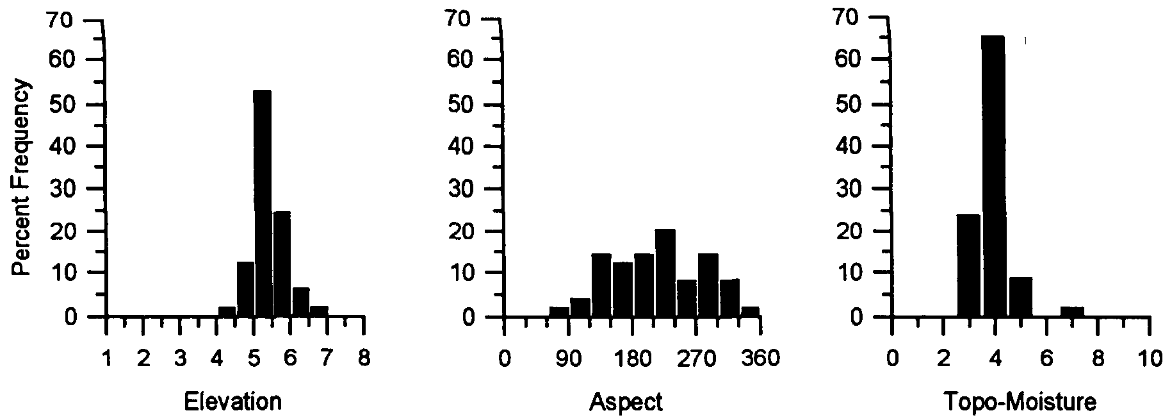


Figure 88. Frequency ofABLA2/XETE plots by elevation (1000 ft.), aspect, and topographic moisture.

VEGETATION

Mature stands are characterized by an open or patchy canopy of subalpine fir over a dense, low shrub layer composed mainly ofbeargrass and big huckleberry. Engelmann spruce is found in most stands but has relatively low cover. Abundant subalpine fir dominates the reproduction layer, and small numbers of Engelmann spruce regeneration are also usually present. Western hemlock and western redcedar often form a minor part of the tree sere. apparently reflecting transitional conditions to the TSHE/XETE Association. Other trees present in early to mid-seral stands are western larch, lodgepole pine and Douglas-fir. Lodgepole pine tends to increase in serai dominance on harsher, upper-elevation sites. Western white pine may be part of the sere on more moderate sites. Whitebark pine may be found occasionally in the extreme upper elevations of this type.

The undergrowth generally consists of abundant beargrass and big huckleberry.

Table 55. Common plants of the ABLA2/XETE Association (n= 10).

		CON	COVER
TREEOVERSTQRYLAYER			
ABLA2	subalpine fir	100	35
PIEN	Engelmann spruce	70	11
PICO	^S^P^	50	6
PSME	Douglas-fir	50	6
TRFRTINDERSTORYLAYRR			
ABLA2	subalpine fir	100	20
p^	Engelmann spruce	70	3
SHRUBSANDSUBSHRUBS			
XETE	beargrass	100	31
SOSC2	mountain ash	100	4
VAME	big huckleberry	90	24
LOUT2	Utah honeysuckle	70	3
VAMY	low huckleberry	50	10
RHAL	Cascades azalea	50	3
HERBS			
LUHI	smooth woodrush	60	3
HIAL	white hawkweed	60	2

Table 56. Environmental and structural characteristics of the ABLA2/XETE Association.

	Mean	S.D.	Min	Max
Environment[1]				
Elevation	5400	443	4500	6680
Aspect[2]	208	58		
Slope	32	15	1	68
Topographic Moisture	3.91	0.73	3.0	7.0
Soil Surface[3]				
Exposed soil	9	10	2	20
Gravel	38		38	38
Rock	9	16	0	38
Bedrock	0	0	0	1
Moss	12	15	3	20
Lichen	1	1	0	2
Litter	38	19	25	60
Diversity[4]				
Richness	15.0	5.6	7	24
N2	4.7	1.8	3.1	7.3

[1] Values for environmental variables were generated using both classification plot and mapping plot data (n=49).
[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.

Mountain ash, Utah honeysuckle or Cascades azalea are usually present in low amounts. A variety of other shrubs may be present, but Cascades azalea is absent or with very low cover. Herbs are inconspicuous. Smooth woodrush is the most common herbaceous species, indicating deep snowpacks.

Average richness and heterogeneity (N2) are relatively low and comparable to the ABLA2/RHAL and ABLA2/RHAL-XETE Associations (Table 56). These values seem to reflect the relatively harsh subalpine environment characteristic of these sites.

MANAGEMENT IMPLICATIONS

Wildlife/Range- ABLA2/XETE sites may produce abundant wildlife forage in early and mid-seral stages (Simpson 1990). Deer, elk and other wildlife use the berries of shrubs such as big huckleberry, mountain ash, elderberry, and serviceberry in late summer and fall. The flowering heads ofbeargrass are heavily used as forage by ungulates, and rodents prefer the seeds. Some of these stands may be in late serai or old-growth stages and provide valuable habitat for species dependant upon these stand

Figure 89. Photo of the ABLA2/XETE Association.

structures. Mature stands on the Sullivan Lake Ranger District may represent important winter range for woodland caribou. The principal forage is epidendric lichens often draping the larger trees. While managing for caribou habitat, severe bums should be minimized to protect *Vaccinium* spp. roots and to avoid dense lodgepole regeneration (Smith and Fischer 1995). There is little herbage for domestic livestock on ABLA2/XETE sites.

Silviculture- Tree growth is slow and reforestation often difficult due to relatively harsh sites and shrub competition. Extremes in environmental conditions include south and west slopes with desiccating winds, large diurnal temperature ranges, droughty soils and snow removal by wind. Selective-cutting techniques expose Engelmann spruce and subalpine fir to windthrow. Clearcutting can lead to the development of open shrubfields which can also retard reforestation efforts. Clearcuts can also increase snow deposition and retard reforestation on these sites. Partial-cutting has been recommended for severe steep and dry sites where regeneration tends to be slow and difficult (DeByle 1981, Fiedler 1982).

Research results concerning site preparation for conifer regeneration has been somewhat mixed. Broadcast-burning following clearcutting has been reported to be both beneficial (Shearer and Stickney 1991) and non-beneficial (Amo *etal.* 1985, Simpson 1990) for enhancing tree regeneration on these sites. Natural regeneration may decrease on sites after burning or piling woody debris. Woody debris is an important source of soil wood, acidifying the soil and nurturing ectomycorhizzal fungi (Harvey 1982). Wood debris also shelters tree seedlings (Smith and Fischer 1995). Very hot bums will favor beargrass but may severely damage the roots of big huckleberry, depleting this species for many years (Smith and Fischer 1995). Low-severity bums can stimulate both beargrass and big huckleberry. In general, broadcast burning heavily favors lodgepole pine, and favors shrubs over herbs, which may discourage pocket gopher expansion (Smith and Fischer 1995). Burning has been used beneficially to remove mistletoe-infested lodgepole pine (Chonka 1986) and inhibit spruce beetles by removing their food supply of cull logs or windthrows (Wright and Bailey 1982).

Generally, natural regeneration is usually adequate to restock these sites. Planting does not seem to improve regeneration in ABLA2/XETE communities (Fiedler 1982). Fiedler (1982) also reported that regeneration in clearcuts in northwestern Montana was improved by scarification compared to burning, and that the "no treatment" option was the least successful method. Natural regeneration after mechanical scarification required approximately 10 years while after broadcast burning required 15 years. Mechanical scarification may be used to reduce shrub competition and enhance Engelmann spruce regeneration. However, both beargrass and big huckleberry are easily damaged by scarification or heavy equipment, so care must be used not eliminate or deplete these species. Regardless of techniques, substantial woody debris must be left on sites to shelter seedlings.

Guidelines for species selection on ABLA2/XETE sites have been given by Simpson (1990). Lodgepole pine appears suited to most ABLA2/XETE sites, and perhaps is the best species for timber management. Douglas-fir may be suited for regeneration on sites where ceanothus or sticky currant are present. In general, Douglas-fir and western larch appear best suited to the warmer, more moderate sites. Utah honeysuckle and swamp currant are useful indicators of potential Engelmann spruce sites. Engelmann spruce or lodgepole pine should do well on harsher, upper-elevation sites containing smooth woodrush.

Watershed management should recognize the moderately high precipitation coupled with high evapo-transpiration and run-off rates on southerly exposures. Snowpack on these sites may melt periodically during mild winter weather and disappear in the spring several weeks earlier than in adjacent types. Beargrass is important to protect watersheds in these exposed sites which are subject to rapid snowmelt. Many of these sites are used by recreationalists in summer. Big huckleberry stems are very sensitive to trampling damage and its shallow rhizomes are also easily damaged by foot traffic or equipment.

COMPARISONS

Similar types are described in northern Idaho (Cooper *et al.* 1991, Daubenmire and Daubenmire 1968), central Idaho (Steele *et al.* 1981) and Montana (Pfister *et al.* 1977). Workers other than Daubenmire and Daubenmire (1968) have generally subdivided the association into phases based on species such as smooth woodrush (LUHI) and globe huckleberry (VAGL). Most of the Colville N.F. plots would best fit the ABLA2/XETE-VAGL Phase due to the low average cover of LUHI on most plots. However, some sampled stands do fit the LUHI Phase of Cooper *et al.* (1991) for northern

Idaho. Braumandl and Curran (1992) do not describe any similar types for the southern interior of British Columbia. However, the authors note that in the extreme southern portions of the Selkirk Mountains there are communities similar to the ABLA2/XETE (with substantial amounts of beargrass) that have yet to be described.

Xerophyllum tenax
beargrass

PIEN/EQUIS ASSOCIATION CE-M2-11
Picea engelmannii/Equisetum
Engelmann spruce/horsetail

DISTRIBUTION AND ENVIRONMENT

The PIEN/EQUIS Association is a minor type on the Colville N.F., and is best developed west of the Columbia River on the Kettle Falls and Republic Ranger Districts (Figure 90). It occurs on moist to wet river bottoms, flats and benches. The association represents meso-riparian conditions where running or standing water is usually evident. It is found on a variety of aspects generally between 3,000 and 4,500 ft. (Figure 91). It occasionally occurs within the geographic range of western redcedar and western hemlock, but is restricted to habitats too cold to support the THPL/OPHO Association.

The regolith is alluvium or glacial till. We have observed on the Colville N.F., but not sampled, PIEN/EQUIS stands on steep slopes (> 60%) where compacted glacial tills have created a perched water table. Some soils are too wet for a soil pit. Okanogan N.F. data are included to augment the sample for the type.

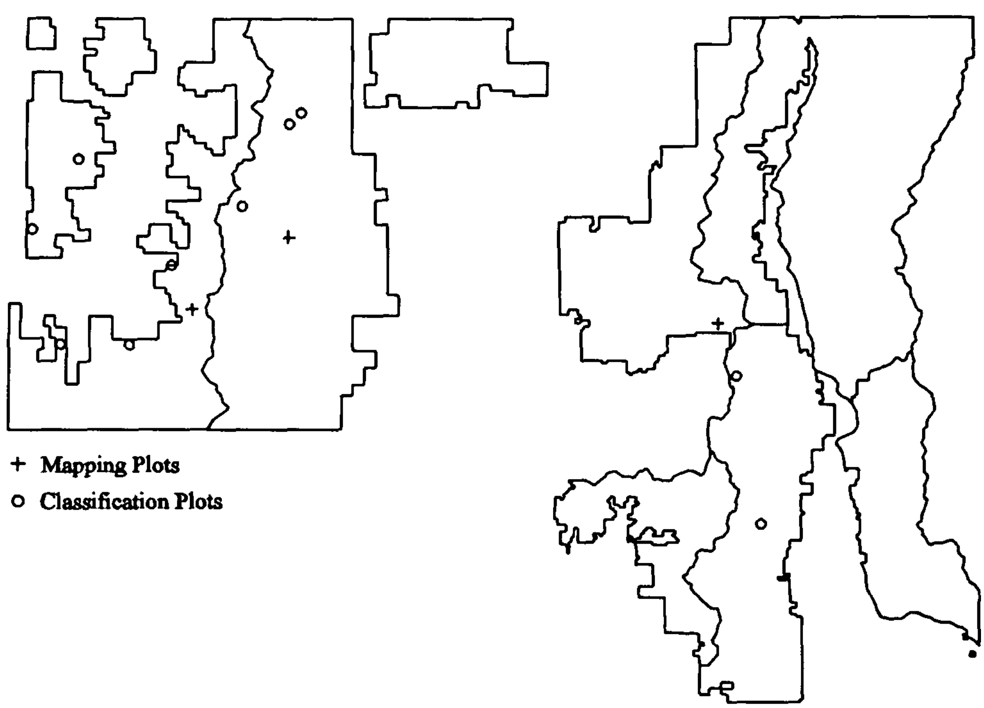


Figure 90. Plot locations for the PIEN/EQUIS Association (n=14).

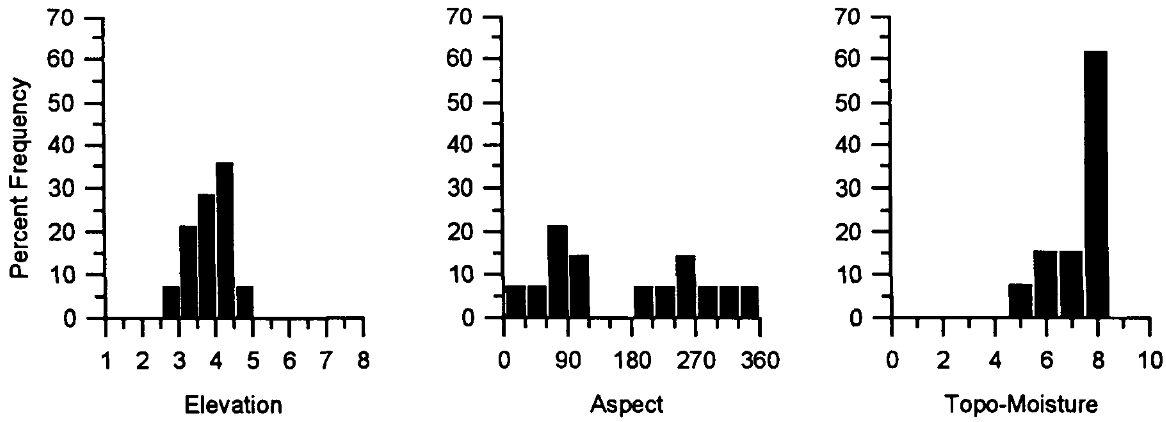


Figure 91. Frequency ofPIEN/EQUIS plots by elevation (1000 ft.), aspect, and topographic moisture.

VEGETATION

Engelmann spruce often dominates the overstory and understory of mature stands. Subalpine fir is often present in these stands but is usually not abundant. Lodgepole pine is reported as a prominent serai species from this type in western Montana (Pfister *etal.* 1977) and central Oregon (Kovalchik 1987). It is generally found on slightly drier hummocks. Western larch or Douglas-fir are also found on hummocks when present. Black cottonwood is common on a few plots from the Okanogan area but is lacking on the Colville N.F. plots.

Undergrowth composition and abundance is variable as a result of variation in water table depth. Common horsetail and moisture-loving herbs and shrubs are prominent in wet, low areas. The most common shrubs are red-osier dogwood, prickly currant and bunchberry dogwood. They occur on relatively dry root-crown hummocks. Common horsetail, lady-fern,

Table 57. Common plants of the PIEN/EQUIS Association (n=5).

		CON	COVER
TREE OVERSTORY LAYER			
PIEN	Engelmann spruce	100	44
ABLA2	subalpine fir	80	13
TREE UNDERSTORY LAYER			
PIEN	Engelmann spruce	100	2
ABLA2	subalpine fir	80	5
SHRUBS AND SIJBSHRUBS			
COCA	bunchberry dogwood	100	8
COST	red-osier dogwood	100	5
RILA	prickly currant	100	4
ALSI	Sitka alder	80	9
LIBOL	twinflower	80	4
RUPE	five-leaved bramble	60	3
VAMY	low huckleberry	60	3
HEREiS			
CACA	bluejoint reedgrass	100	5
EQAR	horsetail	80	36
GYDR	oak-fern	80	19
STAM	claspleaf twisted-stalk	80	4
ATFI	lady-fern	80	3
TRCA3	false bugbane	80	2
TIUN	coolwort foamflower	60	5
OSCH	sweetroot	60	2
SETR	arrowleaf groundsel	60	2

Table 58. Environmental and structural characteristics of the PIEN/EQUIS Association.

	Mean	S.D.	Min	Max
Environment'				
Elevation	3810	472	3000	4630
Aspect[2]	47	68		
Slope	9	19	1	72
Topographic Moisture	7.3	1.03	5.0	8.0
Soil Surface[3]				
Exposed soil	12	3	10	15
Gravel	12		12	12
Rock	0	1	0	1
Bedrock	0	0	0	0
Moss	8	9	0	20
Lichen	1	1	0	2
Litter	38	19	25	60
Diversity[4]				
Richness	27.3	5.0	20	35
N2	7.1	1.0	6.2	8.9

' Values for environmental variables were generated using both classification plot and mapping plot data (n=14).
[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, N2, are expressed as average number of species per plot.

oak-fem, bluejoint reedgrass and claspleaftwisted-stalk are the most common and abundant herbs. Readers should refer to Kovalchik (1993) for a more detailed description of these and other riparian plant associations found on the Colville N.F. Average species richness is slightly above the Series average while heterogeneity (N3) is about equal (Table 58). Higher values might be expected in such moist habitats, but the PIEN/EQUIS Association represents a wet and frosty environment that verges on the extreme cold and wet. Overstory and understory species composition is noticeably poor, and many stands are almost monotypic to spruce.

MANAGEMENT IMPLICATIONS

Wildlife/Range- Wet forests have high value for a variety of wildlife because of abundant lush vegetation that remains succulent throughout the growing season as well as for water and cover. Big game may seek out the lush forbs and use these sites for wallows. In addition, due to the large size many of the Engelmann spruce attain in this type, these sites likely represent important habitat for species dependent upon old-growth-like stand structures. The humid conditions may also attract a large variety of insects, which in turn attract avian species. Herbage for domestic livestock is limited

Figure 92. Photo of the PIEN/EQUIS Association.

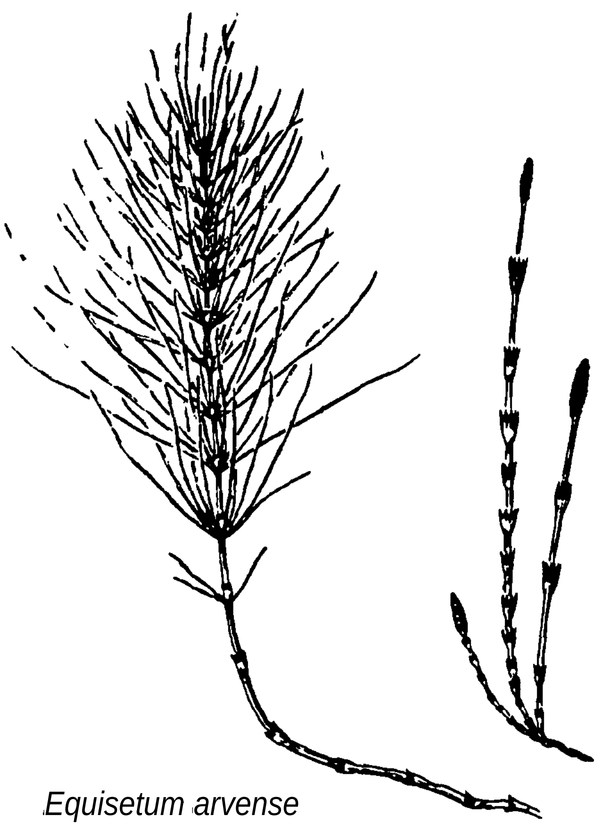
but cattle may congregate seeking water and shade. As with many types of meso-riparian plant communities, concentrated cattle use can destroy the plant cover of these sites. Sites should be monitored very closely.

Silviculture- Timber productivity is relatively high for the Subalpine Fir Series, but saturated soils make management difficult. Engelmann spruce is the conifer best suited to these wet habitats. Tree removal often raises the water table by reducing evapo-transpiration. Engelmann spruce and subalpine fir are highly susceptible to windthrow on these wet sites. Saturated soils also greatly inhibit tree regeneration and creates extreme problems for road construction and maintenance. Roads are subject to repeated movement and mass wasting, especially on steeper slopes. Adequate drainage is difficult to establish because ofsubirrigated soils.

Advanced natural regeneration often occurs only on drier root-crown hummocks under the trees. Tree harvest may create boggy conditions nearly impossible to reforest. Observations of old clearcuts indicate that three decades or more pass before even minimal stocking is attained. Frost is also a serious concern for conifer regeneration. Wet soils, heavy snowpacks and susceptibility of shrubs to mechanical damage makes these sites poor for recreation developments or trails.

COMPAMSONS

Many researchers in the northwest have described plant associations similar to the PIEN/EQUIS Association of the Colville N.F. Pfister *et al.* (1977) describe a PICEA/EQAR Association (spruce/ common horsetail) in Montana that appears nearly identical to the PIEN/EQUIS Association. However, the spruce in their stands exhibited considerable introgression with white spruce *(Picea glaucd).* Steele *et al.* (1981) and Kovalchik (1987, 1993) describe essentially identical types for central Idaho (PIEN/EQAR), central Oregon (PIEN/EQAR-STAM) and northeast Washington (PIEN/EQAR), respectively. A PIEN/EQAR Association is also described for the Blue Mountains in northeast Oregon by Crowe and Clausnitzer (1995). Braumandl and Curran (1992) describe a Subalpine Fir/Common Horsetail/Leafymoss Site Association for the interior of British Columbia which is very similar to the PIEN/EQUIS Association of the Colville N.F. The authors describe several other closely related Subalpine Fir/Common Horsetail Site Associations for the Okanogan Highlands. However, these latter types all contain Labrador tea *(Ledum glandulosum),* a species rarely found on the Colville N.F. OgUvie (1962) described a PICEA/EQUISETUM Habitat Type for the Rocky Mountains of Alberta.



Equisetum arvense
common horsetail

WESTERN HEMLOCK SERIES

WESTERN HEMLOCK SERIES

Tsuga heterophylla

TSHE

DISTRIBUTION AND ENVIRONMENT

Western hemlock has a distribution in Washington which is nearly identical to that of western redcedar, with disjunct coastal and interior populations. The interior distribution, which includes portions of the Colville N. F., is closely correlated with the Inland Maritime climatic regime. Western hemlock is the most shade tolerant and environmentally restricted conifer on the Colville N. F. The Series is limited to the eastern-half of the Forest (Figure 93), and is found primarily east of a line formed by the Columbia and Kettle Rivers. It occurs only sporadically in isolated stands west of this line and is apparently absent (or extremely rare) on the Colville Indian Reservation (Clausnitzer and Zamora 1987). Most stands are found between 2,500 and 5,000 ft. (Figure 94), though the Series can occur as high as 5,800 ft. on warm southerly slopes in areas of high precipitation. Aspects can be variable, though the Series becomes more environmentally restricted to northern aspects towards the southern and central portions of the Forest (Figure 95). Soils tend to be deep and include a significant amount of ash.

With one exception, the presence of western hemlock indicates that the stand belongs in the Western Hemlock Series. These are swampy habitats co-dominated by western redcedar. Very wet habitats

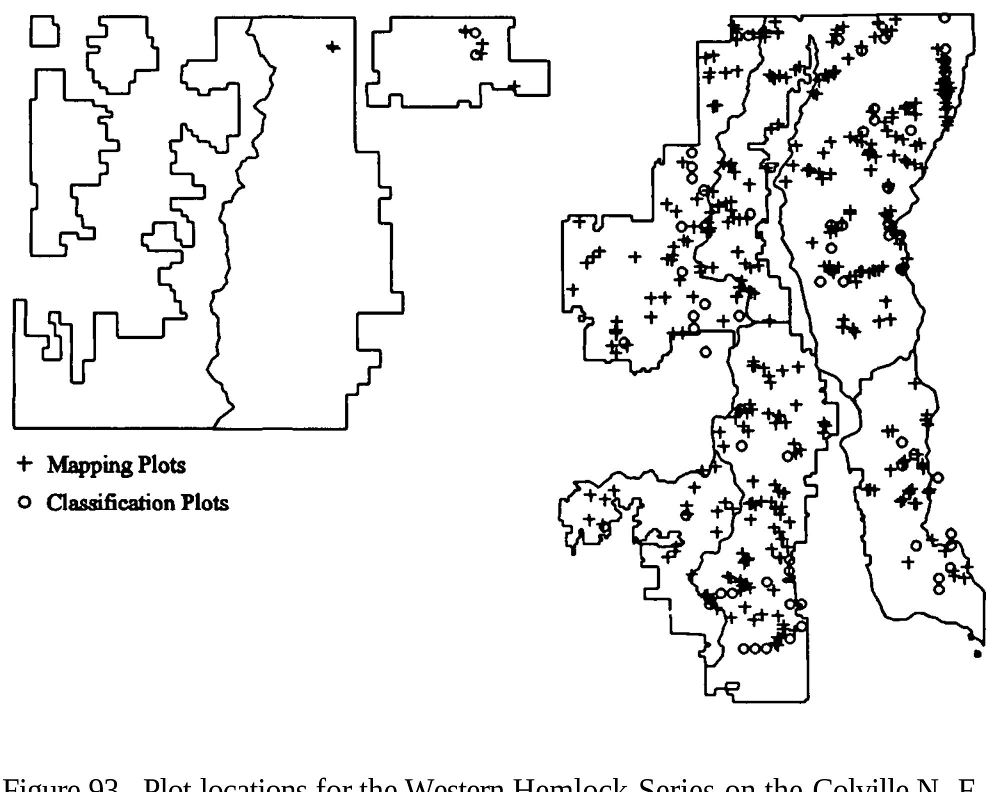


Figure 93. Plot locations for the Western Hemlock Series on the Colville N. F. (n=504).

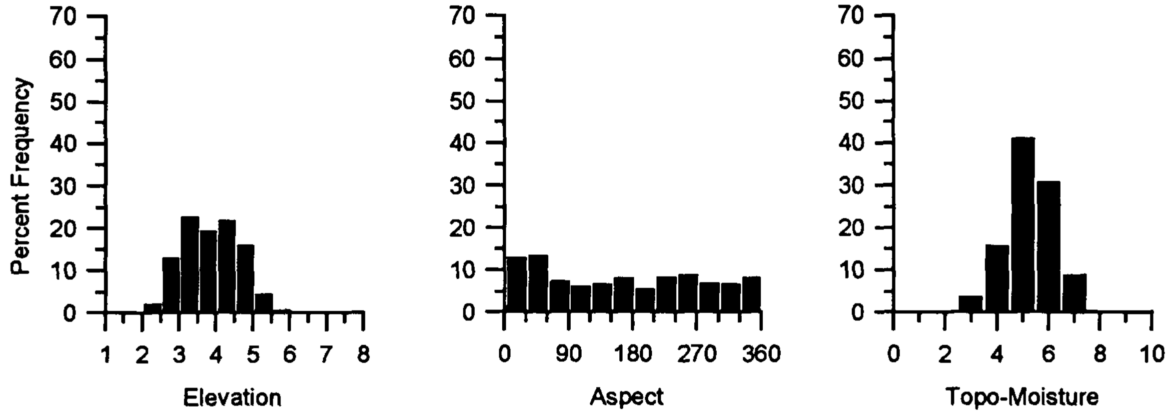


Figure 94. Frequency of Western Hemlock Series plots by elevation (1000 ft.), aspect, and topographic moisture.

where western redcedar and western hemlock co-dominate are assigned to the Western Redcedar Series following the precedent established by Daubenmire and Daubenmire (1968) and Pfister *et al.* (1977). Western redcedar tolerates warmer temperatures, and both wetter and drier conditions better than does western hemlock (Minore 1979). A few individual western hemlock trees are occasionally found in stands that best fit the Western Redcedar Series, though western hemlock is typically located on moist microsites in such conditions. The Subalpine Fir Series occupies colder habitats, while the Western Redcedar or Grand Fir Series occur on warmer, slightly drier habitats.

Six associations are described for the Western Hemlock Series. These include the TSHE/ARNU3, TSHE/CLUN, TSHE/GYDR, TSHE/MEFE, TSHE/RUPE and TSHE/XETE Associations. These associations can be divided into two broad groups based on elevation and, presumably, temperature. The lower elevation (warmer) group includes TSHE/GYDR, TSHE/ARNU3, and TSHE/CLUN arranged from moist to relatively dry. The upper elevation (cooler) group includes the TSHE/RUPE, TSHE/MEFE, and TSHE/XETE associations, again arranged from moist to relatively dry. These relationships are illustrated in figure 96.

VEGETATION

In general, very old stands are rare on the Forest because of widespread disturbance including widespread wildfire, logging and homestead clearing. The oldest western hemlock sampled (550 years old at breast height) was in a swampy site assigned to the THPL/OPHO Association. The next oldest western hemlock (just under 400 years at breast height) was in a stand assigned to the TSHE/RUPE Association. These are the only sampled western hemlock trees over 300 years of age. The oldest tree aged in the Series was a 570-year-old western larch in a stand assigned to the TSHE/XETE Association.

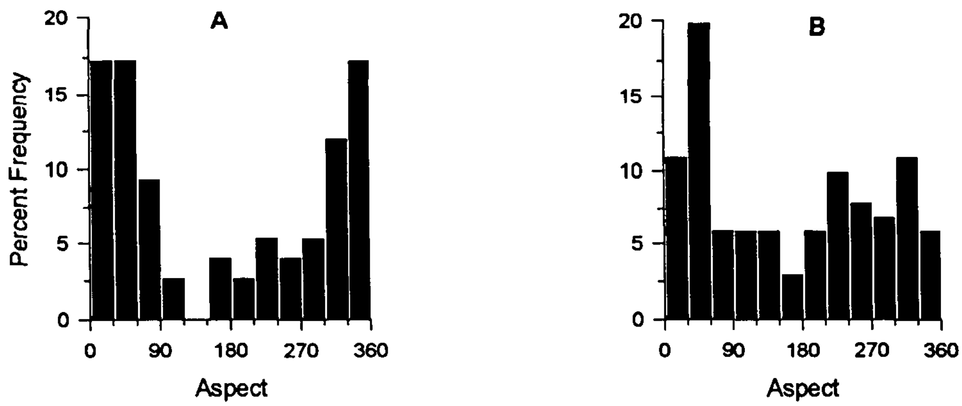


Figure 95. Frequency of western hemlock plots by aspect from Colville (south-half) (A) and Sullivan Lake (B) Ranger Districts.

Mid- (100-200 years) to late-seral (200+ years) stands are normally dominated by western hemlock and western redcedar, although a variety of other tree species may be present dependant on association, type and extent of disturbance and time since disturbance. Grand fir is a common mid- to late-seral component on the TSHE/GYDR, TSHE/ARNU3, and TSHE/CLUN Associations. Subalpine fir and Engelmann spruce are more common late-seral associates in the TSHE/MEFE, TSHE/XETE, and TSHE/RUPE Associations. Tree regeneration layer composition follows a pattern similar to the overstory. Western hemlock and western redcedar typically dominate the understory of mid-serai to mature stands. Grand fir, Engelmann spruce or subalpine fir are present in lesser amounts. Western hemlock reproduces best in closed canopy forests on rotten logs and stumps (Daubenmire and Daubenmire 1968). It is more successful under such conditions than any of its associates. Engelmann spruce regeneration occurs in low amounts in nearly every stand. As organic matter accumulates with time, western hemlock's competitive advantage is increased. However, western hemlock also reproduces on bare mineral soil, especially on moist habitats.

Undergrowth composition varies from dense, tall shrubs to open glades characterized by a mixture of low shrubs and herbs. Many prominent undergrowth species in this series are closely tied to Inland Maritime environments. Many widespread undergrowth species belong to the "Pachistima union" of Daubenmire and Daubenmire (1968). Queencup beadlily is identified as the most useful indicator of the Pachistima union for northern Idaho and western Montana (Cooper *et al.* 1991, Pfister *et al.* 1977). However, on the Colville National Forest, queencup beadlily is nearly ubiquitous over much of the Western Hemlock Series and is therefore less useful as an indicator. Species such as oak-fern, rusty menziesia, beargrass, five-leaved bramble, and wild sarsaparilla have more restricted environments and are more effective environmental indicators. However, dense stands with depauperate shrub and herb layers are frequent and have few or no shrubs and herbs. A thick litter layer is often the most prominent forest floor feature in these stands and the paucity of shrubs and herbs is transitory and more related to tree canopy density and litter accumulation than to intrinsic

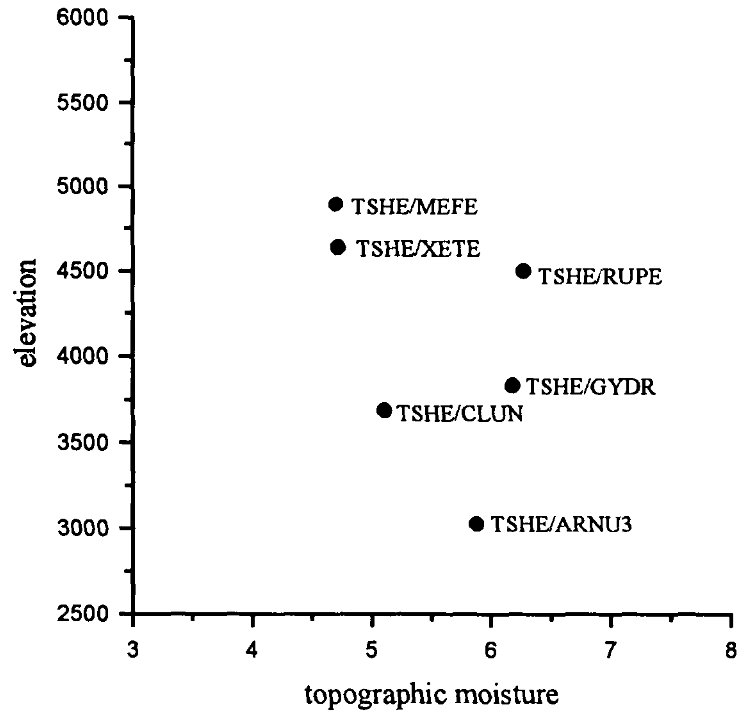


Figure 96. Ordination of western hemlock plant associations by elevation and topographic moisture.

site factors. Most of these stands presently key to the TSHE/CLUN Association with the lack of better indicator species.

The Western Hemlock Series is one of the least diverse series on the Forest (Table 59). Both richness and N2 index are among the lowest for any series on the Forest. A total of 134 different vascular plant species were found on the 118 plots used to described the Series and associations. Close to 157 species would be expected if all mid-seral to climax stands could be inventoried. The per-plot diversity index averages are very close to the overall averages for the entire ecology plot data set for the Forest. These diversity data imply that individual stands belonging to the Series are about average in vascular plant species diversity, but that the Series, as defined, encompasses relatively little habitat variation. Hence, the overall plant species diversity of the Series is low.

Disturbance type, timing, intensity, prior species composition and other biological legacies are important modifiers of secondary succession within the Series. Many possible successional paths exist within this moist Series. Despite this complexity, some general patterns exist and have been discussed in the literature. Nearly any tree species on the Forest may be important during early-seral stages within warmer portions of this series. Ponderosa pine is typically found only on the warmest sites in the TSHE/CLUN and TSHE/ARNU3 Associations. Here it is predisposed to needle diseases

Table 59. Diversity components of the Western Hemlock Series.

	Mean	S.E.[2]
Richness[1]	134	
Number of associations	6	
Expected richness[3]	156.8	5.5
Expected N2[4]	13.1	1.0
Average richness per plot	25.1	0.7
Average N2 per plot	7.3	0.3

[1] Total number of vascular plant species in the Western Hemlock Series data.
[2] Standard error of the estimate.
[3] Jackknife estimate of richness given a sample size of 118 plots.
[4] Jackknife estimate of N2 given a sample size of 118 plots.

because of the relatively moist environment characteristic of the Series. Quaking aspen, paper birch and black cottonwood may form extensive stands early in the sere of several associations after the humus layer has been removed by fire. Grand fir, Douglas-fir, western larch, and western redcedar are markedly less frequent in the cooler TSHE/RUPE, TSHE/MEFE, and TSHE/XETE Associations. Subalpine fir may never be completely excluded from the high elevation TSHE/MEFE and TSHE/XETE types because even mature stands often have relatively open canopies. Mid-seral stands (100-200 years old) in the TSHE/GYDR, TSHE/ARNU3 and TSHE/CLUN Associations often have abundant, vigorous grand fir under a canopy of long-lived serai species such as western larch, Douglas-fir or western white pine. Grand fir may be nearly the same age as the western larch, Douglas-fir and western white pine but slow early growth keeps it in smaller size classes until its superior shade tolerance and vigorous later growth allow it to grow into the upper canopy. After approximately 200 years the proportion of grand fir diminishes, perhaps because of pathogens and/or increased competition from the more shade-tolerant western hemlock and redcedar.

Dense shrubfields often dominate early successional stages following logging, wildfire and other disturbances. Although shrubfield development may initially appear deleterious to conifer establishment and early growth, the ecologic role of the shrub-dominant stage of succession is not well understood. Shrubs provide shade for conifers, add organic matter to the soil and may help retain nutrient capital on site. Species such as ceanothus, alders and russet buffaloberry fix nitrogen. Further, many shrubs provide important forage and cover for insectivorous wildlife which also influence stand health and vigor. Further research is needed on the ecological roles shrubfields have both within stands and in larger landscape heterogeneity. Douglas maple, Scouler willow, big huckleberry, serviceberry, Sitka alder and snowbrush ceanothus are common shrubfield species. Ninebark is generally a minor shrubfield component only on sites within the TSHE/CLUN

Association.

Pacific yew is relatively uncommon shrub on the Colville N. F. Of the 20 ecology plots containing yew, 14 are assigned to the Western Hemlock Series. Three other plots also containing yew are assigned to the THPL/OPHO Association. Yew was most often found in the THPL/OPHO and TSHE/GYDR Associations where it occurred on about half the plots. This indicates that Pacific yew occurrence is strongly related to moist sites where the maritime climatic pattern is strongest. Pacific yew is much less frequent and less abundant on drier habitats. It was found in stands ranging in age from less than 100 years old to over 500 years old. It may enter the sere at an relatively early stage and persist for centuries. All yew on the Colville N.F. had a shrub growth form.

Shrubs such as russet buffaloberry, thimbleberry, elderberry, sticky currant and the two ceanothus species eventually disappear as vegetation physiognomy changes from shrub-field to conifer forest. However, seeds of these species remain viable in the soil long after all other evidence of the plants disappear. Seeds of some species are believed to be viable for decades or perhaps even centuries. These seeds germinate following a disturbance such as fire or logging, leading to rapid shrubfield formation. Other species such as Scouler willow, Douglas-maple, alders, serviceberry, pachistima, baldhip rose and common snowberry often linger as scattered individuals for decades after closed conifer canopies have developed. Seeds of these species are viable for a few years or less in the forest floor. However, individuals which persist vegetatively for many years often respond rapidly after a disturbance from buried roots or root crowns. Nearby populations may also provide seed to the site.

FIRE ECOLOGY

Fire return intervals are not well documented for the Western Hemlock Series, though most sites show some evidence of past fire such as buried charcoal and fire-scarred trees. Fire has certainly been a major influence within the Series on the Forest. Most of the stand data are comprised of stands less than 200 years and often near 100 years old. In north Idaho, a typical fire-return interval for low- to moderate-severity fires is 50-100 years; a stand-replacement interval is 150-500 years (Amo and Davis 1980). In general, it appears that most upland cedar/hemlock stands on the Colville N.F. are characterized by fairly frequent fire activity. However, fire regimes and intensities can be quite variable in this Series. The resulting pattern on the landscape is often a complex mixture of "... 1) complete stand replacement, 2) partially killed overstory (resistant species surviving), 3) underbuming with little overstory mortality and 4) unbumed forest" (Amo and Davis 1980). Variation in fire intensity and frequency may be expected both within similar plant associations *(i.e.* TSHE/CLUN sites on dry compared to wet areas of the forest) as well as between different associations (TSHE/CLUN compared to TSHE/GYDR sites). This is due to the mosaic of different environments which exist across the Colville N.F. landscape. These are major factors in affecting fire regimes of any particular tree series or stand.

The drier western hemlock associations found on uplands are more at risk of burning than the wetter types located in stream bottoms, seeps, and benches. These mid-slope stands are generally warmer, drier, and more wind-exposed, and may form a "thermal belt" which bums more intensely than lower slope positions (Amo and Davis 1980). Most hemlock stands on these slope positions on the Colville

N.F. are TSHE/CLUN sites. None of the sampled stands in the relatively warm TSHE/CLUN or TSHE/ARNU3 Associations had western hemlock trees over 200 years of age. These warmer habitats appear to bum more frequently and perhaps more intensely than cooler and more moist associations. In comparison, the very moist western hemlock associations tend to bum less frequently than the drier types. In many instances, riparian "stringers" of western hemlock/redcedar can form natural firebreaks on the landscape (Fisher and Bradley 1987) and develop into late serai or old-growth stands. Age data for 101 western hemlock trees were recorded. Only 21 western hemlock trees aged on the Colville N. F. were over 200 years old. These trees were all from stands in either the TSHE/GYDR, TSHE/RUPE, TSHE/XETE, TSHE/MEFE or THPL/OPHO Associations. All of these associations are relatively cool and moist and often occur in sheltered locations near streams.

In addition, hemlock stands have an increased risk of burning when surrounded by drier (and more fire prone) grand fir or Douglas-fir communities on adjacent aspects or slope positions. Many of the western hemlock stands on the Colville N.F. are not continuous in nature, but are instead limited to northern exposures or moist stream bottoms on southern exposures. .Douglas-fir communities generally dominate most of the southern aspects. Many fires may originate in these drier Douglas-fir stands on south aspects and then spread (depending upon fire conditions) into the western hemlock stands. Even the very moist hemlock sites can bum, particularly under severe drought conditions when crown fires spread from these drier neighboring stands. Thus, when these narrow cedar/hemlock "stringers" are located in the midst of large stands of drier plant associations such as PSME/PHMA or ABGR/PHMA, the risk of burning is even greater. Many moist cedar/hemlock stands on the Colville N.F. reflect this situation. In comparison, on the wetter portions of the Forest near the Sullivan Lake area, western hemlock and redcedar stands tend to be more widespread and continuous across the landscape. Due to the increased amounts of precipitation and moist forest types, longer fire-return intervals would be expected, allowing the development of older forests.

When fire occurs in these stands, the patch size can be very large. Some very large and intense fires have burned in the cedar/hemlock forests of northeast Washington, north Idaho, and northwestern Montana and include the 20,000 hectare Sundance Fire in north Idaho in 1967 (Anderson 1968). Cooper *etal.* (1991) note other extensive fires in the area in 1889, 1919, 1926, and 1934. Barrows (1952) states that 400,000 hectares burned in north Idaho in 1910 alone. The Colville N.F. was no exception, with a similar history of intense fires in the cedar and hemlock forests. These past fires account for many of the young and dense cedar/hemlock "doghair" stands found on the Forest.

Subalpine fir, Engelmann spruce, lodgepole pine, grand fir, and western hemlock all have naturally low resistance to fire, and are easily killed by moderate severity fires. Western hemlock has a shallow root system which is very susceptible to fire. Species such as Douglas-fir, western larch, ponderosa pine, and western redcedar often survive as residuals due to their higher tolerance to fire. After stand-replacing fires, western redcedar usually enters most sites early in succession due to its prolific seed production (Smith and Fischer 1995). Western hemlock usually regenerates in a stand early in succession in the wetter associations, though may first require the development of an overstory of redcedar to regenerate on the drier sites. Generally, the faster growing serai species (ABGR and PSME) usually overtop the western redcedar and hemlock seedlings and saplings (Smith and Fischer 1995). Western hemlock usually dominates the mid- to late-successional stages on most sites.

INSECTS AND DISEASE

No major foliar diseases are known to cause serious problems for western hemlock. However, wounds on western hemlock are readily infected by several decay fungi. Stem decay caused by the fungus that causes annosus root rot is most common. Indian paint fungus is common in old western hemlock trees, wherever the host occurs. The major butt and root rot pathogens of western hemlock include armillaria, *Schweinitzii*, brown pocket and laminated root rots (Bums and Honkala 1990). Armillaria root rot is present in virtually all stands of the Western Hemlock Series in the northern Rocky Mountains (McDonald *et al.* 1987b). However, the infection rate is low in undisturbed stands. Apparently, the total environmental and biological stress on productive sites does not exceed the tree's tolerance. Infection rates increase threefold after man-caused disturbance *{i.e.* logging or road building). Less productive sites such as those in the Douglas-fir or Subalpine Fir Series have much higher infection rates but as whole these series have a lower overall incidence of the pathogen (McDonald *etal.* 1987a). In addition, western hemlock is very susceptible to windthrow due to its shallow root system.

MANAGEMENT IMPLICATIONS

Some western hemlock forests are among the most productive forests in the world, more so than equatorial rainforests, with very high amounts of net primary productivity. As an example, a western hemlock stand measured on the H.J. Andrews Experimental Forest near Blue River, Oregon, was recorded as having over 600 tons/acre of standing biomass, one of the highest biomasses ever measured. Though not as productive as stands in or west of the Cascade Range, the Western Hemlock Series is the most productive Series found on the Colville N. F. Average basal and average SDI are the highest among all series. However, on an individual basis, most of the serai tree species are more productive than western hemlock.

Both mineral and organic seedbeds are favorable for western hemlock regeneration (Bums and Honkala 1990). Rotten wood and decaying logs are perhaps the most favorable seedbeds, a substrate which provides moisture and nutrients for adequate growth and survival of seedlings. Due to the diversity of seedbeds which western hemlock seedlings can thrive on, successful natural regeneration can be obtained with cutting methods ranging from single-tree selection to clearcutting. However, western hemlock is a shallow-rooted species which does not develop a large taproot. The majority of roots are most abundant near the surface, and are easily damaged by fire and/or harvesting equipment. This shallow root system also makes western hemlock quite susceptible to windthrow as well.

Knowledge of shrub and herb composition can be used to tailor treatments to achieve desired post-treatment condition. Knowledge of serai characteristics or adaptive strategies of shrubs, forbs and graminoids is useful in predicting vegetation response to management or disturbances. Adaptive strategies, species composition, site characteristics, type, intensity and timing of perturbations all affect shrub composition and density. For example, species that resprout from root crowns such as Sitka alder and Scouler willow increase in stem densities after slashing. Appendix 1 lists serai characteristics of the most common shrub, forb and grass species.

As another example, Morgan and Neuenschwander (1988) studied post-clearcut shrub response to high and low intensity bums on Western Redcedar Series sites in north Idaho. Their findings appear applicable to most of the Western Hemlock Series because the Pachistima union of Daubenmire and Daubenmire (1968) was present on most, if not all, study sites. They concluded that bum intensity after clearcutting greatly affects resulting undergrowth species composition and abundance. Low intensity fire favors species with rhizomatous sprouts or buried root crowns while high intensity fire favors shrub establishment from seed. Multiple entries before a clearcut and bum modify the response by opening the canopy and providing disturbed soils that allow establishment of shade-intolerant shrubs. These shrubs then resprout vigorously after the clearcut and bum. In addition, prescribed burning can be used as an effective means of eliminating western hemlock advanced regeneration if necessary due to it's susceptibility to fire.

Shrub height growth and twig production on logged over sites are generally related to time since logging and residual tree cover (Irwin and Peek 1979). Shrub size and twig production peak between 10 and 14 years after logging. Seedtree and shelterwood treatments have significantly less shrub development than clearcuts. Late summer and fall broadcast burning in clearcuts leads to the greatest shrub development due to increased snowbrush ceanothus cover. Optimum germination of ceanothus seed requires both seed coat scarification and cold-wet seed stratification. Fall and late summer burns best meet these requirements. Spring burns usually do not provide the necessary cold-wet stratification resulting in reduced ceanothus germination. However, spring burning does favor species that sprout from root crowns or buried roots (see appendix 1).

Ashy soils are easily compacted or displaced by heavy equipment thereby reducing site productivity and hindering tree regeneration. Harvesting practices that minimize soil compaction and organic matter loss have been suggested by Page-Dumroese (1993). Preserving the rich but somewhat fragile soils on found on many western hemlock sites must be considered during any harvesting or site preparation planning (Smith and Fischer 1995). Soil organic matter content and porosity are both very important soil properties to consider during planning. Soil water-holding capacity is increased by organic matter from duff; roots and plant debris (Smith and Fischer 1995). Harvey (1982) reports that soil wood is an excellent seedbed for regeneration because 1) it retains moisture, 2) reduces non-conifer competition and decay fungi and 3) hosts more mycorrhizae than humus. Soil wood and soil organic matter can be increased from logging debris (Page-Dumroese *et al.* 1994). Slash decays rapidly on the moist sites. Decay of slash can be accelerated and the potential threat of wildfire can be minimized on sites by lopping and scattering slash (Smith and Fischer 1995). Piling fuels with heavy equipment may cause soil compaction and the intense heat generated by burning large slash piles drastically alters soil structure and removes essential nutrients and organic matter. Cool broadcast burns should provide adequate fuel reduction.

Suitable livestock herbage is provided only by early serai stages of succession for most associations. Once tree canopy closure occurs, the herbaceous undergrowth composition changes to include mostly herbs of low palatability. Mature forested stands with shade and available water may receive heavy livestock use as resting areas. Black bear are known to girdle pole-sized hemlock trees and larger saplings. Elk and deer will browse western hemlock and snowshoe hares will eat small hemlock leaders (Burns and Honkala 1990).

COMPARISONS

The interior variant of the Western Hemlock Series or an equivalent syntaxon has been well described by many authors (Bell 1965; Cooper *et al.* 1991, Daubenmire and Daubenmire 1968; Pfister *et al.* 1977). In addition, the coastal variant, which extends from coastal Alaska south into California, has been described by numerous ecologists, including Franklin *et al.* (1988), Henderson *et al.* (1989, 1992) and Topik *etal.* (1986). Meidinger and Pojar (1991) describe the coastal and interior variants of the Series in British Columbia.

KEY TO PLANT ASSOCIATIONS OF THE WESTERN HEMLOCK 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.

Devils club >. 5% . . . . THPL/OPHO Association p. 251

Oak-fem >. 5% and five-leaved bramble <1% . . . . TSHE/GYDR Association p. 209

Rusty menziesia and/or Cascades azalea ≥ 5% . . . . TSHE/MEFE Association p. 215

Beargrass ≥. 5% . . . . TSHE/XETE Association p. 226

Five-leaved bramble ≥ 1% . . . . TSHE/RUPE Association p. 221

Wild sarsaparilla ≥ 1% . . . . TSHE/ARNU3 Association p. 199

Queencup beadlily ≥ 1 % . . . . TSHE/CLUN Association p. 204

TSHE/ARNU3 ASSOCIATION CHF3 12
Tsuga heterophylla/Aralia nudicaulis
western hemlock/wild sarsaparilla

DISTRIBUTION AND ENVIRONMENT

The Western Hemlock/Wild Sarsaparilla Association is found east of the line formed by the Kettle and Columbia Rivers (Figure 97). It typically occupies gentle to moderate lower slope, bench and bottom positions in the xero-riparian zone. Aspects are variable and most sites occur between 2,000 and 3,500 ft. (Figure 98) and average 3,027 ft. (Table 61). The TSHE/ARNU3 Association represents sites which are lower elevation, warmer, and slightly drier than TSHE/GYDR or TSHE/RUPE sites.

Soils are formed in volcanic ash over glacial-fluvial deposits. Compacted subsoils are common at 12 to 24 in. (30 to 60 cm) deep in the profile. Soils are well-drained and have textures that vary from silt to cobbly silt-loam. Average soil temperature at 20 in. (50 cm) was 8 °C. Surface rock is usually absent. Humus and duff ranged from 3 to 5 in. (8-13 cm) in depth. Organic matter turnover is rapid on these relatively warm and humid sites. The TSHE/ARNU3 association is possibly the warmest environment in the Western Hemlock Series. It grades into the similar THPL/ARNU3 Association which occurs on yet warmer sites. The TSHE/GYDR association is found on what are apparently cooler, higher-elevation habitats.

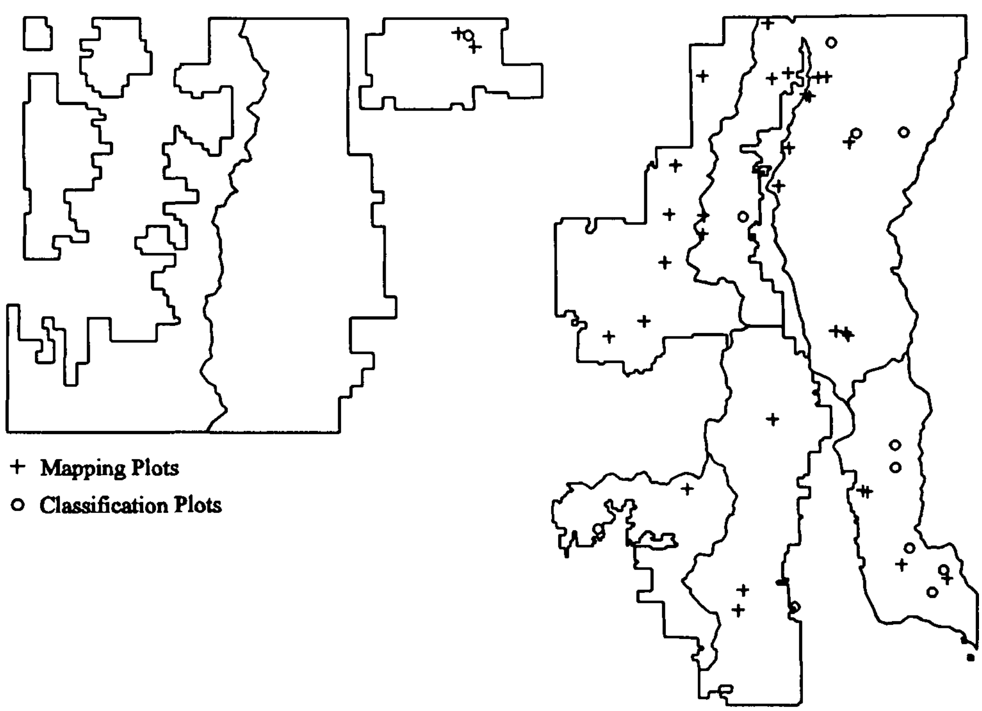


Figure 97. Plot locations for the TSHE/ARNU3 Association (n=48).

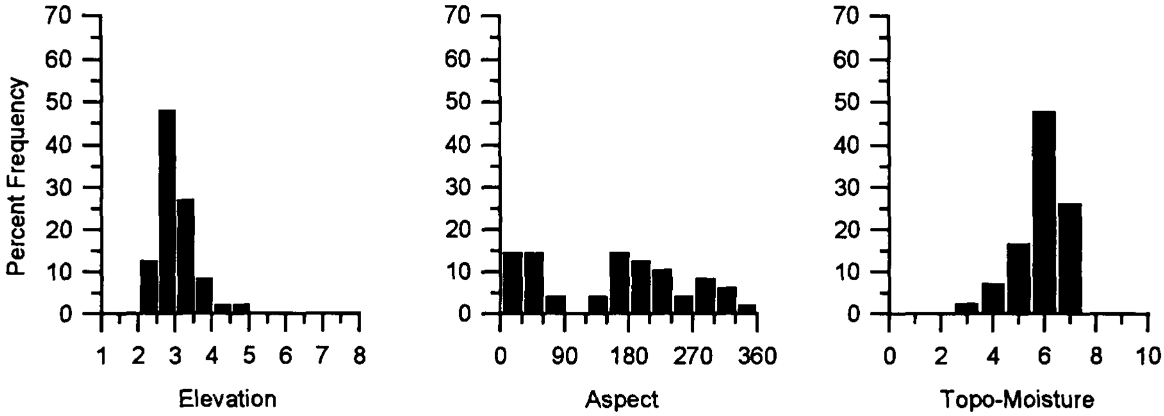


Figure 98. Frequency of TSHE/ARNU3 plots by elevation (1000 ft.), aspect, and topographic moisture.

VEGETATION

All conifer species occurring on the Forest (except subalpine fir and whitebark pine) can be found on the TSHE/ARNU3 Association. It is not uncommon to find six or more conifer species present on any single plot. This is the only association in the Western Hemlock Series where ponderosa pine is more than a minor part of the tree sere. Paper birch and/or quaking aspen are especially important following fires that remove most of the humus.

A dense, multi-layered canopy dominated by western hemlock is characteristic of late-seral and climax stands. Western redcedar is a very important stand component and may never be completely replaced by western hemlock. Both western hemlock and western redcedar are common understory species. Serai grand fir, Douglas-fir, western larch and western white pine are present only as snags or scattered canopy emergents in the oldest

Table 60. Common plants of the TSHE/ARNU3 Association (n=11).

		CON	COVER
TREE OVERSTORY LAYER			
ABGR	grand fir	91	25
TSHE	western hemlock	91	17
THPL	western redcedar	91	11
PSME	Douglas-fir	82	12
LAOC	western larch	64	14
PIM	western white pine	64	10
TREE UNDERSTORY LAYER			
THPL	western redcedar	91	6
TSHE	western hemlock	82	7
ABGR	grand fir	73	3
SHRUBS AND SUBSHRUBS			
LIBOL	twinflower	100	11
CHUM	western prince's pine	100	3
ROGY	baldhip rose	82	3
BEAQ	Oregon grape	82	3
RUPA	thimbleberry	73	4
VAME	big huckleberry	64	4
ACGL	Douglas maple	55	3
HERBS			
ARNU3	wild sarsaparilla	91	18
VIOR2	round-leaved violet	91	2
SMST	starry solomonplume	82	5
CLUN	queencup beadlily	82	5

Table 61. Environmental and structural characteristics of the TSHE/ARNU3 Association.

	Mean	S.D.	Min	Max
Environment[1]				
Elevation	3027	481	2130	4600
Aspect[2]	327	67		
Slope	15	16	1	68
Topographic Moisture	5.88	0.97	3.0	7.0
Soil Surface[3]				
Exposed soil	43	31	5	80
Gravel	16	10	12	38
Rock	0	0	0	0
Bedrock	0	0	0	0
Moss	2	2	1	5
Lichen	0	1	0	1
Litter	56	28	25	85
Diversity[4]				
Richness	30.7	6.5	20	41
N2	8.5	4.8	4	20

' Values for environmental variables were generated using both classification plot and mapping plot data (n=48).
[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.

stands (Figure 99).

A variety of shrubs are present. All but twinflower have low cover. Utah honeysuckle, baldhip rose, and shiny-leaf spirea are common and regenerate from buried roots, rootcrowns or rhizomes after a disturbance. Russet buffaloberry occurs only in stands with lodgepole pine that are less than 100 years old. The herb layer is floristically rich, but only wild sarsaparilla, queencup beadlily and starry solomonplume normally have more than 5% cover. Bracken fern and other early serai opportunists may dominate the herb layer in early serai communities that have not yet developed a full tree canopy. Abandoned homesteads and fields (which are common) are typically dominated by lodgepole pine and/or a wide variety of weedy herbs and grasses, including many introduced species.

MANAGEMENT IMPLICATIONS

Wildlife/Range- Sheltered, relatively warm sites, proximity to streams and rich shrub and herb layers

Figure 99. Photo of the TSHE/ARNU3 Association.

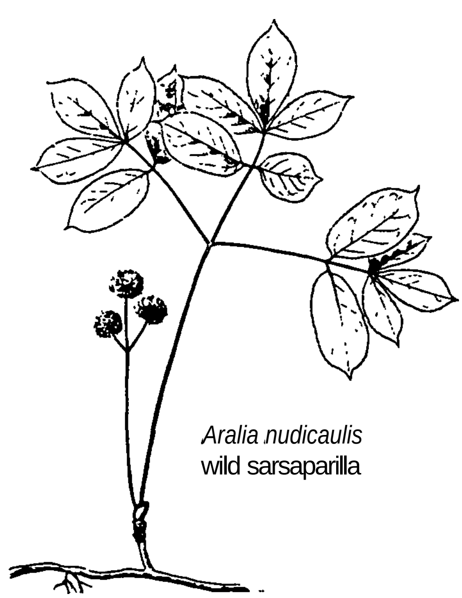
make the association highly valuable for wildlife and domestic livestock. Forage production for elk and deer may be high. Herbage production may be moderate for livestock during early-successional stages. Shrubs such as Oregon grape, bald-hip rose, thimbleberry, and big huckleberry are common in this type and all provide fruits for wildlife species. In addition, stands with high coverage of shrubs such as big huckleberry may provide important winter range areas for big game species. Stands with multiple tree canopies provide good habitat for arboreal mammals and birds. Fire may enhance deer and elk habitat, particularly ifceanothus seeds are present. Pacific yew provides good winter browse for moose.

Silviculture- These are very productive sites that support a wide variety of conifer species and offer a variety of options for timber management. Preserving the rich but somewhat fragile soils on these sites must be considered during any harvesting or site preparation planning (Smith and Fischer 1995). Organic matter, soil nitrogen and other nutrients can be easily lost on these sites (Harvey *et al.* 1987). Organic matter and nutrient loss from similar soils and slope positions appear at least partially responsible for the development of persistent, depauperate, lodgepole pine-dominated communities such as the PICO/SHCA Community Type. Follow the guidelines of Harvey *et al.* (1987) to protect site quality. This is especially a concern in the spring or fall when soils may be wet. Intense heat generated by burning large slash piles drastically alters soil structure and removes essential nutrients and organic matter. The needs for soil protection, fuel reduction, and mineral soil exposure for regeneration all need to be balanced during the planning stages of slash disposal and site preparation methods. Cool broadcast bums should provide adequate fuel reduction.

Most natural or artificial regeneration treatments should be successful. Shelterwood or selection treatments will most likely favor regeneration of grand fir, western redcedar and western hemlock. Seed-tree techniques may be used to favor regeneration of western larch, Douglas-fir and to a lesser extent, western white pine. Complete overstory removal will also generally promote regeneration of these serai species. Subalpine fir and Engelmann spruce are poorly represented in the data and appear to be poor choices for reforestation. Inherently high productivity of these sites can lead to heavy shrub competition following tree harvest, particularly if shrub establishment is allowed to precede tree regeneration by one to two years. Serai shrubs and herbs may especially hinder reforestation following fall broadcast bums. Pre-treatment species composition and serai characteristics (Appendix 1) are important in determining vegetation responses after treatment.

COMPARISONS

Kovalchik (1993) describes a very similar riparian TSHE/ARNU3 Association for eastern Washington. The broadly defined TSHE/ASCA Habitat Type of Cooper *et al.* (1991) for north Idaho has an ARNU3 Phase that is nearly identical to the TSHE/ARNU3 Association. Pfister *et al.* (1977) describe a TSHE/CLUN Habitat Type-ARNU3 Phase in Montana that resembles some TSHE/ARNU3 stands on the Colville N.F. However, this former type also encompasses stands that better fit the TSHE/GYDR and TSHE/RUPE Associations. The TSHE/ASCA3 Association described by Lillybridge *et al.* (1995) for central Washington also characterizes somewhat similar environments and landform positions. Braumandle and Curran (1992) describe a Western Redcedar-Douglas-fir/Falsebox Site Association: Mesic-Subhygric Phase which includes environments very similar to the TSHE/ARNU3 Association. Bell's (1965) Slope Aralia Oakfem Association - alluvial aralia oakfem forest type, also in southern British Columbia, appears similar to the TSHE/ARNU3 association.


Aralia nudicaulis
wild sarsaparilla

TSHE/CLUN ASSOCIATION CHF3 11

Tsuga heterophylla/CUntonia uniflora
western hemlock/queencup beadlily

DISTRIBUTION AND ENVIRONMENT

The TSHE/CLUN Association is the most common western hemlock association found on the Colville N. F., and occurs over a broad range of habitats. It is generally restricted to the eastern-half of the Forest with the exception of the northern portion of the Kettle Falls Ranger District (Figure 100). Aspects are variable and most sites (90 %) are found between 2,500 and 4,500 ft. (Figure 101). Through most of its range, the TSHE/CLUN Association occurs mainly on upland habitats while the TSHE/GYDR, TSHE/ARNU3 or the TSHE/RUPE Associations primarily occupy sub-irrigated upland, stream bottom or toe-slope positions. However, the TSHE/CLUN Association can be found near streams or along stream terraces near the drier southern and eastern geographic range limits of western hemlock.

Soils are formed in ash overlying glacial till. Ash depths range from 2 to 20 in. (5 to 50 cm). Surface horizon soil textures are silt loams changing to sandy loam subsoils (a few profiles had clayey subsoils). Coarse fragments are common but surface rock is usually absent or has low cover. Humus and duff depths ranged from 3 to 9 in. (8-23 cm). Organic matter decays rapidly on these

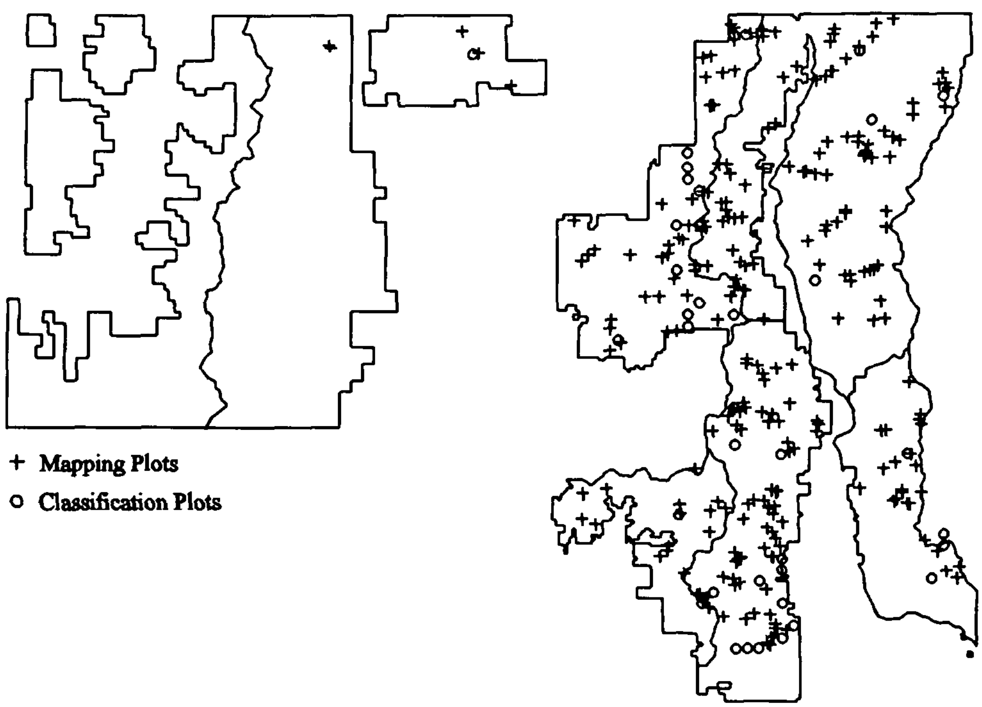


Figure 100. Plot locations for the TSHE/CLUN Association (n=309).

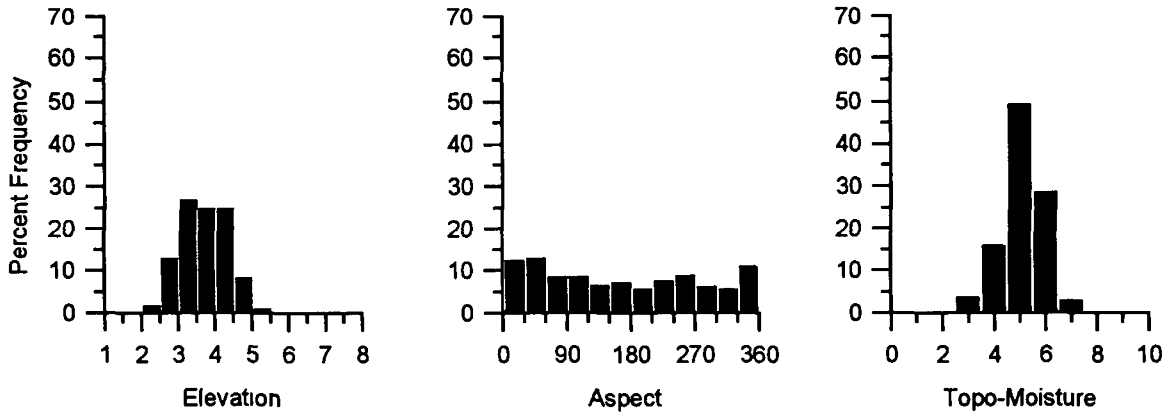


Figure 101. Frequency ofTSHE/CLUN plots by elevation (1000 ft.), aspect, and topographic moisture.

warm and mesic habitats.

VEGETATION

A variety of serai tree species may dominate early serai stands (<100 years old). Exact composition depends on seed source, and the type, intensity, and time since disturbance. Most mid-seral stands (100-200 years old) have abundant, vigorous grand fir or western redcedar under a canopy of early serai species such as western larch, Douglas-fir, or western white pine (Figure 102). Multiple canopy layers often develop in less than 100 years. Grand fir and cedar may be nearly the same age as the larch and pine but slow early growth keeps them subordinate until their superior shade tolerance and vigorous later growth allow them to reach upper canopy positions. Paper birch and quaking aspen are also common in stands which have originated from past fires.

Grand fir tends to decline in abundance and cover as stands exceed 200 years of age.

Table 62. Common plants of the TSHE:/CLUN Association (n=58).

		CON	COVER
IEEE: OVERSTORY LAYER			
THPL	western redcedar	95	25
PSME	Douglas-fir	79	16
LAOC	western larch	79	15
TSHE	western hemlock	74	19
ABGR	grand fir	66	15
PIMO	western white pine	53	5
TREE UNDERSTORY LAYER			
THPL	western redcedar	95	10
TSHE	western hemlock	83	4
ABGR	grand fir	52	5
SHRUBS AND SUBSHRUBS			
LIBOL	twinflower	81	8
PAMY	pachistima	78	5
CHUM	western prince's pine	74	4
PYSE	sidebells pyrola	74	2
ROGY	baldhip rose	69	3
LOUT2	Utah honeysuckle	67	2
VAME	big huckleberry	55	3
HEREIS			
CLUN	queencup beadlily	93	3
VIOR2	round-leaved violet	88	3
GOOB	western rattlesnake plantain	71	2
SMST	starry solomonplume	59	3

Table 63. Environmental and structural characteristics of the TSHE/CLUN Association.

	Mean	S.D.	Min	Max
Environment[1]				
Elevation	3688	616	2290	5150
Aspect[2]	28	75		
Slope	28	17	1	86
Topographic Moisture	5.11	0.83	3.0	7.0
Soil Surface[3]				
Exposed soil	48	36	0	98
Gravel	15	11	12	38
Rock	14	18	0	38
Bedrock	0	0	0	0
Moss	3	3	0	10
Lichen	1	1	0	3
Litter	69	30	0	98
Diversity[4]				
Richness	25.2	8.9	9	43
N2	7.2	3.9	2	17

' Values for environmental variables were generated using both classification plot and mapping plot data (n=49).
[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.

Perhaps this is due to a combination of disease, insects and competition from more shade tolerant western hemlock and western redcedar. Western redcedar is especially persistent and may never be fully replaced by western hemlock between naturally occurring disturbances. Succession to western hemlock is slower on this type than in the other associations in the Western Hemlock Series. It is difficult to distinguish between the TSHE/CLUN and THPL/CLUN Associations on sites burned within the last 100 years . Late serai and climax stands are rare in our data. Successional dynamics suggest that late serai conditions would be characterized by dense shady stands composed primarily of western hemlock and western redcedar with low cover of shrubs and herbs in the understory

A rich variety of herbs and shrubs are present depending on stand history, age and density. Very dense "doghair" stands have very little shrub and herb cover. Common shrubs include twinflower, pachistima, Utah honeysuckle, baldhip rose and big huckleberry. Ninebark, baldhip rose and Douglas maple are especially common on warmer slopes (see series description for more information on shrub succession). Queencup beadlily, round-leaved violet, plantain, starry-solomonplume and trillium are the common herbs. Shrub and herb succession is greatly influenced by previous stand conditions

Figure 102 Photo of the TSHE/CLUN Association

since many resprout from root crowns or rhizomes (see appendix 1) Bracken fem may increase dramatically after disturbance if present

MANAGEMENT IMPLICATIONS

Wildlife/Range- Stands with multiple tree canopies provide excellent habitat for arboreal mammals and birds Multiple tree and shrub canopies common in mid-seral (100-200 year) stands provide considerable forage and shelter for a wide variety of wildlife species A large variety of bird and mammal species utilize these stands for either thermal and hiding cover or forage due also in part to their extensive distribution across the landscape Palatable livestock forage is lacking in natural stands but early serai stages may provide considerable herbage On most sites plant succession is quite rapid towards a temporary dominance by serai shrubs

Silviculture- These sites support a wide variety of conifer species and offer an array of different options for timber management Tree productivity is also quite good on these sites Shrub and herb competition and soil compaction are the main limitations to intensive timber management. Avoid soil compaction and nutrient and organic matter depletion by following the guidelines of Harvey *et al.*

(1987). Soil organic matter content and porosity are both very important soil properties to consider during planning. Soil water-holding capacity is increased by organic matter, which is generated by duff, roots, and plant debris (Smith and Fischer 1995). Either severe fire or slash treatment can destroy soil organic matter. Destruction of soil organic matter can contribute to the development of dense shrubfields (Harvey *et al.* 1987) Fall broadcast bums will likely encourage dense shrubfield formation (see the Western Hemlock Series description for more information). Stands with soils compacted during whole-tree harvest may resemble the depauperate and unproductive PICO/SHCA Community Type.

Selection and shelterwood cuts favor western hemlock, western redcedar and grand fir while seedtree treatments favor adequate natural regeneration of western larch, Douglas-fir and western white pine. Burning harvest units increases shrub competition with conifer seedlings (see series description). Cooper *et al.* (1991) suggest good stands of western larch and Douglas-fir will develop following seedtree or open shelterwood cuts on southeast to west aspects Dense shelterwood and selection treatments favor grand fir, western redcedar, Engelmann spruce, subalpine fir and western hemlock. Ponderosa pine should grow well on warm aspects with good air drainage on clearcuts or seedtree cuts. Poor air drainage areas are frost prone and have higher humidity leading to needle infections such as elytroderma needle cast on ponderosa pine. Many of these stands which originated from stand-replacing fires support moderate amounts of paper birch and quaking aspen. These fairly short-lived species (generally less than 100 years) play an important role in nutrient cycling and organic matter build-up following intense fires. These hardwood species also increase the vegetative diversity of these stands.

COMPARISONS

The TSHE/CLUN Association is part of the broad TSHE/PAMY Association described by Daubenmire and Daubenmire (1968) for eastern Washington and Northern Idaho. They identified the TSHE/PAMY type as the only upland western hemlock association. Types which show more similarity to the TSHE/CLUN Association on the Colville N.F. have been described for northern Idaho (Cooper *etal.* 1991), northwest Montana (Pfister *et al.* 1977) and southern British Columbia (Bell 1965, Braumandl and Curran 1992). It corresponds most closely to the TSHE/CLUN Habitat Type-CLUN Phase described by Cooper *et al.* (1991). However, Cooper *et al.* (1991) generally equate coolwort foamflower with queencup beadlily as diagnostic of their TSHE/CLUN Association in northern Idaho. Coolwort foamflower has relatively low constancy in these data and is less useful as an indicator. Pfister *et al.* (1977) consider all Western Hemlock Series stands to be part of the TSHE/CLUN association in Montana. Lillybridge *et al.* (1995) describe an TSHE/LffiOL/CLUN Association for central Washington which characterizes similar environments. Braumandl and Curran (1992) describe several Site Associations in southern British Columbia which reflect similar environments. The Western Redcedar-Douglas-Fir/Falsebox Site Association appears to be most similar to the TSHE/CLUN Association. Bell (1965) describes a Moss association within which he describes five distinct forest types. Of these, the Slope Normal Moss, Slope Dry Moss and Slope Bunchberry Moss Forest Types appear most similar to the TSHE/CLUN association.

TSHE/GYDR ASSOCIATION CHF4 22
Tsuga heterophylla/Gymnocarpium dryopteris
western hemlock/oak-fem

DISTRIBUTION AND ENVIRONMENT

The TSHE/GYDR Association is found on the three ranger districts east of the Columbia River (Figure 103), and indicates sites with conditions of moisture accumulation and low insolation. It is generally restricted to sheltered slopes, benches and bottoms, and often forms part of the meso-riparian zone, and is perhaps the wettest of the western hemlock associations described. Aspects tend to be variable due to the sheltered locations and sites tend to be at low to mid-elevations between 3,000 and 4,500 ft. (Figure 104).

Soils are formed in volcanic ash overlying mixed alluvium or colluvium. Ash depths range from 3.5 to 30 in. (9 to 75 cm). Silt to silt loam textures are typical of surface horizons. Lower horizons are clayey, sandy or very cobbly and gravelly at the level of old streambeds. Drainage was impeded on two sites and water tables are often close to the surface. Coarse fragments range from 17 to 62% and surface rock is usually absent. Rooting depth ranges from 13 to 32 in. (34 to 81 cm). Average soil temperature at 20 in. (50 cm) was 8 °C (range: 7 to 10 °C). These soils are easily compacted because of the ash in the upper horizons and are moist year-around. Organic matter in the soils is

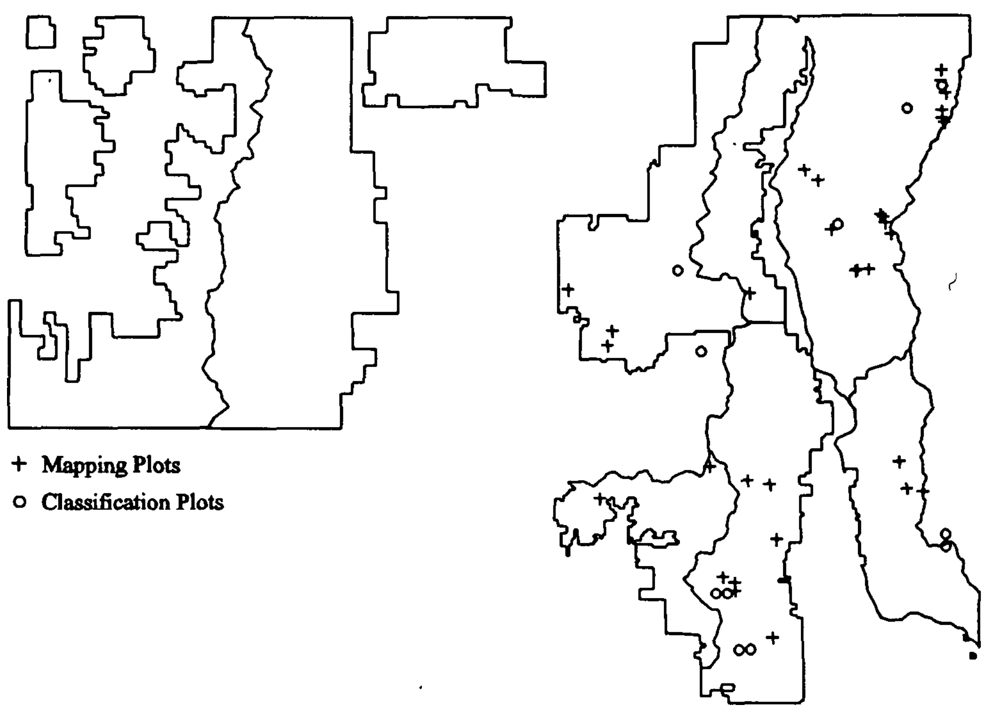


Figure 103. Plot locations for the TSHE/GYDR Association (n=52).

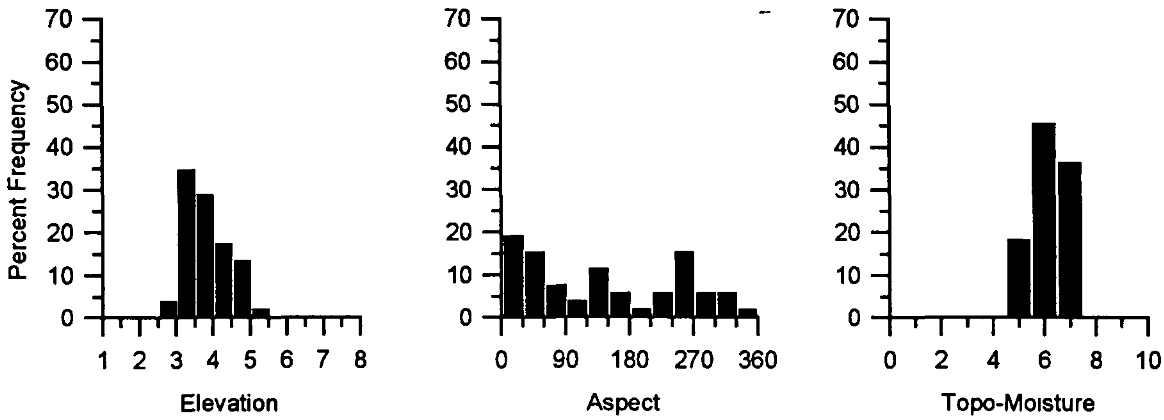


Figure 104. Frequency ofTSHE/GYDR plots by elevation (1000 ft.), aspect, and topographic moisture.

high and humus layers ranged from 3 to 5 in. (8-13 cm) in depth. Cycling of litter and humus is fairly rapid in these moist, cool environments.

The TSHE/GYDR Association occupies areas of intermediate moisture between the saturated soils of the THPL/OPHO Association and the less sheltered and apparently better drained soils of the TSHE/ARNU3 Association. On warmer and somewhat drier habitats TSHE/GYDR grades into the TSHE/ARNU3 Association and on higher and cooler sites into the TSHE/RUPE Association.

VEGETATION

Western hemlock dominates the tree regeneration layer in late serai and climax stands and is co-dominant with western redcedar in the overstory (Figure 105). Red cedar was co-dominant with western hemlock in the oldest stands sampled with no sign of hemlock replacing the cedar.

Table 64. Common plants of the TSHE/GYDR Association (n=15).

		CON	COVER
IEEE OVERSTORY LAYER			
THPL	western redcedar	100	37
TSHE	western hemlock	100	28
ABGR	grand fir	73	13
T'TDdp UNDERS-TORY LAYER			
TSHE	western hemlock	100	4
THPL	western redcedar	87	6
ABGR	grand fir	53	2
SHRUBS AND SIJBSHRIJBS			
LIBOL	twinflower	87	7
VAME	big huckleberry	73	3
LOUT2	Utah honeysuckle	60	2
PAMY	pachistima	53	2
HEKBJS			
GYDR	oak-fern	100	15
CLUN	queencup beadlily	100	6
SMST	starry solomonplume	100	5
TIUN	coolwort foamflower	93	7
VIOR2	round-leaved violet	87	3
ATFI	lady-fern	87	2
DIHO	Hooker fairybells	80	3
ADBI	pathfinder	73	3
GOOB	western rattlesnake plantain	73	2
GATR	sweetscented bedstraw	73	2

Table 65. Environmental and structural characteristics of the TSHE/GYDR Association.

	Mean	S.D.	Min	Max
Environment[1]				
Elevation	3832	562	2900	5350
Aspect[2]	38	58		
Slope	19	15	1	52
Topographic Moisture	6.18	0.72	5.0	7.0
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=52).
[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.

Western redcedar individuals were almost always the oldest trees sampled on these sites, apparently because they had survived one or more fires. The largest cedars were often 100 or more years older than the other associated tree species. Relict Douglas-fir, western larch and western white pine may linger for hundreds of years in the canopy but are rarely able to survive as reproduction. They must await a stand opening disturbance such as fire or perhaps windthrow to establish on sites in the TSHE/GYDR Association.

Western larch dominates many early serai stands. Western larch and western white pine are favored by periodic, severe wildfires that occur at 200 year or longer intervals. Grand fir and western redcedar are often prominent in 100-200 year old stands. In the absence of stand-opening disturbances, the more shade tolerant and competitive western hemlock and western redcedar will increase in prominence as stands age. Grand fir declines in abundance once stands exceed 200 years in age, providing soil wood and logs for hemlock regeneration in the older stands. Small amounts of grand fir remain in the oldest stands sampled but it is not nearly as abundant as western hemlock or western redcedar. Douglas-fir is an important component of the tree overstory in some stands

Figure 105. Photo of the TSHE/GYDR Association.

but is poorly represented in the ecology plot data. Subalpine fir and/or Engelmann spruce may be important serai species on cooler sites and the spruce may live for more than 300 years. Some mid- and late-seral stands have two or more tree canopies with rapidly growing species such as western white pine or western larch over a denser canopy of shade tolerant western redcedar, western hemlock, or grand fir.

Lodgepole pine is absent from the plot data and also the data of Cooper *et al.* (1991) in north Idaho for their similar TSHE/GYDR Habitat Type. The lack of lodgepole pine may be related to the relatively nutrient-rich and high organic matter of the soils. The relationship is not well understood and is not simply a matter of stand age. These data span stand ages of less than 60 years to stands with some trees older than 400 years. Establishment of western or paper birch, quaking aspen or black cottonwood is favored by fires that remove the duff layer.

The species rich shrub and herb layers reflect the moderate temperatures and abundant moisture on these sites. Oak-fem, queencup beadlily. Hooker fairybells, pathfinder, wild ginger, starry solomon plume, round-leaved violet, and coolwort foamflower are common herbs. These mesophytic herbs often survive fire or logging but are reduced in abundance until a tree canopy is re-established when they once again become the characteristic undergrowth species. Very dense conifer stands with heavy shade often have low total shrub and herb cover, although oak-fern tolerates shade reasonably well. Twinflower, Utah honeysuckle, pachistima, and big huckleberry are typical shrubs. Utah honeysuckle and pachistima tend to decrease in cover as stands age but big huckleberry, twinflower and yew are better able to maintain higher cover values in older stands. Pacific yew is more common in this type than any other association on the Forest except the THPL/OPHO Association. Pacific yew is seldom abundant, perhaps because of native ungulate browsing. The presence oflady-fem and devil's club indicate especially moist sites which are transitional to the THPL/OPHO Association.

MANAGEMENT IMPLICATIONS

Wildlife/Range- Stands with more than one tree canopy layer provide more and higher quality habitat for arboreal mammals and birds than do those with a single canopy layer. Complex canopy structures are common with two or more tree layers in the canopy. Due to the large size many of the cedar and hemlock may attain in this type, some sites represent important habitat for species dependent upon old-growth stand structures. Such sites may serve as important refugia for old-growth-dependent species. The humid conditions also attract a large variety of insects, which in turn attract avian species. The TSHE/GYDR Association has little utility for domestic livestock except for shade or water. Good forage production for wild ungulates occurs during early serai stages and is fair in mature stands (Cooper *et al.* 1991).

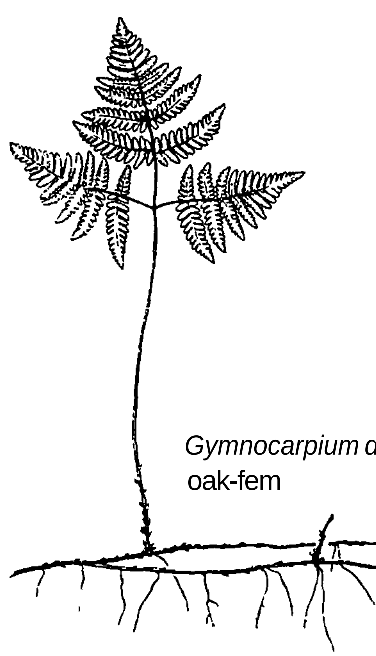
Silviculture- The TSHE/GYDR is one of the most productive associations on the Forest, as indicated by average SDI and BA values (appendix 2). Average site index for western larch, western hemlock, and western redcedar are all in the top 25% range. Both even- and uneven-aged management techniques can be used on these sites due to the moderate environment and variety of serai species which are present. A short rotation, even-aged management regime with serai species such as western larch, Engelmann spruce or western white pine (blister rust resistant stock) has been recommended for a comparable habitat type in northern Idaho (Cooper *et al.* 1991). When western larch is the dominant serai species, Barrett (1982) recommends even-aged management with broadcast burning. However, Harvey *et al.* (1987) caution that organic matter, soil nitrogen and other important nutrients could be lost, leading to reduced long-term site productivity. In addition, complete overstory removal may raise water tables on these sites, creating boggy conditions which may be hard to regenerate.

Regeneration on drier aspects is enhanced by shelter from residual overstory trees (Ferguson *et al.* 1986). Serai species such as ponderosa pine, western larch, or Douglas-fir may be enhanced by underburning in combination with shelterwood or selection cutting techniques (Amo and Davis 1980). Moeur (1992, 1993) reports that selective cutting could be used to alter the structure oflate-seral or old-growth stands by opening the canopy and encouraging reproduction by the shade-tolerant species. Adequate stocking is not usually difficult to obtain on these sites, but site preparation and planting are often needed to obtain a high proportion of serai species (Zack and Morgan 1994). The needs for soil protection, fuel reduction, and mineral soil exposure for regeneration all need to be balanced during the planning stages of slash disposal and site preparation methods. Avoid or restrict activities that compact the soil such as unrestricted tractor logging, whole tree harvest, slash piling or scarification. Managers need to consider wildlife habitat values and proximity to streams when planning management activities in or near this type.

Mature stands are cool and shady, have large trees, gentle topography and are near streams; thus seeming to be attractive campsites and possible campground locations. However, the natural vegetation is highly sensitive to trampling from vehicles and foot traffic. Additionally, the soils are moist or wet much of the spring and summer. Therefore TSHE/GYDR stands are not suitable for campgrounds.

COMPARISONS

Cooper *etal.* (1991) describe a TSHE/GYDR Habitat Type from north Idaho nearly identical to this one. However, some Colville stands would key to their THPL/ATFI Habitat Type because lady-fern, claspleaf twisted-stalk or false bugbane are present. However, no TSHE/GYDR stands on the Colville N.F. are fully representative of the preceding authors' THPL/ATFI Habitat Type. The TSHE/GYDR Association described for eastern Washington by Kovalchik (1993) is also nearly identical to the type described here. Some TSHE/GYDR stands fit the TSHE/CLUN Habitat Type-ARNU3 Phase described for Montana (Pfister *etal.* 1977). Daubenmire and Daubenmire (1968) did not recognize a TSHE/GYDR type. but many of their TSHE/PAMY plots fit within this TSHE/ GYDR Association. Only two of their plots are from Washington, the rest are in north Idaho. The TSHE/GYDR Association falls within the Aralia Oak-fem Association of Bell (1965). Of the seven "Forest Types" recognized by Bell, the Slope Aralia Oak-fem Southern Variant appears the most similar to this TSHE/GYDR Association. The Western Redcedar-Hemlock/Oak-fem-Foamflower Site Association described for the southern interior of British Columbia (Braumandl and Curran 1992) is also very similar to the TSHE/GYDR Association. However, some of those sites contain more five-leaved bramble and would key out to the TSHE/RUPE Association.



Gymnocarpium dryopteris
oak-fem

TSHE/MEFE ASSOCIATION CHS7 11
Tsugaheterophylla/Menziesiaferruginea
western hemlock/rusty menziesia

DISTRIBUTION AND ENVIRONMENT

The TSHE/MEFE Association is found east of the Columbia River and is most common on the Sullivan Lake Ranger District (Figure 106). It occurs on all aspects, though is primarily found on northwest to northeast aspects (Figure 107). It is generally restricted to wet topographic positions when found on southern exposures. Most sites are between 4,500 and 5,500 ft. (Figure 107), and average 4,900 ft. (Table 67). This type indicates relatively high-elevation, heavy snowpack and high precipitation sites within the Western Hemlock Series.

The regolith is ash overlying colluvium which, in turn, often overlies glacial till. The colluvium and till are derived from a variety of rock types. Ash depths range from 7 to 11 in. (17 to 29 cm). Surface horizon soil textures are silt loams with sandy or cobbly loam subsoils. Coarse fragments range from 19 to 60% and surface rock is usually absent. Soils are apparently deep, with coarse fragments increasing with depth. Humus and duff ranged between 2 and 6 in. (5-15 cm). Cool temperatures and lingering snowpacks slow the rate of organic matter turnover relative to warmer associations with the Western Hemlock Series. The TSHE/MEFE Association grades into the

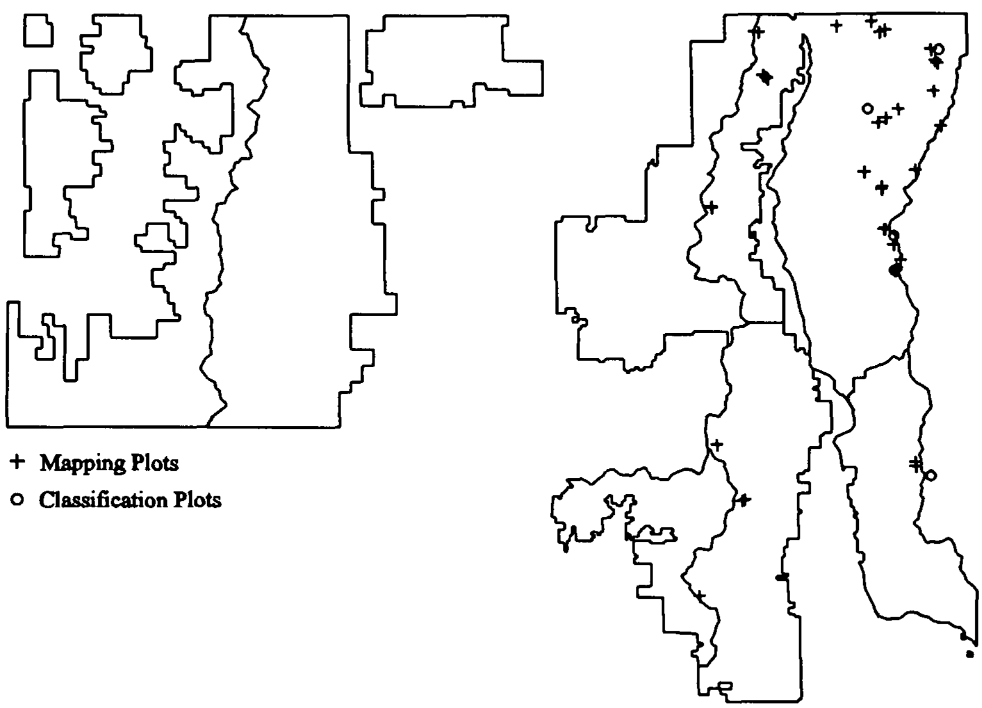


Figure 106. Plot locations for the TSHE/MEFE Association (n=48).

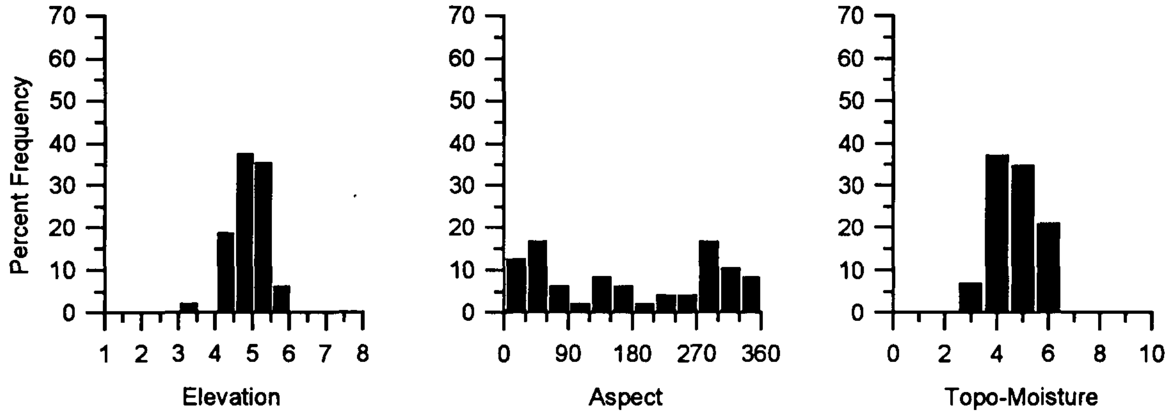


Figure 107. Frequency ofTSHE/MEFE plots by elevation (1000 ft.), aspect, and topographic moisture.

TSHE/CLUN or TSHE/GYDR Associations on warmer habitats and the ABLA2/RHAL-XETE or ABLA2/RHAL Associations on cooler habitats. The TSHE/ XETE Association occurs on similar slopes and elevations but apparently where soil moisture and/or snowpack accumulations are insufficient for rusty menziesia or Cascades azalea to thrive.

VEGETATION

Western hemlock dominates both the understory and overstory of late serai and climax stands (Figure 108). The oldest stands often have a somewhat discontinuous tree canopy over a well developed shrub and subshrub layer. The oldest stand in the data is 300 years old based on the age of the oldest tree measured. This stand is almost wholly dominated by western hemlock in both the overstory and tree regeneration layers. Snags of western larch are present but no live trees remain.

Table 66. Common plants of the TSHE/MEFE Association (n=ll).

		CON	COVER
TREE OVERSTQRY LAYER			
PIEN	Engelmann spruce	91	18
ABLA2	subalpinefir	91	11
TSHE	western hemlock	73	36
LAOC	western larch	9	40
TREE UNDERSTORY LAYER			
TSHE	western hemlock	91	6
ABLA2	subalpinefir	91	5
SHRUBS AND SIJBSHRUBS			
VAME	big huckleberry	100	12
MEFE	rusty menziesia	100	8
PAMY	pachistima	100	4
XETE	beargrass	91	14
RHAL	Cascades azalea	91	10
LOUT2	Utah honeysuckle	91	6
SOSC2	mountain ash	91	2
PYSE	sidebells pyrola	73	3
HERBS			
TIUN	coolwort foamflower	73	7
CLUN	queencup beadlily	55	9

Table 67. Environmental and structural characteristics of the TSHE/MEFE Association.

	Mean	S.D.	Min	Max
Environment[1]				
Elevation	4892	477	3150	5830
Aspect[2]	2	72		
Slope	33	14	7	74
Topographic Moisture	4.70	0.89	3.0	6.0
Soil Surface[3]				
Exposed soil	19	16	1	40
Gravel	20	17	12	38
Rock	10	19	0	38
Bedrock	0	0	0	0
Moss	7	4	1	10
Lichen	0	1	0	1
Litter	34	15	10	50
Diversity[4]				
Richness	22.1	8.8	11	34
N2	8.3	3.7	2	13

[1] Values for environmental variables were generated using both classification plot and mapping plot data (n=48).
[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.

Subalpine fir and Engelmann spruce are important serai trees in early to mid-successional stands (<200 years). Subalpine fir is present in nearly all plots and may be the most abundant species in the tree regeneration layer in mid-seral stands. However, subalpine fir is much less disease resistant and shorter lived than western hemlock and does not regenerate as well in heavy shade. Both species can persist into late serai and climax stand conditions. Western larch and lodgepole pine are abundant early in the sere in some stands, apparently because of differences in disturbance patterns and stand history. Douglas-fir rarely dominates and is most abundant as a serai species on the warmest extremes of the type. Western redcedar is often only a minor stand component. This is in marked contrast to its relative abundance in warmer types within the Western Hemlock Series.

Most stands have two or more shrub layers with rusty menziesia. Cascades azalea and mountain ash as the tall shrub layer. Big huckleberry and Utah honeysuckle often form the intermediate shrub layer, while beargrass and sidebells pyrola are common species in the low or subshrub layer. Cascades

Figure 108. Photo of the TSHE/MEFE Association.

azalea is more abundant at higher elevations and indicates conditions transitional to the Subalpine Fir Series. The herb layer is normally inconspicuous under the thick tall shrub layer. Only coolwort foamflower, round-leaved violet and queencup beadlily are in more than 50 percent of the plots.

MANAGEMENT IMPLICATIONS

Wildlife/Range- Wildlife use these cool, shaded north-slope areas in summer for thermal and hiding cover. These stands represent important thermal and browse areas for deer and elk. Elk use some of the wetter sites for wallows. Wildlife values are high because of the abundance of shrubs, some of which produce fruits. In addition, some of these stands are in late-seral or old-growth stages, representing high value to other old-growth dependent species Mature stands serve as critical winter range for woodland caribou, their principal forage being epidendric lichens covering many of the older trees. While managing for caribou habitat, severe bums should be minimized to protect *Vaccinium* spp. roots and to avoid the potential for dense lodgepole regeneration (Smith and Fischer 1995). This will also help retain large trees and their associated lichens. Old-growth stands may be important winter habitat for martin (Koehler and Homocker 1977). Forage for livestock is poor in natural stands and livestock grazing has little potential except for shade and water.

Silviculture- Although timber productivity is moderate to high, particularly for western larch and Douglas-fir (appendix 2), attempts at intensive management for timber production presents some major problems. Cold temperatures, heavy precipitation (mostly snow) and short growing seasons limit growth rates and management activities. These stands usually occur in areas of deep snow accumulation at the headwater areas of streams. Management actions need to consider maintaining or improving water yields (Pfister *et al.* 1977). In addition, toe slope and bench positions often have high water tables, and overstory removal on these sites may raise water tables, creating boggy conditions. These boggy areas may reforest slowly, and early serai species on these sites may include false hellebore, arrowleaf groundsel, licorice-root, drooping woodreed, or blue-joint reedgrass.

Selection or partial-cutting generally favors the regeneration of the shade-tolerant western hemlock, subalpine fir and Engelmann spruce, though partial-cutting predisposes these species to blowdown. Clearcutting or group selection is suggested except for sites near seeps or streams with high water-tables, though this can lead to increased snowpacks. Deep snowpacks in clearcuts can then promote shrubfields dominated by Cascades azalea, rusty menziesia or Sitka alder which can retard reforestation (Cooper *et al.* 1991). Fiedler (1982) found that natural regeneration can be retarded by up to 60% of a sites potential stocking for up to 12 years when total understory shrub coverages exceed 50%. Shrubby understories require site preparation for good regeneration, with scarification reported as being the most successful method on gentler slopes. Prescribed burning is the only feasible method on steep slopes, but due to moist fuels, successful burning can usually only be accomplished during a brief time period in certain years. In addition, if abundant slash is present on the site, low-severity fires can cause high tree mortality. Dominance by lodgepole pine can occur after severe broadcast bums if a seed source is present (Smith and Fischer 1995).

Under natural conditions, subalpine fir and western hemlock dominate conifer regeneration. Western hemlock, subalpine fir and Engelmann spruce are adapted to most sites. Engelmann spruce is recommended for reforestation on most sites, and should do especially well on sites that accumulate moisture or are frost prone such as benches or toe slopes. Douglas-fir and western larch are suitable on the drier and warmer habitats within the type which have good soil and air drainage such as midslopes. Few plots contained lodgepole pine but this species should be suited to the type since it is common in the drier parts of the ABLA2/RHAL Association and Cooper *et al.* (1991) have lodgepole pine in several of their plots in both the TSHE/CLUN-MEFE Phase habitat type and their TSHE/MEFE habitat type. Other tree species are questionable for timber management.

These stands may require occasional fire protection during periods of severe fire conditions. However, disturbances to these moist forest soils that may accompany modem fire suppression can produce more lasting damage than fire would cause (Bradley *et al.* 1992). The dense undergrowth and steep slopes of many sites limits most recreational opportunities. Moist conditions, heavy snowpacks and susceptibility of shrubs to mechanical damage makes these sites of limited value for recreational developments or trails.

COMPAMSONS

Cooper *et al.* (1991) describe a similar TSHE/MEFE Habitat Type from northern Idaho. They also describe a TSHE/CLUN Habitat Type-MEFE Phase that resembles the TSHE/MEFE Association, but it appears to have a different serai tree species pattern and is found at generally lower elevations. Lillybridge *et al.* (1995) describe a TSHE/MEFE Association for the Cascade Range in central Washington which is also similar. Braumandl and Curran (1992) describe a Subalpine Fir-Western Hemlock/Rhododendron-Azalea Site Association for the southern interior of British Columbia. This type resembles the TSHE/MEFE Association, though contains more subalpine fir and Engelmann spruce and less western redcedar than the TSHE/MEFE Association. Bell (1965) recognized a Degraded Aralia Oakfem Northern Variant within his Aralia Oakfem Association that appears similar to the TSHE/MEFE Association.

Menziesia ferruginea
rusty menziesia

TSHE/RUPE ASSOCIATION CHS4 11

Tsuga heterophylla/Rubus pedatus
western hemlock/five-leaved bramble

DISTRIBUTION AND ENVIRONMENT

The TSHE/RUPE Association is a very minor meso-riparian type on the Colville N. F. and is primarily restricted to the Sullivan Lake Ranger District (Figure 109). It typically occurs in riparian zones near streams at upper elevations on gentle lower slopes and benches with flat or concave microrelief. Aspects are variable. Over 90% of sites are located between 4,000 and 5,000 ft. (Figure 110). The type characterizes a cool, moist and sheltered environment with relatively acid soils and deep humus accumulations. These sites are very similar (though slightly drier) to TSHE/GYDR sites except for perhaps differences in soil acidity indicated by the presence of *Rubus pedatus,* and higher average elevations.

Soils are formed in glacial or alluvial material mixed with volcanic ash. Five-leaved bramble indicates thick, add humus (Bell 1964) as well as cold environments. Duff, litter and humus layers are thick. Humus and duff ranged in depth for 3 to 13 in. (8-33 cm) in depth. The oldest stands had thicker duff and humus layers. Gravelly silt loams in the upper parts of the profile shift to cobbly silt loams deeper in the profile. Coarse fragments composed 16% to 56% of the soil profile and surface rock

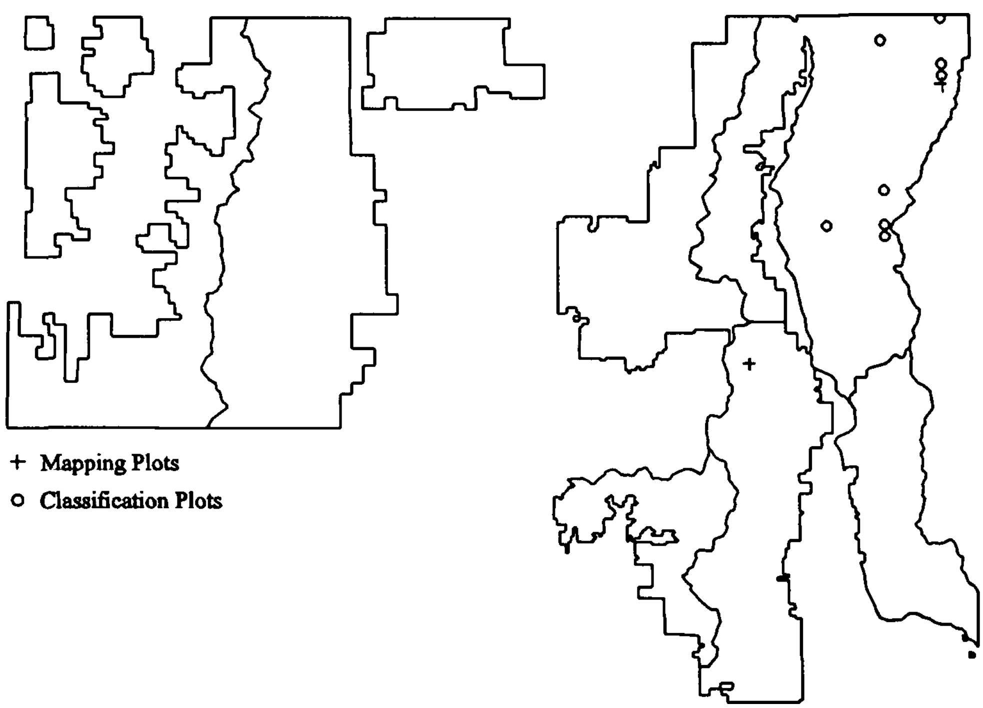


Figure 109. Plot locations for the TSHE/RUPE Association (n=18).

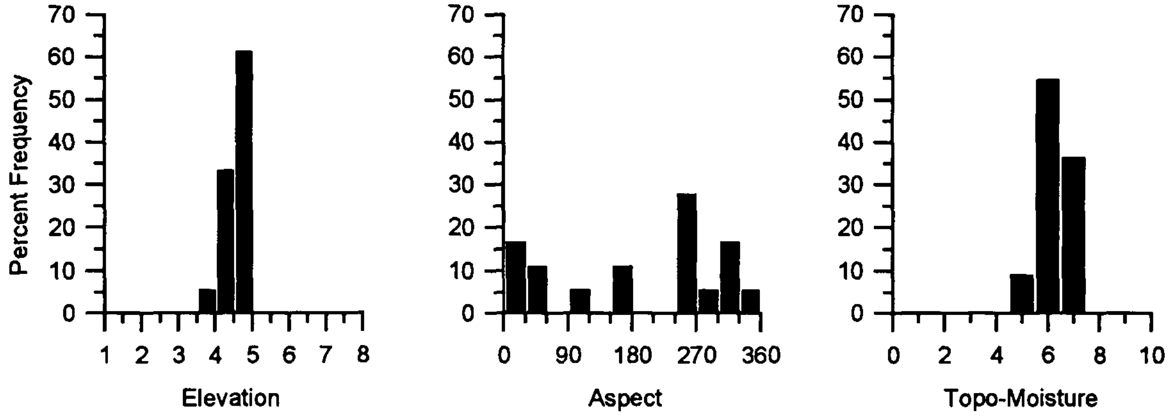


Figure 110. Frequency ofTSHE/RUPE plots by elevation (1000 ft.), aspect, and topographic moisture.

is usually present. Pistol-butted trees and frequent tip-ups suggest unstable soils or difficulty of deep root establishment.

VEGETATION

A dense overstory of western redcedar and western hemlock characterizes late serai and climax stands. Multiple canopies are common in mature stands. Serai species which are occasionally present include subalpine fir and lodgepole pine. Some of the oldest trees sampled on the Colville N.F. were in the TSHE/RUPE Association. One western redcedar was nearly 550 years old. Several plots had trees over 300 years old.

Western hemlock tends to dominate the tree regeneration layer in the oldest stands (Figure 111). However, western redcedar is extremely long-lived and simple abundance of trees in the regeneration size classes may not adequately reflect the long-term successional dynamics of a stand.

Table 68. Common plants of the TSffiE/RUPE Association (n=15).

		CON	COVER
	OVERSTORY LAYER		
IREE			
TSHE	western hemlock	100	36
THPL	western redcedar	93	29
ABLA2	subalpine fir	53	6
PICO	lodgepole pine	7	30
	UNDERSTORY LAYER		
TRFF			
TSHE	western hemlock	100	5
THPL	western redcedar	93	5
SHRUBS AND SIJBSH			
RUPE	[illegible]	100	9
VAME	big huckleberry	93	7
PYSE	sidebells pyrola	87	3
PAMY	pachistima	80	3
LOUT2	Utah honeysuckle	73	3
MEFE	rusty menziesia	73	2
GYDR	oak-fern	100	12
CLUN	queencup beadlily	100	7
VIOR2	round-leaved violet	100	4
TIUN	coolwort foamflower	93	8
STAM	claspleaf twisted-stalk	93	2
TROV	trillium	93	2
GOOB	western rattlesnake plantain	73	2
OSCH	sweetroot	60	2