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Classification and Management of Aquatic, Riparian, and Wetland Sites on the National Forests of Eastern Washington: Series Description

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ABSTRACT

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This is a classification of aquatic, wetland, and riparian series and plant associations found within the Colville, Okanogan, and Wenatchee National Forests. It is based on the potential vegetation occurring on lake and pond margins, wetland fens and bogs, and fluvial surfaces along streams and rivers within Forest Service lands. Data used in the classification were collected from 1,650 field plots sampled across the three forests. This classification identifies 32 series separated into four physiognomic classes: coniferous forests, deciduous forests, shrubs, and herbaceous vegetation. In addition, keys to the identification of 163 plant associations or community types are presented. The report includes detailed descriptions of the physical environment, geomorphology, ecosystem function, and management of each series. This classification supplements and expands information presented in upland forest plant association classifications previously completed for the three eastern Washington forests. It is a comprehensive summary of the aquatic, riparian, and wetland series and contributes to the understanding of ecosystems and their management in eastern Washington.

Keywords: Riparian, aquatic, wetland, vegetation classification, series description, plant association, plant community, riparian vegetation, riparian ecosystems, eastern Washington.

CONTENTS

PREFACE

There is tremendous diversity in the aquatic, wetland, and riparian ecosystems of eastern Washington. Bernard L. Kovalchik describes this variation at the series level in this vegetation guide for national forest lands in Washington. Here "series" refers to the group of plant associations having the same climax species characterizing the dominant plant cover. For example, the Pacific silver fir series is composed of all plant associations potentially dominated by Pacific silver fir at climax. The series is a level in the classification hierarchy above the plant association level. This level is useful in describing environmental conditions, community composition, and management opportunities and limitations at a scale broader than plant association descriptions. The guide describes ecosystem diversity in a manner helpful to resource managers with a fundamental understanding of wetland ecology and vegetation.

Included in this guide are series descriptions and keys to hydrophytic vegetation dominated by conifers, deciduous trees, shrubs, and herbaceous plants. The author describes the biotic and abiotic environments; the series distribution within the Colville, Okanogan, and Wenatchee National Forests; and ecosystem management of the series and its components. Plant association keys and association tables are presented for those who want additional information for site classification. Future classification efforts can build on this framework and expand descriptions of the lower levels in the classification taxonomy (plant associations).

Kovalchik has expanded the work of other Area 2 plant ecologists in his treatment of the coniferous series; he defines and describes those wetland and riparian sites dominated by mountain hemlock, Pacific silver fir, western hemlock, western redcedar, subalpine fir, Engelmann spruce, grand fir, Douglas-fir, subalpine larch, and lodgepole pine. In addition, he describes conifer types occupying moist sites adjacent to streams, rivers, lakes, and ponds that are transitional to upland vegetation described in earlier guides.

Vegetation dominated by deciduous trees is summarized in the descriptions of the quaking aspen, black cottonwood, red alder, paper birch, Oregon white oak, and bigleaf maple series. The author describes the composition, distribution, and management of these important landscape elements in northeast Washington forests. He demonstrates that these series provide habitat diversity fundamental to maintaining wildlife, fish, and rare plant resources of the area, and he provides the framework for ecosystem management of these types.

The shrub-dominated series include the willow, heath, vine maple, Sitka alder, mountain alder, red-osier dogwood, Douglas spiraea, Douglas maple, devil's club, salmonberry, shrubby cinquefoil, Cascade azalea, and common snowberry series. Kovalchik presents these complex and dynamic systems in a manner that facilitates good stewardship of these riparian/wetland resources. He identifies the environmental matrix supporting the 13 series and the management concerns that span the environmental variation in this diverse group.

Herbaceous vegetation is described in the aquatic series, the meadow series, and the forb series. Unlike series within the previous life-form groups (conifers, deciduous trees, and shrubs), these three series of herbaceous vegetation do not have a singular climax dominant (for example, Pacific silver fir series). Rather, the series is named for recognizable habitat (aquatic and meadow) or life form (forb). A variety of climax herbaceous species can dominate sites within each of these three series. The aquatic series includes all herbaceous plant associations supporting rooted vascular or emergent vegetation that grows in deep water or in shallow water along the shoreline of permanently standing water. Graminoids dominate sites classified in the meadow series; this complex series includes 24 plant associations. These associations occur across a variety of habitats representing different environmental conditions of moisture, temperature, pH, aeration, and organic soil fraction. Five plant associations with perennial forb dominance are found in the forb series. The forb series includes all terrestrial riparian and wetland sites dominated by forbs; it does not include forb-dominated sites in the aquatic series. The author's treatment of herbaceous vegetation has provided a simplified description of the variation inherent in these diverse ecosystems and helps resource specialists become familiar with the distribution and management of these types.

The appendixes include information that both supplements and enhances the series descriptions. It has been a rewarding experience working with Bud Kovalchik to finish this aquatic, wetland, and riparian classification guide. The field sampling, synecological analyses, and draft document were his work; I have only assisted in the preparation of the final guide. Our hope is that the completed work is a valuable addition to the store of ecological information that will aid resource stewardship in northeastern Washington.

Rod Clausnitzer
July 2004

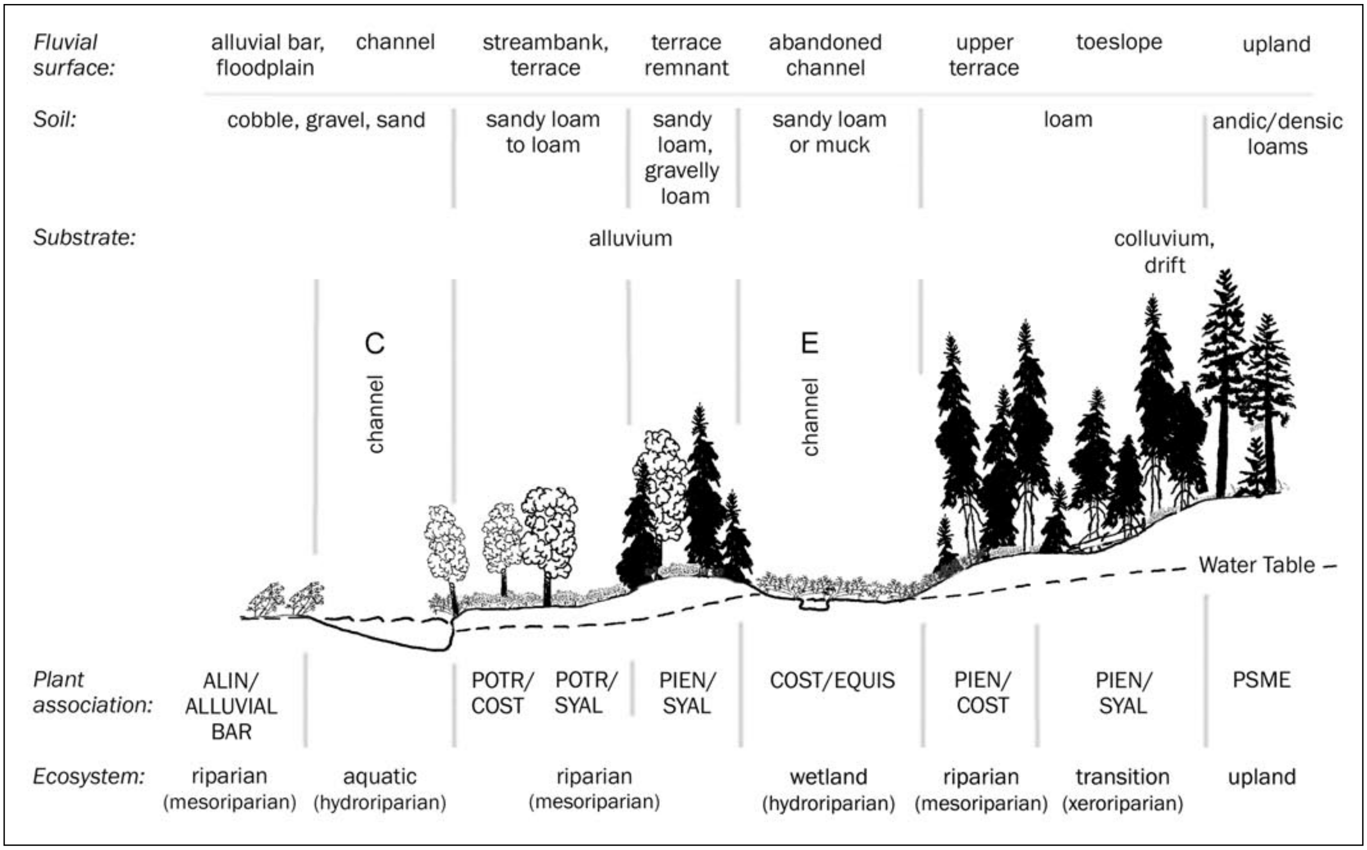

Figure 1—Riparian and wetland ecosystems form a narrow interface between aquatic and upland ecosystems.

INTRODUCTION

This study presents a classification of (and management options for) aquatic, wetland, and riparian series and plant associations occurring within the Colville, Okanogan, and Wenatchee National Forests (NF) (fig. 1). Aquatic, wetland and riparian ecosystems are only a small portion of the eastern Washington landscape. They are, however, disproportionately important as habitats for plants and as sources of food, water, cover, and nesting habitat for animals (Crowe and Clausnitzer 1997, Hansen et al. 1995, Kovalchik 1987). Vegetation production is generally higher in these ecosystems than in nearby uplands, and their cool, moist microclimate provides a contrasting habitat. These areas also are valued for human uses including recreation; livestock grazing; as a water supply for irrigation, mining operations, and crop production; and as transportation corridors. The structure and composition of riparian and wetland systems influence the rate, amount, and timing for water, nutrients, organic debris, and inorganic materials that enter lakes, ponds, streams, and rivers. The energy, and ultimate amount, timing, and erosive power of floodwaters are influenced by the soils, vegetation, and geomorphology of soil surfaces (fluvial surfaces) within valley bottoms. Decades of intensive use of riparian areas and other wetlands have caused substantial degradation of their ecological structure, composition, and function throughout most of the United States. Rehabilitation and restoration are currently high priorities for the U.S. Department of Agriculture (USDA) Forest Service (FS) and other agencies charged with managing public land. To improve conditions, an understanding of wetland and riparian ecosystems is necessary. Classification of aquatic, riparian, and wetland series and their plant associations provides a means of stratifying these ecosystems into recognizable and repeatable units that integrate potential natural vegetation, soil characteristics, fluvial geomorphology, hydrology, and climate. This classification is integral to ecosystem management providing a common framework for communicating about wetland ecosystems among various disciplines, and for planning management activities and analysis of their effects.

"Wetlands are areas that lie between terrestrial (upland) and aquatic systems and generally considered to be inundated or saturated by surface or groundwater at a frequency and duration sufficient, under normal circumstances, to support a prevalence of vegetation typically adapted for life in saturated soil conditions" (Federal Interagency Committee for Wetland Delineation 1989). The U.S. Fish and Wildlife Service (USFWS) wetlands classification (Cowardin et al. 1979) uses the term "wetland vegetation" to describe "vegetation within or adjacent to, and hydrologically influenced by, streams, rivers, lakes, meadows, and seeps." The term "riparian vegetation" is used specifically for vegetation located within the valley of, and hydrologically influenced by, a stream or river. "Aquatic vegetation" grows in deeper, permanently standing water in lakes and ponds (or in the sluggish backwaters of streams and rivers).

These riparian and wetland zones form a narrow interface between aquatic and terrestrial ecosystems. In the mountainous regions of the Pacific Northwest (Kovalchik 1987, Youngblood et al. 1985b), these water-oriented ecosystems are well defined by the presence of free, unbound water and are next to much drier upslope ecosystems. They occur on a variety of sites, such as floodplains, bogs, marshes, lakeshores, springs, and basins. Jurisdictional wetlands must (under current regulations) have three components: wetland hydrology, hydric soils, and hydrophytic vegetation. The Natural Resources Conservation Service (NRCS) has devised the list of soil types that qualify as hydric soils (USDA SCS 1987); the definitions of wetland hydrology are found in the Corps of Engineers Wetland Delineation Manual (Environmental Laboratory 1987); and the USFWS has prepared the list of hydrophytes and their degree of wetland affinity (USFWS 1996). Included are plant associations occurring on fluvial surfaces in valley bottoms that may not be classified as jurisdictional wetlands but that do function as "xeric" or "transitional" riparian or wetland areas (Crowe and Clausnitzer 1997, Kovalchik 1987). These fluvial surfaces usually are drier terraces and the adjacent toeslope. They also may include the transition to uplands that occurs at the margins of true wetlands.

Thus, typical riparian and wetland sites (as used in this report) are composed of three distinct ecosystems (fig. 1) (Kovalchik 1987):

- Aquatic—The permanently flooded portion of the riparian or wetland zone, which includes streams, rivers, ponds or lakes.
- Riparian and wetland—The land next to water where plants that are dependent on a perpetual source of water live.
- Transitional or xeroriparian—Subirrigated sites lying between riparian/wetland sites and upland. This ecosystem does not have true hydrophytic vegetation such as sedges and willows, yet is uniquely different from uplands.

The consistent occurrence of similar series and plant associations in these ecosystems can be used to stratify the landscape (Daubenmire 1976, Pfister et al. 1977). Although not all questions about a piece of land can be answered by a series/plant association classification (Hemstrom and Franklin 1982), vegetation, soil, water, and physical characteristics can usefully indicate plant responses to management, productivity potential, and future species composition. Such a classification allows us to:

- Plan management strategies—Evaluate resource condition, productivity, and responses to management.
- Communicate—Provide a common description of riparian conditions for various disciplines, record successes or failures of management actions, and repeat the successes.
- Apply research—Provide a direct link between research results and practical land management.

Recent classifications of series and plant associations integrate potential natural vegetation, soil characteristics, fluvial geomorphology, hydrology, and climate (Crowe and Clausnitzer 1997, Diaz and Mellen 1996, Hansen et al. 1995, Kovalchik 1987). This classification follows their lead as it classifies aquatic, wetland, and riparian series and plant associations (with some community types) occurring on the Colville, Okanogan, and Wenatchee NFs.

This classification covers all riparian and wetland sites within the Colville, Wenatchee, and Okanogan NFs, as well as a large tract of land on the west side of the Cascades between Washington Pass and the North Cascades National Park (fig. 2). It includes aquatic, riparian, wetland, and transitional series and plant associations that (1) occur repeatedly in eastern Washington, (2) are large enough to be mapped for project-level wildland management, and (3) have distinct management differences.

This classification supplements and expands information presented in upland forest plant association classifications in eastern Washington (Lillybridge et al. 1995, Williams et al. 1995). It focuses on riparian and wetland ecosystems but also includes aquatic ecosystems. Intermittent streams, dry draws, and other land features that may at times transport water are poorly represented in the classification, although they may support vegetation described by one of the series or plant associations. Seeps and springs support wetland or riparian vegetation but were not sampled often. Small portions of the NFs, such as parts of the eastern half of the Tonasket Ranger District (RD) of the Okanogan NF and the Table Mountain area of the Wenatchee NF, may have riparian zones in deteriorated condition. They are weakly represented in the database because of the lack of riparian and wetland ecosystems in late-seral to climax ecological status.

This study has been prepared to meet the following objectives of the Pacific Northwest Region Ecology Program:

- Provide a useful classification of water-defined ecosystems as a step toward completing the USDA Forest Service, Pacific Northwest Region classification program.

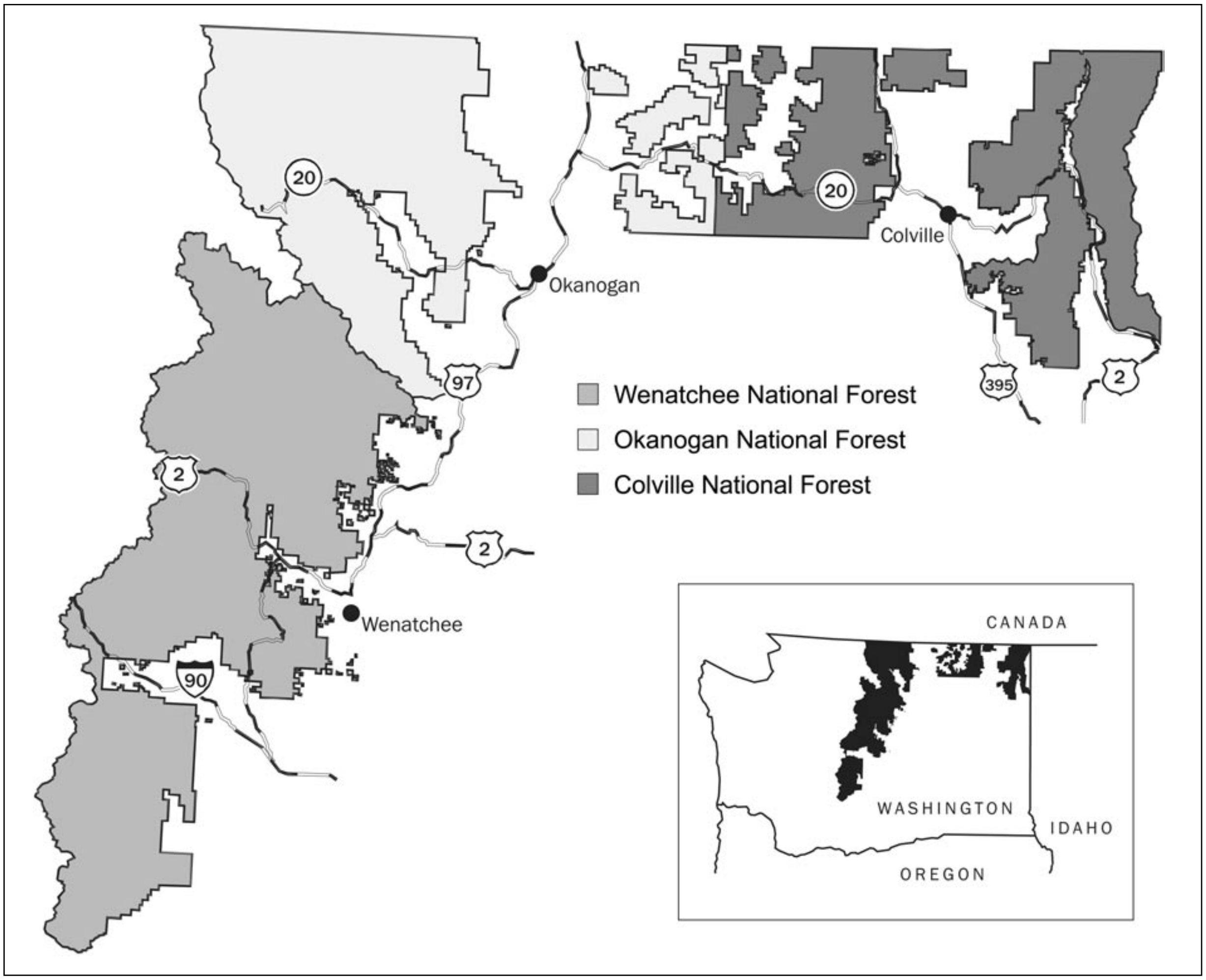

Figure 2—Location of the Colville, Okanogan, and Wenatchee National Forests.

- Describe the general geographic, topographic, edaphic, functional, and floristic features of aquatic, riparian, and wetland ecosystems.
- Describe successional trends and predict vegetative potential on disturbed aquatic, riparian, and wetland ecosystems.
- Present information on resource values and management opportunities.

METHODS

Field Methods—

Aquatic, riparian, and wetland ecosystems in north-central and northeastern Washington were first sampled from 1990 through 1992 and incorporated into a draft classification for the Colville NF and Tonasket RD of the Okanogan NF (Kovalchik 1992c). The database for that draft included about 700 sample plots that were selected to represent the best available environmental conditions. Field sampling continued on the Okanogan and Wenatchee NFs from 1993 through 1995 and provided an additional 950 plots for the final riparian/wetland classification for eastern Washington.

Stands in climax ecological status (good ecological condition) were sampled wherever available. In areas of consistently high levels of disturbance, climax stands were difficult to find, and late-seral stands in fair ecological condition were sampled. Exceptions included a few plots in naturalized community types such as the Kentucky bluegrass community type or obviously seral communities such as those dominated by lodgepole pine, quaking aspen, black cottonwood, red alder, bigleaf maple, or paper birch. The final classification thus provides a foundation of series and plant associations in fair to good ecological condition (late-seral to climax ecological status) against which stands of other condition stages can be compared in order to determine their potential.

A reconnaissance of drainages was made prior to plot selection. Sample sites representing best conditions were then chosen in distinct reaches (as defined by valley gradient, valley width, and elevation) of riparian/wetland zones. A stream reach might include several progressively drier, distinct series and plant associations on the succession of fluvial surfaces occurring between the aquatic and upland ecosystems. Sketches delineating the stream, fluvial surfaces, and each plant association across the valley reach were drawn. Each plant association became a plot site, and a cross section of the valley located clusters of plots. Actual sample plot size per site was usually one-tenth of an acre. For small sites (e.g., alluvial bars, floodplains, streambanks) that were less than one-tenth of an acre, the entire site became the plot. In either case, the plot had to represent the stand and not include ecotones.

A complete inventory of vascular plants and ocular estimates of canopy cover was taken on each plot. Generally, the ocular estimates were to the nearest percent up to 10-percent canopy coverage and to the nearest 5 percent thereafter. Plants not field identified to the species level were collected for later identification in the office. Although usually field identified, all willows (*Salix* spp.[1]) and most sedges (*Carex* spp. and their relatives) were collected for further study of these difficult genera.

Soil pits were described by using standard pedon descriptions (USDA SCS 1975). Thickness, moist color, texture, coarse fragments, rooting depth, and root abundance were recorded by horizon. Other soil data included water table levels, soil moisture, rooting depth, total soil depth, and parent material. A 3-inch soil auger proved most effective for digging pits in fine-textured mineral or organic soils, but auger penetration was often limited in cobbly soils. The hole was augered only to the depth of an impenetrable layer (such as cobbles).

Other data collected on each plot included elevation, aspect, slope, landform, microtopography, and ecological status. The percentages of cover of bare ground, gravel, rock, bedrock, and moss were estimated for the soil surface. Wildlife habitat was briefly described. Tree heights, tree ages (at 4.5 feet), basal area of live tree species, and snag data were measured on forested plots. Log information was collected on all plots. Stream channels were described by using Rosgen's stream classification (Rosgen 1994, 1996). Valley width, shape, and gradient were recorded for each plot.

Taxonomic Considerations—

Wetland plant identification is considered difficult by many of the potential users of this report. Thus, considerable collections were made of willows, sedges, other difficult genera, and unknown plant species. Joy Mastroguiseppe at the Washington State University Herbarium verified sedges and sedgelike graminoids during the first 2 years of the study. Similarly, Steven Brunsfeld at the University of Idaho verified willow collections in early years of the study. The author verified later collections of sedges and willows. Willow taxonomy follows Brunsfeld and Johnson (1985) and Hitchcock and Cronquist (1973). Monocot taxonomy and other flora generally follow Hitchcock and Cronquist (1973).

About 25 willow species and varieties have been identified on eastern Washington NFs. The author is very familiar with willow taxonomy, but identification of willows was difficult for summer field crews. Many willows bloom before or simultaneously with mature vegetation development, and the characteristics of female and male aments are used for identification. Later in the summer, aments are often lacking so that growth form, leaves, and twigs become important identifying criteria. Some species may hybridize, and a few species are very similar to one another. This has created considerable confusion in nomenclature. (A willow comparisons table is included in app. F).

Readers please note that a recent review of the willow collections for the study area and subsequent voucher verifications by George Argus (2004) have revealed some earlier misidentifications. Piper's willow (*Salix piperi*) collected in northeastern Washington is best considered Barclay's willow (*Salix barclayi*)—albeit, extremely large specimens of that taxon. In addition, most of the Farr's willow (*Salix farriae*) identified in the study area is likely *S. barclayi*. The remaining Farr's willow specimens were reexamined and identified as bog willow (*Salix pedicellaris*) by Argus and Kovalchik. Further, some of the *S. barclayi* collected in northeastern Washington has been verified as tea-leaved willow (*Salix planifolia* var. *monica*). Although Barclay's willow, bog willow, and tea-leaved willow are well distributed and quite common in the study area, apparently Farr's willow is more limited in its distribution. Consequently, the authors find it more appropriate to rename the short willow types (SAFA) after the more common taxon, *Salix planifolia* var. *monica* (SAPLM2).

Sedges, sedgelike plants, and wet-site grasses also were difficult species for summer crews. The taxonomy for sedges in Hitchcock and Cronquist (1973) required some clarification. Their keys to sedges are based on characteristics that are at times variable and overlapping. A comparisons table for sedges is provided in appendix E.

Aquatic plants presented a problem because of their slow development relative to riparian and wetland species. A site with the potential to support aquatics may not have aquatic growth in June, may have some vegetative development but no flower development in July, and flowering material may not be available until late August. Some of the most common aquatics, such as pondweed (*Potamogeton*), bur-reed (*Sparganium*), and bladderwort (*Utricularia*), were grouped into genera because of the difficulty identifying them to species without flowering parts.

[1] See appendix A for common and scientific names of plant, animal, and insect species and diseases mentioned in this classification.

The separation between individuals clearly recognizable as Oregon hollygrape and those clearly identifiable as creeping hollygrape was problematic. Most plants appeared to fit *Berberis aquifolium*, although there is considerable variation from plant to plant. Cascade hollygrape (*Berberis nervosa*) was recorded as such.

Big huckleberry (*Vaccinium membranaceum*) and globe huckleberry (*V. globulare*) are morphologically similar species that occur in the study area and are easily confused (Steele et al. 1981). Globe huckleberry is more common in the Rocky Mountains and big huckleberry in the Cascade Range. Most of the material seems to better fit big huckleberry so all plants of this group are arbitrarily referred to as big huckleberry.

Low huckleberry (*V. myrtillus*) appears at times to intergrade with both big (*V. membranaceum*) and grouse huckleberry (*V. scoparium*). However, the difference in indicator value of the species is most significant when low or grouse huckleberry or both are the only or the greatly predominant species. Species identification is normally readily apparent under these conditions.

Pfister et al. (1977) indicated that most spruces in northern Montana are hybrids of Engelmann (*Picea engelmannii*) and white spruce (*Picea glauca*). White spruce is prominent closer to the Montana-Canada border, especially in geologic areas with limestone parent material or at low elevations near the border. The same pattern seems true in eastern Washington, especially in strong continental climate near the Canadian border, but cone scales were not collected to prove or disprove hybridization. Most of the spruce found on the ecology plots readily keyed to Engelmann spruce, so that name was used for all spruces.

Paper birch and water birch often hybridize, and it is unclear what to call these hybrid forms. Paper birch has striking white bark and is a moderately large tree. Water birch is usually more shrublike, with many stems and brownish-reddish bark. Hybrids are small trees with pinkish bark that were lumped with paper birch because of their treelike stature.

Mountain alder can grow to more than 40 feet tall in the study area, which is much taller than described in the literature (Hitchcock and Cronquist 1973). Some persons have called these specimens red alder because of their unusual height, but a close look at cones and leaves of the species indicates they best fit mountain alder. This problem seemed to be especially prominent on the Colville NF, but mountain and red alder also intermix on the Wenatchee and Okanogan NFs. In the Colville NF data, all were called mountain alder. In Cascades data, red and mountain alder were named separately, even though hybridization may account for the large size of some mountain alder.

Classification Techniques—

Arriving at a vegetation classification involved reiterative interactions between data gathered in the field (the "real" world) and the more abstract, analytical activities in the office.

Manipulating data via various computer programs was important from the beginning of the study. Field data were entered and edited in a PARADOX[2] (later MS Access) database to analyze field data and aid classification development. Association tables were made to group stands with similar floristic characteristics. Pacific Northwest Region ecology programs (adapted for personal computers by Brad Smith in 1991[3]) such as TWINSPAN, DECORANA, and SIMILARITY (Hill 1979a, 1979b) provided more objective techniques for analyzing field data and developing the classification. For synthesis of the many tables and figures in the classification, data were queried in MS Access, transferred to MS Excel, assembled in workbooks by series, and further massaged and collated to various data subsets by series and plant association. The data subsets are displayed as tables, charts, and maps in this classification.

Data collected from 1990 through 1992 were used to write a preliminary draft of the riparian and wetland plant associations found on the Okanogan's Tonasket RD and the Colville NF (Kovalchik 1992c).

Later data were used in 1999 to write a draft manuscript for wetland and riparian series in all three NFs that was made available on the Colville NF intranet site (http://fsweb1.f21.r6.fs.fed.us). This rough draft was missing considerable management information.

Plant association keys and constancy/cover tables, production information, and additional management information were added to this report in 2000 and 2001. The current report focuses on riparian and wetland series classification for eastern Washington NFs but also includes keys and constancy/cover tables for the plant associations.

CLASSIFICATION CONCEPTS AND TERMINOLOGY

Series, Plant Association, and Community Type Concepts—

Series, plant association, and community type are the basic units of the classification. The series refers to all the plant associations and community types dominated by the same species at climax or in good ecological condition (for example, the willow series). Pfister et al. (1977) define a plant community as an assembly of plants living together, reflecting no particular ecological status. The community

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[2] The use of trade or firm names in this publication is for reader information and does not imply endorsement of any product or service by the U.S. Department of Agriculture.

[3] Brad Smith was the associate ecologist and acting area ecologist for the Area 2 Ecology Program from 1989 to 1994.

type is an aggregation of all plant communities distinguished by floristic and structural similarities in both overstory and undergrowth (Youngblood et al. 1985a). Pfister et al. (1977) define the plant association as a climax community type. This classification (and Crowe and Clausnitzer 1997) uses riparian and wetland plant association as an assemblage of native vegetation in equilibrium with the environment on specific fluvial surfaces (the vegetative potential on the fluvial surface). This potential may change in time as soil and water characteristics of the fluvial surface change through erosion or, more typically, flooding and silt deposition. The *Classification and Management of Montana's Riparian and Wetland Sites* (Hansen et al. 1995) follows this lead and defines a riparian or wetland plant association as a vegetation type representing the latest (most stable) successional stage attainable on a specific hydrologically influenced surface.

This study concentrated on sampling riparian associations in climax and late-seral ecological status (fair or better ecological condition) and avoided disturbed sites. The aquatic/riparian/wetland series and associations are often restricted to very specific fluvial surfaces within a valley segment. Together, plant associations and fluvial surfaces provide a meaningful way of integrating various environmental factors such as water regime and soils that affect vegetation. They represent a relatively narrow portion of the environmental variation found in riparian landforms and reflect certain potential for vegetation and fluvial surface development. Therefore, riparian association and community types are useful as an ecological basis for management guidelines related to ecological status, wildlife, fisheries, productivity, silviculture, succession, range management, hydrology, and mapping. The following four criteria must be met before a particular assemblage of plants can be classified as a riparian series or plant association (Hall 1973): The series or plant association (or community type) (1) differs from other associations in opportunities and limitations to land management, (2) can be recognized on the ground in any stage of disturbance, (3) has limited variation in species composition, and (4) has limited variability in productivity.

Nomenclature—

Each series is named after its tallest, most dominant life form (for example, the mountain alder series). Plant associations are named based on a combination of the dominant life form plus the characteristic or dominant plant species in the various plant layers (trees, shrubs, and herbs) (for example, the mountain alder–common snowberry (ALIN–SYAL) and Engelmann spruce/saw-leaved sedge (PIEN/CASCP2) associations). A slash (/) is used to separate the various life forms in a community name, and a dash (–) separates members of the same life form. The association may have only one species in its name (e.g., the herb layer in meadows), two where shrubs are superimposed over the herbaceous layer, or three where there are tree, shrub, and herb layers.

Shade tolerance is also a consideration in nomenclature (Williams and Lillybridge 1983). Thus, the name will be suggestive of plants most capable of growing on a site in more mature stands. For example, willows may be present in small amounts in the mountain alder–Douglas spiraea association (ALIN–SPDO), but mountain alder is used to name the association because it will dominate the willows as the plant composition and structure proceeds towards maturity. In the Engelmann spruce/saw-leaved sedge association (PIEN/CASCP2), the shrub undergrowth may contain both willows and saw-leaved sedge, but the sedge is used to name the association because it is more tolerant of conifer shade and is more dominant under mature forest canopies than willows. In the willow/saw-leaved sedge association (SALIX/CASCP2), however, trees are uncommon and willows are used to name the plant association. The dominant or most characteristic graminoid or herb is used to name the herbaceous layer. For instance, queencup beadlily is the most consistent species in a group of mesic forbs in the undergrowth of the relatively dry western redcedar/queencup beadlily association (THPL/CLUN), saw-leaved sedge forms a sward below trees in the wet Engelmann spruce/saw-leaved sedge association (PIEN/CASCP2) and the wet willow/saw-leaved sedge (SALIX/CASCP2) association. On the other hand, meadow series plant communities dominated by saw-leaved sedge alone are called the saw-leaved sedge (CASCP2) association.

Appendix A contains a list of the plant species codes, scientific names, and common names used in the text. Common names and Pacific Northwest (PNW) Region species codes are used in the constancy/cover tables. Series, plant associations, and community types are referred to in the text and tables by capital letter codes (for example, the PIEN series and PIEN/CASCP2 plant association). These codes are used instead of longhand species names to save space in some tables. The code is derived from the first two letters of each scientific name for a species. For example, the code for Geyer's willow (*Salix geyeriana*) is SAGE. The scientific code is better adapted to computer use and helps distinguish between series and plant associations in the text. All codes follow Garrison et al. (1976). The national plant species list codes (USDA SCS 1982) are included in appendix A. Scientific names largely follow Hitchcock and Cronquist (1973) except for a few exceptions. Common names follow Garrison et al. (1976) or Hitchcock and Cronquist (1973). Appendix A entries list the USDA FS PNW Region alpha code; newer national PLANTS database alpha code, scientific name, common name, the plant's indicator status, and each plant's hydrologic status.

THE PHYSICAL ENVIRONMENT

Climate—

The Cascade Range is a significant barrier to the movement of maritime and continental air masses. The study area has a climate with both maritime and continental climate because air masses from the continent and the Pacific Ocean cross this region. North-south trending mountain ranges and narrow valleys also create variation in climate. The central portion of the study area is under the influence of an intense rain shadow formed by the north Cascade Range. This effect is pronounced on the eastern half of the Wenatchee NF and occurs in areas just a few miles east of the Cascade crest on the Okanogan NF. This rain-shadow effect continues eastward through the Tonasket and Republic RDs. The far northeastern portion of the region has a moist inland maritime climate caused by westerly airflow being lifted over the 5,000- to 7,000-foot peaks of the Selkirk Mountains. Through most of the year, maritime air from the Pacific exerts a moderating influence on temperatures, whereas drier air from the interior can bring more extreme temperatures and drought.

Precipitation is greater in winter and spring. Most low-elevation valleys receive 10 to 25 inches of precipitation per year (fig. 3). The towns of Wenatchee, Okanogan, Republic, and Colville, Washington, receive about 9, 13, 20, and 18 inches of yearly precipitation, respectively. Precipitation increases in the mountains to 25 or more inches on the higher ridges of the Kettle River Range, 50 inches or more in the Selkirk Mountains, and over 80 inches along the Cascade crest. During the warmest summer months, maximum afternoon temperatures in the valleys range from the mid to upper 80s (degrees Fahrenheit), while minimums range from the 40s to the mid 50s (degrees Fahrenheit), (Phillips and Durkee 1972). During an average winter, afternoon temperatures are near freezing with minimums from 10 to 20 degrees Fahrenheit. In average years, summer temperatures exceed 100 degrees Fahrenheit for 1 to 5 days, and winter temperatures below 0 degrees Fahrenheit occur for 5 to 12 nights. Conditions are more severe in the mountains.

Climatic gradients between riparian and upland sites are sharp (Youngblood et al. 1985a). Cold air draining downhill into broad flats, basins, and valley bottoms can create severe summer frost problems in riparian and wetland zones. Summer droughts common in the uplands are largely moderated by moist to wet soils in riparian and wetland zones. Sites next to larger bodies of water, especially lakes, may have air temperatures moderated by the standing water.

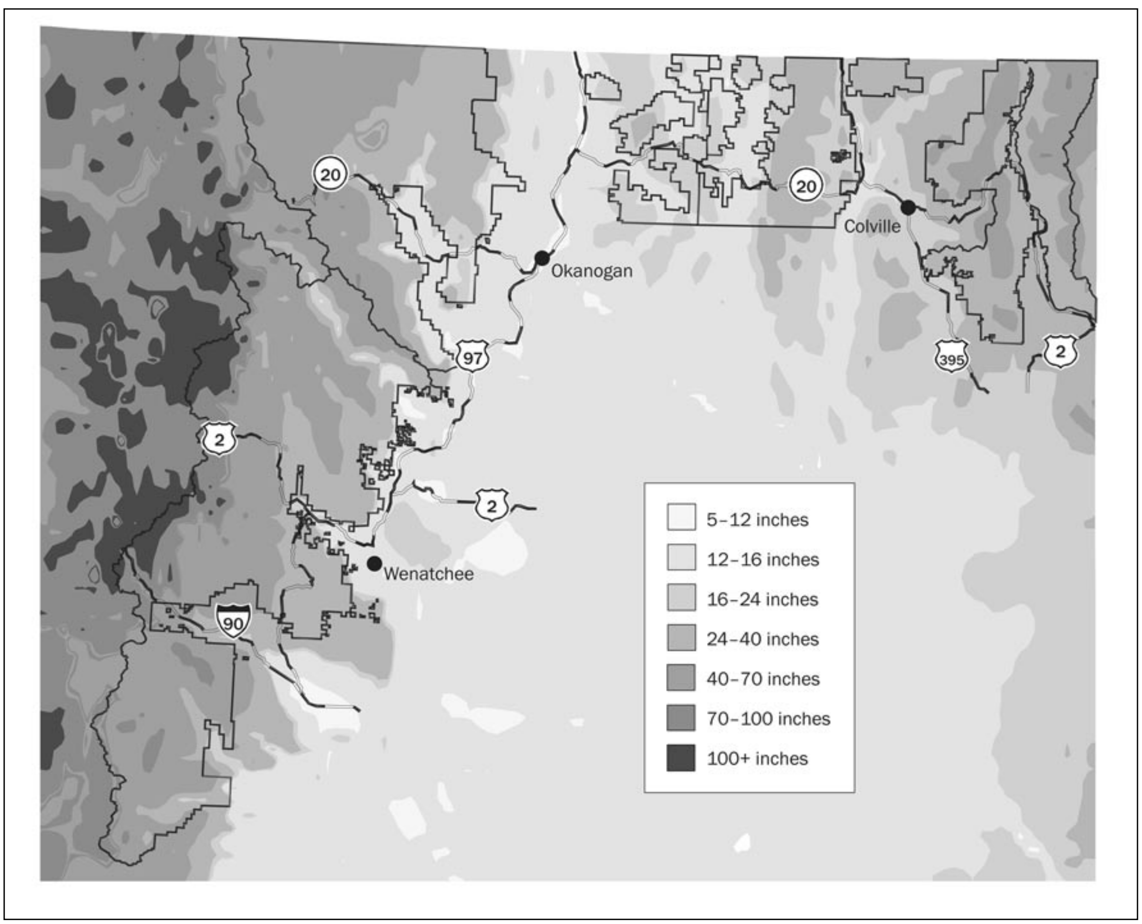


Figure 3—Annual precipitation zones for eastern Washington national forests.

Soils—

Soils in riparian and wetland ecosystems usually are much more complicated than those on adjacent uplands (Youngblood et al. 1985a). Soil texture, chemistry, and temperature, amount and kind of organic matter, and especially water tables, have a strong effect on plant species composition. Seasonally or permanently high water tables are necessary for a soil to support riparian and wetland vegetation. High water may be brief, with mid- to late-summer drought, as in the case of the timber oatgrass association (DAIN), or nearly season-long as in the bladder sedge association (CAUT). Fine-textured soils have stronger capillary action and remain wet longer than coarse soils. Organic matter also helps the soil draw water up from the water table and then retain it. Peat bogs are especially good "sponges;" their surfaces are often saturated even when the water table lies below the soil surface. Mineral soils that are saturated for long periods function in an anaerobic state and become gleyed, as evidenced by iron oxide spotting and a neutral gray to bluish-gray color.

Water levels also have a marked influence on accumulation of organic matter. Organic soil material is produced onsite in most riparian and wetland ecosystems, although water does move some organic material from site to site. Accumulation and decomposition proceed rapidly near the soil surface. Whether organic matter accumulates depends on the hydrology of the site. Under anaerobic conditions, less decomposition occurs, and thick layers of organic material accumulate with time. Organic material accumulation is accelerated if low soil and water fertility, low soil and water temperatures, and minimally fluctuating water tables accompany anaerobic conditions, such as in bogs. The reverse is true where water tables fluctuate and soils function aerobically.

Taxonomy of riparian soils is in its infancy, and soils were not identified beyond suborder. Even at this level, the taxonomy was of questionable value. For instance, a bog community with a peat surface horizon 4 to 14 inches thick and with the bulk of the root mass in this layer would not be considered an organic soil because soil taxonomy requires at least 16 inches of organic matter to key to a Histisol. Therefore, descriptions in the text use general soil texture within the rooting zone, instead of standard soil taxonomy terminology. Thus:

- Organic loam refers to very fine-textured, black soils judged to contain more than 12 percent organic matter. They are generally sapric Histisols. Saturated organic loam soils may be called ooze or muck.
- Sedge or moss peat soils are either fibric or hemic Histisols.
- Sedimentary peat refers to limnic Histisols on the bottom or margins of lakes and ponds.
- Ooze or muck refers to black semiliquid soils and are equivalent to sapric Histisols.
- Skeletal soils are medium- to coarse-textured mineral soils that occur on floodplains and streambanks, and are generally Entisols.
- Most fine-textured mineral soils on grass-dominated or the drier end of meadow associations such as the timber oatgrass association (DAIN) are Mollisols containing 2 to 12 percent organic matter in the surface horizons.
- Other mineral soils with no mollic epipedon occur mostly in transitional riparian associations (usually on terraces or toeslopes) such as subalpine fir/bunchberry dogwood (ABLA2/COCA) and are Inceptisols.

Geomorphology—

Geomorphology is best defined as the study of landforms (Ritter 1978, Thornbury 1969), and these concepts were used in developing this classification throughout the field and office stages. Geologic structure, modification process, and stage (time) of modification are the controlling factors in the evolution of landforms.

- Structure refers to rock orientations in space (i.e., joints, faults, bedding, and the variation of hardness or permeability of rocks)—the pattern in which the Earth's crust differs from location to location.
- Modification processes are the many chemical, biological, and physical ways in which the Earth's surface undergoes change.
- Stage is a description of the temporal progression of these modification processes and their consequent effects on landforms.

These factors are neither static nor uniformly directional. In most of eastern Washington, the wearing process from weathering has been periodically interrupted by extension of massive ice sheets during the ice ages (Pleistocene Epoch). The last advance of the Cordilleran ice sheet covered much of the study area until some 12,000 years ago. Although most of the Wenatchee NF escaped the continental ice advance, areas at higher elevation were influenced by extensive alpine glaciation.

The geomorphological aspects of this study are based on concepts from the classic text by Thornbury (1969). The formation of watersheds and both upland and riparian landforms is mostly determined by five interdependent factors: geology, climate, valley gradient, soils, and vegetation (Lotspeich 1980, Thornbury 1969). By using these factors, riparian classifications can be physically organized into four hierarchical levels (Kovalchik 1987, Kovalchik and Chitwood 1990) (fig. 4).

The broadest levels are the sections and subsections used in the national land mapping system (Maxwell et al. 1995).

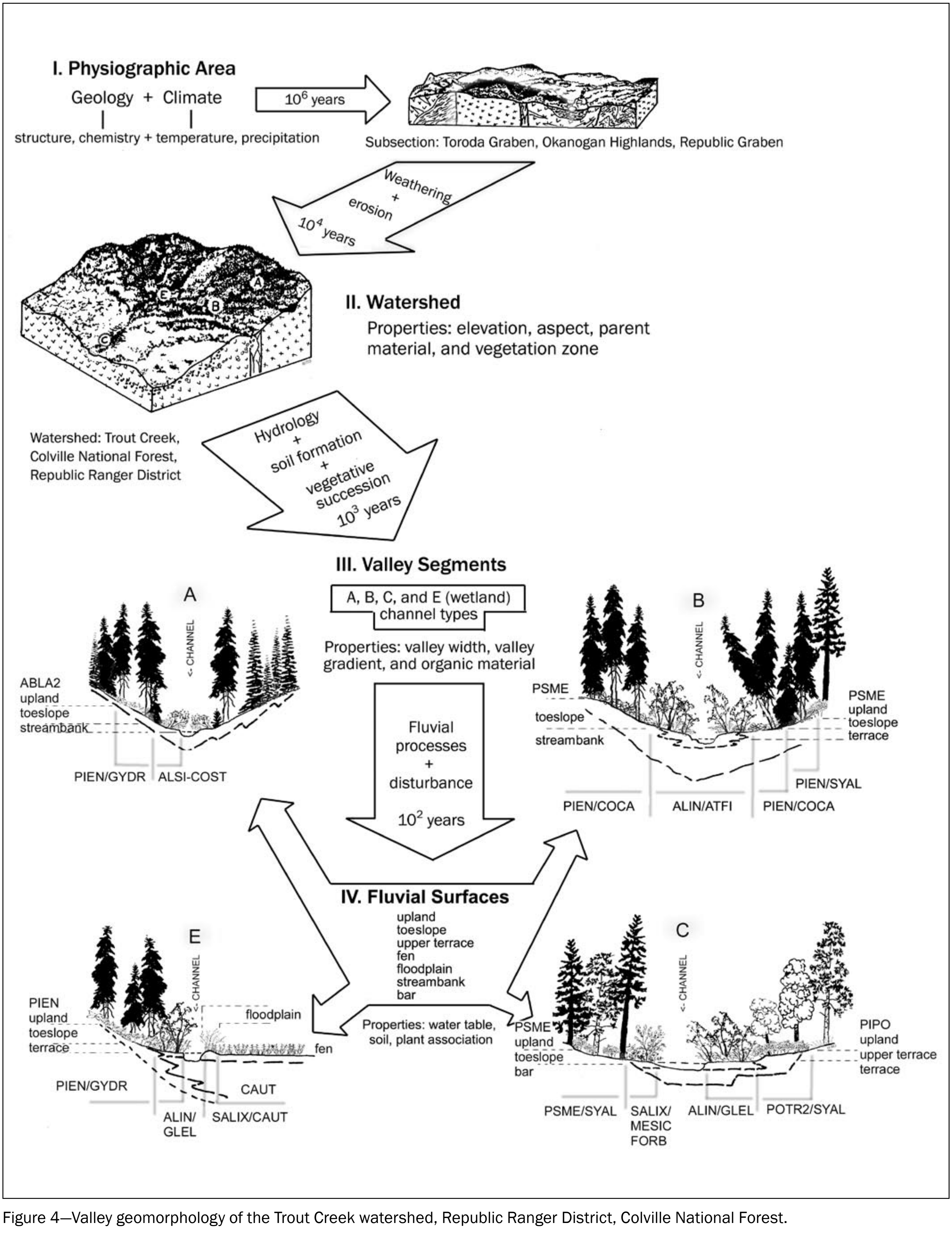


Figure 4—Valley geomorphology of the Trout Creek watershed, Republic Ranger District, Colville National Forest.

Sections and subsections are recognized based on broad uniformity in vegetation, geology, climate, and stage of modification in the evolution of landforms.

The second level is the watershed. Watersheds were not included in the riparian classification for central Oregon (Kovalchik 1987) but are proposed for this work. Lotspeich (1980) proposed the watershed as the conceptual framework for a natural geomorphic classification system. The effects of modification processes, such as weathering or erosion, on geologic formations result in the development of characteristic watersheds. These, in turn, ultimately determine the structure and function of associated riparian and wetland zones. Considering sections and watersheds allows a shift from a classification that focuses on the riparian and wetland zone only (i.e., the series and plant associations), to the zone's relationship to the larger geomorphic picture. Because of the interaction between uplands and lowlands, management activities in upland zones may change management potentials in riparian and wetland zones. Although watersheds may be relatively uniform within a section or subsection, differences exist in stream order, aspect, elevation, geology, soils, sediment supply, water regimes, timing and frequency of floods, and vegetation. Understanding these factors is critical for land management planning in riparian and wetland zones.

The third level is the valley segment. These smaller land units are equivalent to the land types defined in the national land classification system (Maxwell et al. 1995). They are segments of riparian and wetland zones characterized by distinctive relation to the upland, surface expression, internal structure, and vegetation. Valley segments reflect local uniformity in elevation, valley gradient and width, fluvial processes, water regime, and soils. Streams may occur in steep, narrow, V-shaped valleys in their headwaters (bedrock channels of Montgomery and Buffington 1993), but open downstream to flat-bottomed, wide, depositional valleys at lower elevations. Wide, flat valleys also may occur in high-elevation, glacial troughs or behind hard points such as rock outcrops or log debris jams in otherwise steep stream reaches.

The fourth basic level is the fluvial surface occurring within each valley segment and the riparian and wetland plant associations that grow there. Fluvial surface examples include alluvial bars, point bars, floodplains, streambanks, terraces, overflow channels, fens, carrs, and bogs. Fluvial surfaces are similar to land-type phases and represent response to patterns of stream erosion, overflow, and deposition. They also represent environmental variations found in a valley segment and reflect a specific potential for vegetation development. Riparian and wetland plant associations respond characteristically to differences in soil structure, soil texture, and water tables in fluvial surfaces. Together, fluvial surfaces and riparian plant associations provide a meaningful way of integrating various environmental factors, such as water regime and soils, which affect vegetation potentials in riparian landforms.

Four interdependent factors mostly determine the mosaic of riparian associations and fluvial surfaces in any one valley segment in eastern Washington: (1) Climate is mostly determined by the geographic setting. Annual precipitation, hydrologic regime, and temperature range determine factors such as soil formation rates, disturbance regime, and species composition. Climate varies with elevation and aspect such that similar climates can occur at different elevations or aspects in different areas. (2) Geology largely determines drainage pattern and the kind of soil deposited on fluvial surfaces. (3) Steep valley gradients (over 4 percent) tend to form narrow, downcutting valley cross sections. Intermediate gradients (1 to 3 percent) interact with biological factors, such as large wood and beaver dams to form infinitely varied habitats. Flat gradients (under 1 percent) form wide, depositional floodplains. (4) Vegetation filters and traps sediments and helps build and anchor fluvial surfaces. In steeper segments the roots of large trees can both stabilize banks or alter the course of the stream when the trees fall.

Stream action is a major factor in landscape formation. Valley deepening is often associated with relatively early stages of landscape formation and is a result of hydrologic, corrosive, abrasive, and weathering processes on the valley floor (Thornbury 1969). Valley widening is the result of lateral erosion, slumping, soil creep, and other hill-slope processes (Horton 1945). Valley lengthening is the result of headwall erosion, meander development, and the formation of fans and deltas. All these are indirectly tied to the effects of water and result in the formation of water-related landforms in the vicinity of streams and other bodies of water that form the riparian and wetland zone.

For the transportation of a stream's sediment load, changes in structure or process require change in gradient and channel characteristics (Leopold et al. 1964). The gradient or steepness of a valley is often related to the width of the valley floor. Narrow valleys, especially those in headwater or first-order drainages, often have V-shaped profiles, moderate to steep gradients, and narrow riparian zones. Streams in these valleys have high energy, relatively straight channels, and if they adjust to dissipate energy, they do so vertically, over steps or cascades. Steep channels cut downward by deepening the pools, and move relatively coarse material along the bed and in suspension. They build streambanks and terraces with moderate- to coarse-textured, well-aerated soils. At lower elevations, third- to fifth-order streams predominate (Strahler 1952); valley gradients are low, and most valleys are wide. These streams oscillate horizontally, forming meanders, and lateral erosion is predominant. These streams carry fine-grained sediment loads and form floodplains with finer textured soils. They may have numerous overflow and cutoff channels. Steep and shallowly graded sections are often present on the same stream.

Continent Physiography—

The study area lies within the Okanogan Highlands, Northern Cascades, and Southern Washington Cascades Provinces described by Franklin and Dryness (1973). In this study area, those provinces coincide with the eastern Cascades M242 and Okanogan Highlands M333 sections, which were delineated by Maxwell et al. (1995). Because the geologic and climatic diversity within a province is so great, more difference occurs among riparian habitats within the large units than among provinces or sections. To be definitive for riparian classification, we have chosen the hierarchical subsections of Maxwell et al. (1995) to subdivide the province for series descriptions.

Geologic Basis of the Sections—

The geology and geologic history of the study area are among the most complex on the North American continent (fig. 5). In brief, beginning with a sedimentary cover on an ancient, granite crust, the continent was rifted approximately 700 million years ago. The line of that rift lies, at depth, under the Okanogan Dome subsection, a few miles east of the Okanogan River. From the time of rifting until 55 million years before present, mixes of locally derived and far-traveled rock packages were added to the western edge of that foundation. During that interval, as the lithosphere below the old continent cooled and sank, collision with the Pacific plate pushed the added crust up and over (Alt and Hyndman 1984). The surface boundary between the old cover and the added crust is now along a line from the northeastern corner of Washington to near the mouth of the Spokane River. Building of the present mountain topography then began with faulting, volcanism, and the intrusion of large igneous rock masses. The mountain building progressed from east to west and continues just beyond the western edge of the study

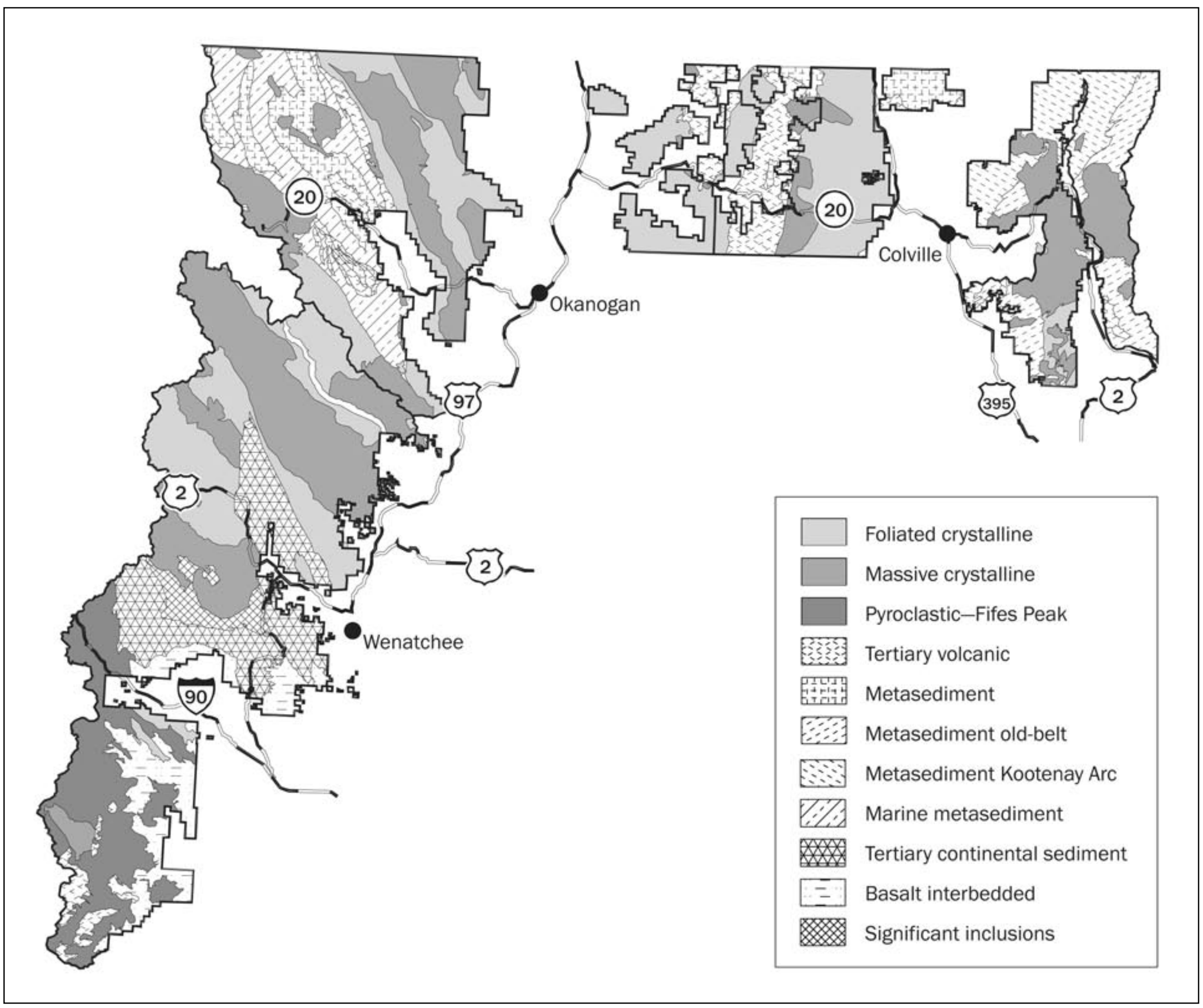


Figure 5—Bedrock geology for eastern Washington national forests.

area (Burchfiel et al. 1992). The mountain building exhumed large domes of gneiss in the eastern part of the study area. West of the Okanogan River, volcanic rocks were added to mountains that already consisted of metamorphic rock ridges and northwest trending basins full of sediment.

The most recent event to revise the topography was glaciation. The ice advanced and retreated in at least two and possibly four pulses during the last 800,000 years. The Cordilleran Continental Ice Sheet formed a continuous cover over most of the study area that is east of the Sinlahekin River. Alpine glaciers occupied most of the major valleys in the western part of the area (Richmond et al. 1965). The continental glacier stripped almost all the soil and weathered material from the area that it covered and left a discontinuous cover of less weathered material. As volcanic activity continued to the west, fine-grained tephra fell over the whole area. The addition of the volcanic ash hastened and altered soil development on the glaciated area.

The bedrock of the study area includes nearly the full range of possible chemistries, types, and textures. The varieties that are present in significant abundance and concentration can be grouped into eight functional complexes (Davis 2000):

Granular crystalline rocks are primarily granite rocks that are mostly high in silica, potash, and soda; and tend to weather to uniformly sand-size particles. Examples are the Cathedral Batholith, in the Pasayten Wilderness, and Starvation Flat quartz monzonite, east of Colville (Stoffel et al. 1991).

Structured crystalline rocks have undergone intense, repeated metamorphism and weather to very mixed-size debris that is often dominated by large, blocky fragments. They are of intermediate composition with more lime and alumina than the granular crystalline complex. Examples are Coryell intrusive rocks, near Northport, and the Tonasket gneiss, east of Tonasket.

Fractal metasedimentary rocks that are thinly layered occur in very steeply dipping, folded structures. With abundant silica and micas, they weather to soils that are rich in small, irregular fragments in a matrix of sand, silt, and clay. Ground water collects in deep and extensive aquifers in these rocks. Examples are the Entiat schist, southwest of Lake Chelan, and the Belt Supergroup, flanking the Pend Oreille River.

Euxinic metasedimentary rocks are very fine grain and rich in carbon and sulfur. They are often finely layered or sheared but have many massive lenses and layers. The carbon occurs as elemental carbon, hydrocarbons, and carbonate. Sulfur is present as sulfide and sulfate. The infiltration and storage of ground water is very irregular, and many of the springs yield sulfurous, corrosive, or acid water. They underlie mostly rounded and gentle topography, but where the structures are steep or the rock is massive, there are anomalous cliffs. Examples are the Ledbetter Slate, near Metaline Falls, and the Anarchist Group, west of Oroville.

Younger sedimentary rocks are frequently massive rocks derived from the debris of island arcs and volcanic ocean platforms. These are less altered by metamorphism and weather more readily than other metasedimentary complexes. Highly variable slopes gradually shed sandy debris into the riparian zones. Because their chemistry is rich in calcium and alumina, but poor in silica, they yield neutral and alkaline soils. Examples are the Virginian Ridge Formation between Twisp and Winthrop, and the Swauk Formation, at Blewett Pass (Walsh et al. 1987).

Cenozoic Continental Rocks combine volcanic flow rocks and sedimentary rocks derived from volcanic debris. The exposures of these rocks are mixed, by faulting and erosion, with outcrops of the conduit and magma chamber rocks that fed the volcanoes. Massive layers alternate with less resistant layers, all at moderate dip angles. The result is valleys that stairstep at amplitude of tens of meters to a few kilometers. Examples are the Columbia River basalt group around the forks of the Naches River and the Republic volcanic series along the Sanpoil-Curlew valley.

Ultramafic rocks are present in scattered areas and in a large area at the head of the North Fork Teanaway River. They are fragments of the lower crust that originated at ocean floor spreading centers. They have exotic chemistries, which include chromium and other heavy metals. The resulting iron-rich and nutrient-poor soils are related to narrowly endemic upland floras.

Glacial drift is distributed throughout the study area but is most abundant in the north-central and eastern parts. Although the drift is unconsolidated, it frequently functions as bedrock. Many areas have naturally compacted (densic) subsoils. Present stream and slope processes act differently on the drift than on the alluvium. The difference is greatest where the drift is compact or includes large boulders. The floor of the Yakima River valley, west of Ellensburg, is composed of alpine drift; moraines left by continental ice impound the Little Pend Oreille Lakes.

AQUATIC/RIPARIAN/WETLAND CLASSIFICATION

Relating riparian plant associations to physiographic areas, watersheds, valley segments, and fluvial surfaces enables the prediction of potential natural vegetation on degraded sites. Geomorphic concepts are used to help describe the series in this classification.

This classification recognizes 32 series and 163 aquatic, wetland, and riparian plant associations or community types. Nineteen of the series have two or more plant associations and are described in detail. Thirteen series have only one plant association or community type, are considered minor series, and are discussed briefly. One hundred plant associations are represented by five or more plots (major associations). An additional 63 plant associations and community types are represented by fewer than five plots (minor associations). The large number of associations and community types are the result of the remarkable climatic, geologic, and floristic diversity in eastern Washington.

First, a vegetative key provides an orderly process for determining the series. After determining the series, users should validate site characteristics against the series descriptions. The major associations and community types for each series are listed after the keys. Second, series descriptions give information for the distribution, vegetation characteristics, physical setting, and management for each series. Third, plant association keys and constancy/mean cover tables for plant associations are provided at the end of each series.

SERIES DESCRIPTION CRITERIA

Each series description begins with a figure showing a map of sample plot locations followed by a summary of the distribution of the dominant species and the series. Following this, the series description is divided into several descriptive sections: classification database, vegetation characteristics, physical setting, ecosystem management, adjacent series, and relation to other classifications.

The section entitled "Classification Database" defines the series, provides the number of plots in the series, and lists the major and minor plant associations within the series.

The "Vegetation Characteristics" section provides a brief description of the dominant or characteristic vegetation found on the sample plots of each series. Constancy and cover tables comparing plant species in each series are found in appendix G. Constancy and cover tables comparing plant species for plant associations are found at the end of each series description.

The "Physical Setting" section provides a brief description of the prevailing environment associated with each series and its plant associations. Tables display the number of plots by category under each of the subsections. It is important to note that the total number of plots may differ among the tables because of missing and/or incorrect data. This section includes the following:

- "Elevation" describes the general climatic environment associated with the series. Tables display elevation by NF and plant association.
- "Valley geomorphology" describes the character of the valleys where series plots occur. Tables display the distribution of valley width and valley gradient classes by both series and plant associations. Parameters for measured classes are:
- Valley width:
    - Very broad >984 feet (>300 meters)
    - Broad 328–984 feet (100.1–300 meters)
    - Moderate 99–327 feet (30.1–100 meters)
    - Narrow 33–98 feet (10.1–30 meters)
    - Very narrow <33 feet (<10 meters)
- Valley gradient:
    - Very low <1%
    - Low 1–3%
    - Moderate 4–5%
    - Steep 6–8%
    - Very steep >8%
- "Channel types" (classes) describes the character of stream channels that occur within valley landforms associated with series. The Rosgen stream classification system (Rosgen 1994, 1996) provides all disciplines with a standard method for describing and communicating about stream morphology, how streams fit the landscape, and how management actions affect them. Streams adjacent to sample transects were classified with this system to establish correlations between valley segments, Rosgen channel types, fluvial surfaces, and plant communities. Briefly, streams generally fit one of the following common classes (fig. 6):
- A channels—Steep, highly entrenched, step pool systems with high sediment transport potential.
- B channels—Gentle to moderately steep terrain, moderate-gradient streams that are moderately entrenched, have low sinuosity, and are riffle dominated.
- C channels—Low gradient, moderately high sinuosity, pool/riffle bedform with well-developed floodplains.
- D channels—Braided with moderate channel slope.
- E channels—Very low gradient, highly sinuous, with low width-to-depth ratios.
- F channels—Highly entrenched, high width-to-depth ratio streams.

Wetland sites without streams do not fit Rosgen's classification; however, description of the water regime associated with their plant associations and valley configuration requires some classification. Categories used to describe these sites include:

- Lake or pond—Wetlands adjacent to lakes or ponds.
- Ephemeral or intermittent—Riparian zones within draws or valleys without perennial streamflow.
- Seep or spring—Wetlands associated with seeps or springs.

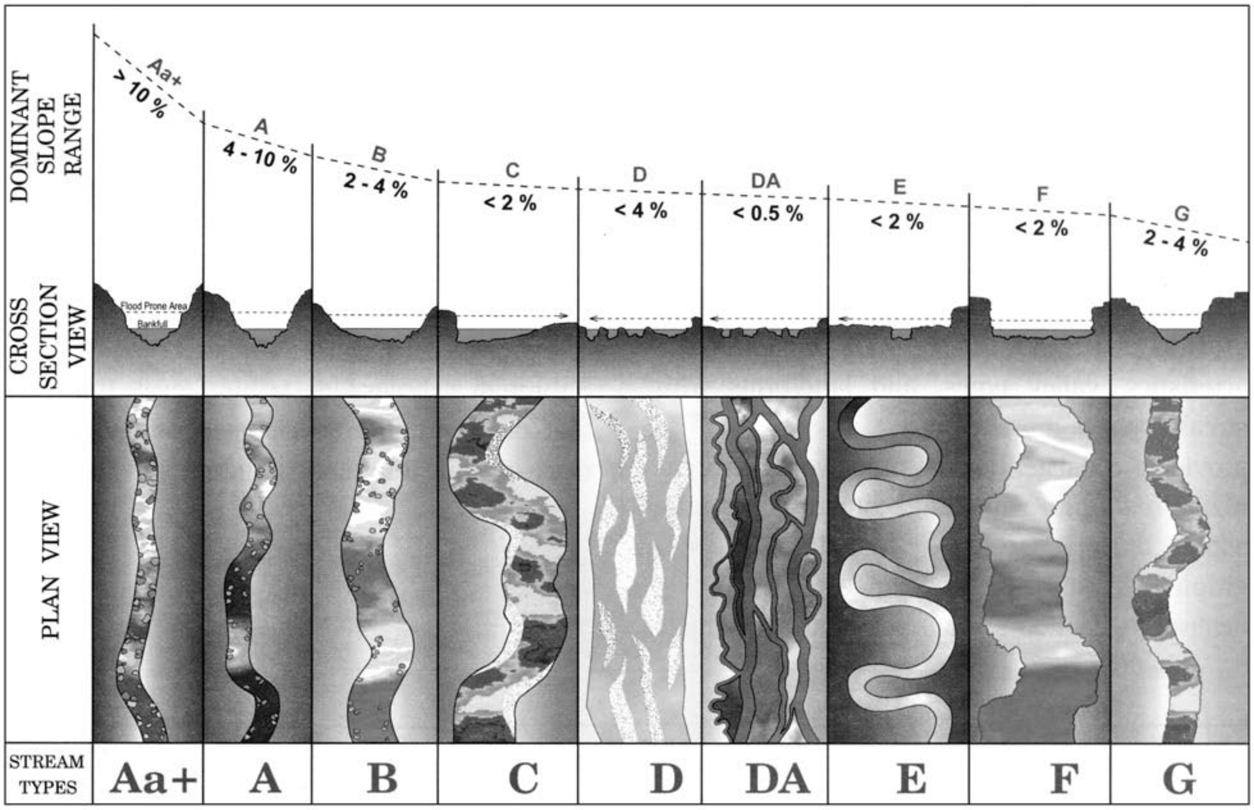


Figure 6—Longitudinal, cross-sectional and plan views of major Rosgen channel types (Rosgen 1996).

- Shrub wetland—Wetlands dominated by shrub plant associations.
- Forest wetlands—Wetlands dominated by coniferous or deciduous tree plant associations.

Within the descriptions for each series, a chart shows the distribution of Rosgen channel classes. A table relates these classes to the plant associations.

- "Fluvial surfaces" describes the character of the various land surfaces on which the series occurs such as point bars, alluvial bars, floodplains, streambanks, terraces, overflow channels, and wetlands. Definitions are found in the glossary. Within the series descriptions, a small chart shows the distribution of fluvial surfaces for each series. Another small table shows the distribution of fluvial surfaces for the plant associations.
- "Soils" describes the general texture of surface soils, depth of water tables, soil surface flooding, and soil temperature (degrees Fahrenheit). The distribution of soil texture classes for each series is shown in a chart. Another small table shows the distribution of plant associations by texture class. Other small tables relate plant associations to water table, surface flooding, and soil temperature where data are available.

ECOSYSTEM MANAGEMENT

The section provides detailed descriptions for the management of each series. Descriptions of the various categories that may be in a series discussion include the following:

- Natural regeneration—Describes the natural regeneration processes associated with the plant that names the series.
- Artificial establishment—Describes the means for artificially establishing vegetation on disturbed sites.
- Stand management—Helps managers develop management plans for the series.
- Growth and yield (labeled "Tree Growth and Yield" in the coniferous and deciduous tree series)—Provides productivity information for the series (if available). A table shows the site index (height in feet by base years) and basal area (square feet per acre) for the trees dominating the series. References for the site index equations used in determining site index are shown in the following tabulation:

Scientific name	Site index source
Abies amabilis	Hoyer and Herman 1989 (base 100)
Abies grandis	Cochran 1979 (base 50)
Abies lasiocarpa	Clendenen 1977 (based on Alexander 1987) (base 50)
Abies procera	Herman et al. 1978 (base 100)
Acer macrophyllum	Worthington et al. 1960 (base 50)
Alnus rubra	Worthington et al. 1960 (base 50)
Betula papyrifera	Edminster et al. 1985 (base 80)
Chamaecyparis nootkatensis	Barnes 1962 (base 100)
Larix lyallii	Schmidt et al. 1976 (base 50)
Larix occidentalis	Schmidt et al. 1976 (base 50)
Picea engelmannii	Clendenen 1977 (based on Alexander 1967) (base 50)
Pinus albicaulis	Alexander et al. 1987 (base 100)
Pinus contorta	Alexander et al. 1987 (base 100)
Pinus monticola	Brickell 1970 (based on Haig's 1932 curve) (base 50)
Pinus ponderosa	Meyer 1961 (base 100)
Populus tremuloides	Edminster et al. 1985 (base 80)
Populus tricocarpa	Edminster et al. 1985 (base 80)
Pseudotsuga menziesii	Monserud 1985 (base 50)
Thuja plicata	Hegyi et al. 1981 (base 100)
Tsuga heterophylla	Wiley 1978 (breast height age <150 years only) (base 50)
Tsuga mertensia	Hegyi et al. 1981 (base 100)

Much of the management information came from Crowe and Clausnitzer 1997; Fischer et al. (1996); Hansen et al. 1995; Kovalchik 1987, 1991a, 1992a, 1992c; Kovalchik and Chitwood 1990; and Kovalchik and Elmore 1991.

- "Down wood and snags"—Provides information on numbers, species, biomass, height, and class for snags and logs. Within each description, a table shows log attributes (tons per acre, cubic feet per acre, linear feet per acre, square feet per acre, and percentage of ground cover) for each series. Another table shows the snag attributes (snags per acre by condition class by diameter class in inches) for each series. Classes 1 through 5 for logs and snags are defined as:
  - Log decomposition classes:
    1. Bark intact, twigs present, texture intact, shape round, color original, elevated, retains original shape
    2. Bark intact, twigs absent, partly soft, shape round, color original, slightly sagging
    3. Bark largely gone, a few hard pieces, shape round, color faded, sagging
    4. Bark gone, soft blocky pieces, round to oval, light brown to yellowish, all of log on the ground
    5. Soft to powdery, flattened, light yellow to gray, all of log on ground
  - Snag condition classes:
    1. Recent dead
    2. Fine branches gone, bark intact
    3. Bark loose, large branch stubs
    4. Solid buckskin snag
    5. Broken and rotten
- Fire—Describes the sensitivity of important series indicator plants to fire. When possible, evidence for and discussion of stand age and fire regime is included.
- Animals—Describes the use of the series by various classes and includes:
  - Browsing—Describes the palatability of the series indicator species to various classes of browsers and some of their potential impacts on the species.
  - Livestock—Describes palatability of important plants and describes season of use and influences on sites by domestic livestock.
  - Wildlife—Describes the use of the association by various classes of wildlife.
  - Fish—Describes the utility of the association for streambank stabilization and fish habitat and cover.
- Recreation—Helps recreation managers to develop recreation management plans.
- Insects and disease—Describes some of the common insect and disease pests of the series indicator plant.
- Estimating vegetation potential on disturbed sites—Gives the user hints on how to recognize the vegetative potential for stands in poor ecological status.
- Sensitive species—Provides a description of sensitive plants or animals found. Each table displays the number of populations found in the described plant associations or series.

ADJACENT SERIES AND RELATIONSHIPS TO OTHER CLASSIFICATIONS

The section called "Adjacent Series" describes other series found on adjacent portions of the riparian/wetland zone as well as uplands.

Finally, the section "Relationships to Other Classifications" lists other classifications in adjacent states that describe the same series.

Attributes for the USFWS, which define very broad categories of wetlands that often contain several dissimilar plant associations or community types, also are given. The plant associations and community types complete Cowardin's classification (Cowardin et al. 1979) at the dominance level. Transitional or xeroriparian plant associations may not fit into any "type" in Cowardin's classification.

KEYS FOR FIELD IDENTIFICATION

(Plant association keys are found at the end of each series description)

INSTRUCTIONS FOR USING THE KEY

1. Use this key for riparian and wetland plant associations and community types located on or near lands of the Wenatchee, Okanogan, or Colville NFs.
2. Determine the boundaries of the various riparian stands that exist within the riparian or wetland zone being investigated. (As many as eight distinct riparian plant associations have been sampled along a single valley cross section and up to 25 plant associations within a single wetland basin.)
3. Locate an approximately 1/10-acre plot (37-foot radius in size is suggested) in a uniform and representative portion of each stand. Small or irregularly shaped stands may need smaller or irregularly shaped plots. Stay near the center of the stand and avoid ecotones or crossing stand boundaries.
4. Identify and record canopy coverages or cover classes for all key indicator species as well as the environmental information located on the field form provided in appendix H.
5. While on the plot, key to the appropriate life-form group. In general, a species or group of species will appear to dominate a community if the coverage is 25 percent or more.
6. Within the life-form group, key to the appropriate aquatic, riparian, or wetland plant association or community type. All conditions stipulated in the key must be satisfied in order to make a correct determination. Complete the selection by comparing the community composition and site characteristics with written descriptions and the appendixes. In addition, when classifying a site, be aware of and account for microsites. Microsites are small areas that are atypical for the stand or site as a whole. Examples include small depressions such as windthrow holes, raised hummocks within bogs, etc.
7. The key and written descriptions are based largely on samples of relatively undisturbed stands in late-seral to climax ecological status. On disturbed sites, evaluate each stand against the written descriptions for the associations. Use the landform and fluvial surface key to riparian associations for disturbed sites. In addition, extrapolating from the nearest nondisturbed condition occurring on a comparable site will assist in the correct determination of the type.
8. Depauperate undergrowth. In stands where the undergrowth is obviously reduced in cover by heavy grazing, shade, litter, and competition from conifers or shrubs, adjust keys downward to reflect the scant herbaceous cover. For instance, a few SALIX/CAUT ecology plots had only 1 or 2 percent canopy coverage for sedges because of dense willow shade and competition. In addition, extrapolation from the nearest nondepauperate condition occurring on a comparable site will assist in the correct determination of the type.

Caution: The potential of a site may change if there is a long-term change in the soil or water characteristics of the site.

Warning: The key is not the classification! Users should validate their determination by comparing the site characteristics with the written description of the type. Be aware that the environmental conditions described in the text are from both sampled sites and personal observations and may not include all the sites on the landscape in which the type is found.

Series-level constancy/cover tables are found in appendix G. They are a useful aid in determining whether the correct series has been keyed. Users should note that **the keys are tools and are not the classification**. Series and plant association descriptions portray modal riparian and wetland stands in late-seral and climax ecological status. Thus, highly disturbed stands will not key well and the user will have to refer to the series descriptions and to his or her personal experience and intuition. In any dynamic ecosystem (aquatic, riparian, and wetland included), variation can be expected in any series and plant association. The user is cautioned to validate the “keyed” determination by reading the written description, supporting tables, and appendixes before leaving the stand or plot.

VEGETATIVE KEY TO THE MAJOR VEGETATION LIFE FORMS

1. Potential vegetation dominated by conifers with at least 25 percent canopy coverage. Conifers reproducing successfully **and not** restricted to microsites; deciduous trees subordinate ....**Coniferous forest series**
2. Potential vegetation dominated by deciduous tree species with at least 25 percent canopy coverage. Deciduous tree species reproducing successfully; coniferous tree species subordinate or restricted to microsites ....**Deciduous forest series**
3. Potential vegetation dominated by shrubs with at least 25 percent canopy coverage ....**Shrub series**
4. Potential vegetation dominated by herbaceous plants with at least 25 percent canopy coverage ....**Herbaceous series**

KEY TO THE CONIFEROUS FOREST SERIES

(Coniferous trees present **and** reproducing successfully **and not** restricted to microsites)

1. Subalpine larch (*Larix lyallii*) present with ≥10 percent canopy coverage and reproducing ....**Miscellaneous conifer series** (p. 99)
2. Mountain hemlock (*Tsuga mertensiana*) present with ≥10 percent canopy coverage and reproducing ....**Mountain hemlock series** (p. 19)
3. Pacific silver fir (*Abies amabilis*) present with ≥10 percent canopy coverage and reproducing ....**Pacific silver fir series** (p. 29)
4. Western hemlock (*Tsuga heterophylla*) present with ≥10 percent canopy coverage and reproducing ....**Western hemlock series** (p. 39)
5. Western redcedar (*Thuja plicata*) present with ≥10 percent canopy coverage and reproducing ....**Western redcedar series** (p. 51)
6. Subalpine fir (*Abies lasiocarpa*) present with ≥10 percent canopy coverage and reproducing ....**Subalpine fir series** (p. 63)
7. Engelmann spruce (*Picea engelmannii*) present with ≥10 percent canopy coverage and reproducing ....**Engelmann spruce series** (p. 77)
8. Alaska yellow-cedar (*Chamaecyparis nootkatensis*) present with ≥10 percent canopy coverage and reproducing ....**Alaska yellow-cedar communities: return to No. 1 above and try another series**
9. Grand fir (*Abies grandis*) present with ≥10 percent canopy coverage and reproducing ....**Grand fir series** (p. 89)
10. Douglas-fir (*Pseudotsuga menziesii*) present with ≥10 percent canopy coverage and reproducing ....**Miscellaneous conifer series** (p. 99)
11. Lodgepole pine (*Pinus contorta*) dominates the stand, other conifers not reproducing; the successional sequence to climax is unknown ....**Miscellaneous conifer series** (p. 99)

KEY TO THE DECIDUOUS FOREST SERIES

1. Quaking aspen (*Populus tremuloides*) the dominant deciduous tree and reproducing .... **Quaking aspen series** (p. 109)
2. Black cottonwood (*Populus trichocarpa*) the dominant deciduous tree and reproducing .... **Black cottonwood series** (p 119)
3. Oregon white oak (*Quercus garryana*) present with ≥10 percent canopy coverage and reproducing .... **Miscellaneous deciduous tree series** (p. 129)
4. Red alder (*Alnus rubra*) the dominant deciduous tree and reproducing .... **Miscellaneous deciduous tree series** (p. 129)

5. Bigleaf maple (*Acer macrophyllum*) the dominant deciduous tree and reproducing .... **Miscellaneous deciduous tree series** (p. 129)
6. Paper birch (*Betula papyrifera*) the dominant deciduous tree and reproducing .... **Miscellaneous deciduous tree series** (p. 129)
7. Shrubs and small trees such as mountain alder, Saskatoon serviceberry, Douglas hawthorn, Douglas maple, and some willows may be more than 18 feet tall and may be considered trees but vegetation described as shrub life form .... **Go to shrub series key (below)**

KEY TO THE SHRUB SERIES

1. Tall or dwarf willows (*Salix* spp.) or bog birch (*Betula glandulosa*) ≥25 percent canopy coverage .... **Willow series** (p. 141)
2. Cascade huckleberry (*Vaccinium deliciosum*), moss-heathers (*Cassiope* spp.), mountain heaths (*Phyllodoce* spp.), and/or partridgefoot (*Luetkea pectinata*) ≥25 percent canopy coverage .... **Heath series** (p. 161)
3. Vine maple (*Acer circinatum*) ≥25 percent canopy coverage ....**Vine maple series** (p. 169)
4. Sitka alder (*Alnus sinuata*) ≥25 percent canopy coverage .... **Sitka alder series** (p. 177)
5. Mountain alder (*Alnus incana*) ≥25 percent canopy coverage .... **Mountain alder series** (p. 187)
6. Red-osier dogwood (*Cornus stolonifera*) ≥25 percent canopy coverage .... **Red-osier dogwood series** (p. 201)
7. Devil's club (*Oplopanax horridum*) ≥5 percent canopy coverage ...... **Miscellaneous shrub series** (p. 219)
8. Salmonberry (*Rubus spectabilis*), stink currant (*Ribes bracteosum*), or Hudsonbay currant (*Ribes hudsonianum*) ≥25 percent canopy coverage .... **Miscellaneous shrub series** (p. 219)
9. Cascade azalea (*Rhododendron albiflorum*) or rusty menziesia (*Menziesia ferruginea*) ≥25 percent canopy coverage .... **Miscellaneous shrub series** (p. 219)
10. Douglas maple (*Acer glabrum* var. *douglasii*), common chokecherry (*Prunus virginiana*), or Saskatoon serviceberry (*Amelanchier alnifolia*) ≥25 percent canopy coverage .... **Miscellaneous shrub series** (p. 219)
11. Douglas spiraea (*Spiraea douglasii*)and/or pyramid spiraea (*Spiraea pyramidata*) ≥25 percent canopy coverage .... **Douglas spiraea series** (p. 211)
12. Common snowberry (*Symphoricarpos albus*) ≥25 percent canopy coverage .... **Miscellaneous shrub series** (p. 219)
13. Shrubby cinquefoil (*Potentilla fruticosa*) ≥25 percent canopy coverage .... **Miscellaneous shrub series** (p. 219)

KEY TO THE HERBACEOUS SERIES

1. Aquatic sites on the edges of lakes or ponds or in sluggish streams, usually with standing water for all or much of the growing season, potential vegetation dominated by species such as Indian waterlily (*Nuphar polysepalum*), cow-lily (*N. variegatum*), pondweed (*Potamogeton* spp.), bur-reed (*Sparganium* spp.), softstem bulrush (*Scirpus validus*), hardstem bulrush (*S. acutus*), northern mannagrass (*Glyceria borealis*) western mannagrass (*G. occidentalis*), water horsetail (*Equisetum fluviatile*), and/or creeping spike-rush (*Eleocharis palustris*) with a combined canopy coverage of at least 25 percent ....**Aquatic series** (p. 231)
2. Potential vegetation dominated by sedge (*Carex*) species and/or other wetland sedgelike species or graminoids with a combined canopy coverage of at least 25 percent ....**Meadow series** (p. 241)
3. Sedge and grasslike species with a combined canopy coverage of less than 25 percent, forbs the dominant vegetation .... **Forb series** (p. 263)

Return to Part 1 Return to Part 2

MOUNTAIN HEMLOCK SERIES

Tsuga mertensiana

TSME N = 25

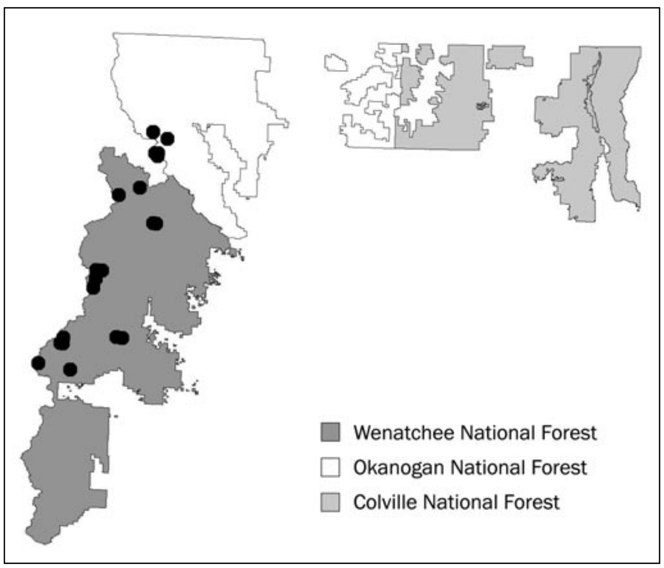


Figure 7—Plot locations for the mountain hemlock series.

THE PRIMARY RANGE of mountain hemlock[1] extends from northern British Columbia and southern Alaska through the Cascade Range and Olympic Mountains to northern California (Arno and Hammerly 1984, Hitchcock and Cronquist 1973). It also extends inland to southeastern British Columbia, northern Idaho, and northwestern Montana. Mountain hemlock is abundant along the Cascade crest in eastern Washington (Lillybridge et al. 1995). Mountain hemlock stands are quite extensive in the Rocky Mountains of northern Idaho and Montana but are limited to very snowy areas with a maritime climate (Pfister et al. 1977). A few outlying stands occur in the Blue Mountains of northeastern Oregon. Stands of mountain hemlock usually are associated with uplands but also are prominent in riparian zones, primarily on streambanks and terraces, and occasionally on the margin of wetlands.

Mountain hemlock is one of the most shade-tolerant and environmentally restricted conifers in eastern Washington (Lillybridge et al. 1995). It is the major upper subalpine and timberline conifer along the Cascade crest. Its presence indicates cold, snowy habitats where deep snow accumulations are typical. Average annual precipitation often exceeds 50 inches. At its highest elevations, mountain hemlock quickly grades into subalpine parklands variously dominated by open woodlands, tree islands, or krummholz of mountain hemlock, subalpine fir, and (occasionally) subalpine larch or whitebark pine (Lillybridge et al. 1995). Therefore, the TSME series is found only in areas of strong maritime influence, usually in climatic zones within 15 miles of the Cascade crest. This maritime influence is particularly strong on the western portions of the Wenatchee NF. The TSME series is also prominent on the west side of the Okanogan NF, generally west of a line formed by Washington Pass, Harts Pass, and Reynolds Peak. Most of this land lies west of the Cascade crest on lands once administered by the Mount Baker NF but are now administered by the Okanogan NF. The TSME series is absent on the Colville NF.

Mountain hemlock and Pacific silver fir broadly overlap in their ecological distribution so that distinguishing between the TSME and ABAM series can be difficult (Lillybridge et al. 1995). Where Pacific silver fir is present in the TSME series, it will likely never be totally excluded and is essentially a codominant, even in climax and near-climax stands. Only in colder, harsher, wetter sites is Pacific silver fir absent. Predicting mountain hemlock canopy coverage that exceeds 10 percent in older stands is the convention used in this guide for placing stands within the TSME series.

CLASSIFICATION DATABASE

The TSME series includes all closed-forest stands potentially dominated by mountain hemlock at climax. It occurs on all but the Tonasket RD on the Wenatchee and Okanogan NFs. Twenty-one riparian and wetland plots were sampled in the TSME series (fig. 7). Information from an additional four plots from other ecology samples was added to facilitate development of the classification and to augment species composition, distribution, and elevation data for the series. From this database, three major and one minor plant associations are recognized. Five other potential one-plot plant associations (TSME/ATFI, TSME/LEGL/ERPO2, TSME/MEFE-VAME, TSME/RULA, and TSME/VAME) are not used in the data for the TSME series nor described in this

[1] See appendix A for a cross reference for all species codes and common and scientific names used in this document.

Mountain hemlock plant associations

	Scientific name	Common name	Ecoclass code	Plots
Major associations:				
TSME/MEFE-VAAL	*Tsuga mertensiana/Menziesia ferruginea-Vaccinium alaskaense*	Mountain hemlock/rusty menziesia-Alaska huckleberry	CMS256	5
TSME/PHEM-VADE	*Tsuga mertensiana/Phyllodoce empetriformis-Vaccinium deliciosum*	Mountain hemlock/red mountain-heath–Cascade huckleberry	CMS354	5
TSME/RHAL-VAME	*Tsuga mertensiana/Rhododendron albiflorum-Vaccinium membranaceum*	Mountain hemlock/Cascade azalea-big huckleberry	CMS356	11
Minor associations:				
TSME/OPHO-VAAL	*Tsuga mertensiana/Oplopanax horridum-Vaccinium alaskaense*	Mountain hemlock/devil's club-Alaska huckleberry	CMS450	4

classification. Some of these associations are found in the classification by Lillybridge et al. (1995). These samples were mostly located in late-seral to climax mountain hemlock stands.

VEGETATION CHARACTERISTICS

The TSME series exhibits high species diversity owing partially to its inherent site variability but also, perhaps even more importantly, to its role in the transition from closed forest to parkland environments. Indeed, the TSME/RHAL-VAME and (especially) TSME/PHEM-VADE associations often occur within the upper several hundred feet of closed forest as well as in tree islands within parklands. Thus, species from both types of environments are present. Mature stands are generally dominated by large, long-lived mountain hemlock and, within its elevation range, Pacific silver fir. The understory of mature stands is usually dominated by mountain hemlock and Pacific silver fir with lesser amounts of western hemlock (low elevations), subalpine fir, and Engelmann spruce. The compositions of seral stands vary by association and stand history but usually include mountain hemlock, Pacific silver fir, whitebark pine, Alaska yellow-cedar, western hemlock, Engelmann spruce, or subalpine fir. Upper elevation stands (TSME/PHEM-VADE and TSME/RHAL-VAME associations) are typically dominated only by mountain hemlock, and seral tree species are limited to Engelmann spruce, Alaska yellow-cedar, whitebark pine, and subalpine fir. Subalpine larch appears to be absent in strong maritime environments but may be present in stands in more continental climates. Western redcedar and western hemlock are seral trees in the lower elevation associations (TSME/MEFE-VAAL and TSME/OPHO-VAAL) and occur as scattered large individuals in mature stands. The TSME series is usually too high in elevation to support ponderosa pine, grand fir, Douglas-fir, western white pine, or western larch.

Shrubs form a rich layer in the undergrowth. Composition and abundance vary by stand history and plant association. The primary association indicators are devil's club, rusty menziesia, Cascade azalea, Alaska huckleberry, Cascade huckleberry, big huckleberry, and red mountain-heath. Oval-leaf huckleberry was not present on any of the sample plots but can be used as an ecological equivalent of Alaska huckleberry when keying the TSME/MEFE-VAAL association. Other common medium and tall shrubs include Sitka alder, Hudsonbay currant, salmonberry, and Sitka mountain-ash. Low shrubs include dwarf and five-leaved bramble.

The herb composition is also rich and varied. It includes deerfoot vanilla-leaf, lady fern, oak fern, queencup beadlily, sidebells pyrola, arrowleaf groundsel, starry solomonplume, claspleaf twisted-stalk, coolwort foamflower, and Sitka valerian.

PHYSICAL SETTING

Elevation—

Elevations for the TSME series span a moderately broad elevation range, although 80 percent of the sites are between 3,500 and 5,500 feet. The 1,000-foot elevation difference between the Okanogan and Wenatchee NFs is caused by a rain-shadow effect in the Okanogan Cascade Range created by high mountains such as Bacon, Picket, Colonial, and Pilchuck Peaks to the west (Henderson 1998). Therefore, the TSME series occurs at higher elevations on the Okanogan NF to compensate for the lower precipitation.

Additional insight is gained by looking at the individual associations. TSME/PHEM-VADE and TSME/RHAL-VAME are high-elevation associations generally found well above 4,500 feet. TSME/PHEM-VADE is often found above continuous forest in parklands, occupying areas covered by snowfields until late summer. The TSME/RHAL-VAME association also tends to be high elevation but usually occurs in zones of closed forest that are transitional to continental climates. It also occurs as tree islands scattered within subalpine parklands. The remaining two associations (TSME/

	Elevation (feet)			
Forest	Minimum	Maximum	Average	N
Okanogan	5,075	5,980	5,398	6
Wenatchee	3,100	5,890	4,326	19
Series	3,100	5,980	4,583	25

OPHO-VAAL and TSME/MEFE-VAAL) are found at lower elevations, often following cold air drainage to unusually low elevations for the TSME series.

Plant association	Elevation (feet)			N
	Minimum	Maximum	Average	
TSME/PHEM-VADE	4,130	5,980	5,344	5
TSME/RHAL-VAME	4,140	5,775	5,085	11
TSME/OPHO-VAAL	3,125	4,150	3,584	4
TSME/MEFE-VAAL	3,100	4,200	3,518	5
Series	3,100	5,980	4,583	25

Valley Geomorphology—

Plot locations in the TSME series are found in a variety of valley width and gradient classes. Plots appear to occur in two clusters. The most common landform is moderate to very narrow valleys with moderate to very steep valley gradient. The other landform is moderate to broad valleys with moderate to low valley gradient, which is unusual, and more likely located in high-elevation cirque basins, lower elevation subalpine sites along narrow streams, or on the edge of wetland systems. Still, no patterns are clear for the TSME series overall, and data are limited.

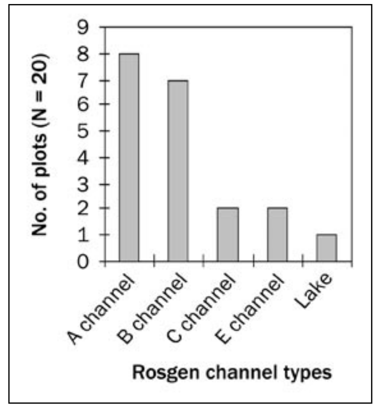
Valley width	Valley gradient					N
	Very low	Low	Moderate	Steep	Very steep	
Very broad	0	0	0	0	0	0
Broad	1	2	1	0	1	5
Moderate	0	0	2	0	2	4
Narrow	0	1	0	1	3	5
Very narrow	0	1	1	0	4	6
Series total	1	4	4	1	10	20

Looking at individual associations is not very helpful. TSME/OPHO-VAAL is the one exception, as it appears to be restricted to narrow riparian valleys as much as plant associations in other series that use devil's club to indicate the characteristic ground cover. TSME/PHEM-VADE appears to be largely associated with very steep valleys; however, this may be largely an artifact of small sample size and plot distribution. This association has been observed on many sites, including the margins of riparian and wetland zones. Unfortunately, no valley, Rosgen channel type, fluvial surface, or soils data are available for the TSME/MEFE-VAAL association (data used are from Lillybridge et al. 1995).

Plant association	Valley width					N
	Very broad	Broad	Moderate	Narrow	Very narrow	
TSME/OPHO-VAAL	0	0	0	2	2	4
TSME/PHEM-VADE	0	1	2	1	1	5
TSME/RHAL-VAME	0	4	2	2	3	11
Series total	0	5	4	5	6	20

Plant association	Valley gradient					N
	Very low	Low	Moderate	Steep	Very steep	
TSME/OPHO-VAAL	0	1	1	1	1	4
TSME/PHEM-VADE	1	0	0	0	4	5
TSME/RHAL-VAME	0	3	3	0	5	11
Series total	1	4	4	1	10	20

Channel Types—

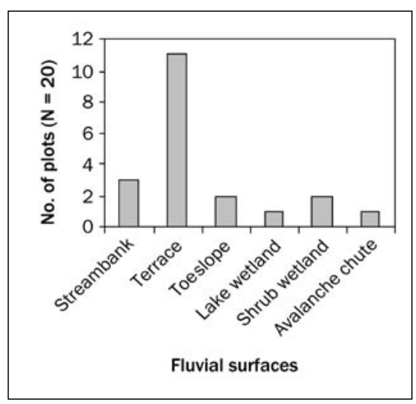


TSME series plots are located along a variety of channel types. Rosgen channel types A and B are prevalent as many sites lie within moderate to very steep gradient valleys. The Rosgen C channel, E channel, and the pond type are found in low to very low gradient valleys, usually in cirque basins or large, moderate-elevation valleys.

The data for individual associations support these observations as most stands are located along A and B channel types. However, the TSME/PHEM-VADE and TSME/RHAL-VAME associations are probably more common around lakes than shown.

Plant association	Rosgen channel types					N
	A	B	C	E	Lake	
TSME/OPHO-VAAL	3	1	0	0	0	4
TSME/PHEM-VADE	3	0	1	1	0	5
TSME/RHAL-VAME	2	6	1	1	1	11
Series total	8	7	2	2	1	20

Fluvial Surfaces—



Plots in the TSME series are predominantly located in riparian zones, with most plots (about 80 percent) on streambanks, terraces, and toeslopes. The rest of the plots are associated with wetlands, wet high-elevation cirque basins, or avalanche chutes. For the most part, the TSME series requires sites with good drainage; very wet or active fluvial surfaces do not support the TSME series. Some TSME/OPHO-VAAL sites are moderately wet and poorly drained, at least early in the growing season.

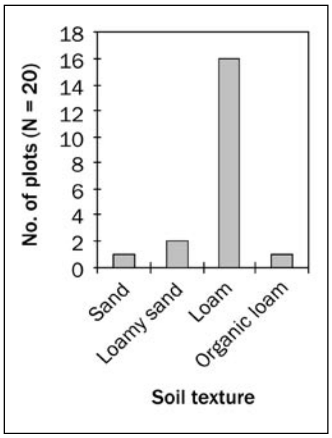
The individual plant associations are similar to the TSME series as a whole. Almost all plots in the TSME/OPHO-VAAL and TSME/RHAL-VAME associations are located in the riparian zone. TSME/PHEM-VADE is equally distributed between riparian zones and the dry margins of wetlands, although one plot was in an avalanche chute.

	Fluvial surfaces						
Plant association	Stream-bank	Terrace	Toe-slope	Lake wetland	Shrub wetland	Avalanche chute	N
TSME/OPHO-VAAL	1	2	1	0	0	0	4
TSME/PHEM-VADE	0	2	0	0	2	1	5
TSME/RHAL-VAME	2	7	1	1	0	0	11
Series total	3	11	2	1	2	1	20

Soils—

The TSME series is dominated by mineral soils with loam textures. Few plots are located on sand (indicates recent alluvial deposition) or organic loam (indicates wetland soils).

Little additional insight is gained by looking at individual associations, as all are strongly associated with loam soils.



	Soil texture				
Plant association	Sand	Loamy sand	Loam	Organic loam	N
TSME/OPHO-VAAL	0	1	3	0	4
TSME/PHEM-VADE	0	0	4	1	5
TSME/RHAL-VAME	1	1	9	0	11
Series total	1	2	16	1	20

Water tables were not measurable on most sites. The TSME/OPHO-VAAL association presumably has the highest water table as it is the wettest of the TSME plant associations. Appreciable differences in soil temperature do not appear to occur among the associations. Of the three shown, the TSME/OPHO-VAAL association reasonably represents the warmest soils owing to its lower elevations compared with the TSME/PHEM-VADE and TSME/RHAL-VAME associations.

	Soil temperature (°F)			
Plant association	Minimum	Maximum	Average	N
TSME/OPHO-VAAL	46	54	49	4
TSME/PHEM-VADE	43	53	47	5
TSME/RHAL-VAME	42	54	47	10
Series	42	54	47	19

ECOSYSTEM MANAGEMENT

Natural Regeneration of Mountain Hemlock—

Mountain hemlock reproduces from seed and vegetatively (Means 1990). Seed production begins at about 20 years of age. Mature trees produce moderate to very heavy crops of cones at about 3-year intervals, but crops may fail in other years. The winged seed is dispersed by the wind and may travel long distances across the snow. Seed germination occurs on mineral or organic soils if sufficient moisture is available. Seedlings are drought intolerant and grow best in partial shade. Initial growth is very slow, and small saplings are often 50 to 100 years of age under dense canopies but grow well when released by removal of overstory competition.

Mountain hemlock also reproduces vegetatively by layering (Means 1990). This is an effective way of reproducing at timberline as layered saplings are sheltered by the parent tree and initially receive their nutrients through the established root system of the parent tree.

Artificial Establishment of Mountain Hemlock and Associated Shrubs and Herbs—

If accessible, mountain hemlock is as valued a timber species as western hemlock. However, any timber harvest should be restricted to lower elevations for the TSME series. Natural regeneration is preferred over planted stock. Regeneration is suitable on a variety of sites ranging from mineral soils to well-decomposed organic material. Direct seeding is possible where bare mineral soil is available. It is probably better to rely on the release of natural seedlings and saplings when using selection-cutting methods in riparian zones.

Many of the shrubs that characterize the TSME series are well adapted to planting on disturbed sites. Sitka alder and devil's club can be established from nursery stock, seed, cuttings, or layering. Stink and Hudsonbay currant, salmonberry, and dwarf and five-leaved bramble can be easily grown from seed. Dwarf and five-leaved bramble, salmonberry, bunchberry dogwood, and other trailing plants can be easily propagated from root runners. Huckleberry cuttings root poorly; they can be established from seed but growth is slow. Oak fern, lady fern, and common horsetail can be easily propagated from rhizomes. (For more information on the short- and long-term revegetation potential of selected riparian/wetland plant species, see app. B-5.)

Stand Management—

Many sites in the TSME series are poorly suited for intensive timber management (Lillybridge et al. 1995). This is primarily due to the heavy snowpacks and short growing seasons that characterize most of these sites. These factors lead to slow growth of seedlings, and overall low productivity of mountain hemlock stands, and make it difficult to ensure reforestation within 5 years after harvest. Reliance on natural regeneration is probably the only way to ensure regeneration in 5 years (Atzet et al. 1984). In addition, many of the TSME sites are in inaccessible areas at high elevation or in wilderness. High water tables and the presence of seeps and springs associated with these riparian and wetland sites preclude many timber management activities. Loam soils predominate and are susceptible to compaction during most of the short growing season. Easily displaced organic soils are rare. Coarse-textured, compaction-resistant soils are unusual except on a few more fluvially active sites. Loam soils predominate and are subject to compaction. Therefore, machinery and livestock easily compact or otherwise damage the soil during periods of excessive soil moisture or high water tables (Hansen et al. 1995). For these reasons, any tree harvesting and associated management activities need to be carefully planned.

Many of the larger trees have extensive heart rot, shallow root systems, and are susceptible to windthrow. Snow damage to trees is also common. Timber harvesting in these sites or adjacent sites that are upslope may increase the risk of windthrow and rising water tables. Management options in riparian zones appear to be limited to single tree selection or small group selection to open the canopy and increase understory production. Activity during late summer/fall or during winter on snowpack to minimize soil disturbance is preferable. Only the lowest elevation sites (usually TSME/MEFE-VAAL) would be suitable for forestry, if appropriate techniques were used.

Tree Growth and Yield—

Short, cold growing seasons limit tree growth in the TSME series (Lillybridge et al. 1995). The lower elevation TSME/MEFE-VAAL and TSME/OPHO-VAAL associations are probably more productive than the high-elevation TSME/PHEM-VADE and TSME/RHAL-VAME associations. The TSME series is one of the least productive forested series in eastern Washington as indicated by low basal area and site index values. Basal area averages only 157 square feet per acre, one of the lowest for the forested tree series (apps. C-1a and C-1b). Only the LALY, BEPA, and ALRU series are lower. Similarly, site index (feet) for individual tree species is low compared with other tree series (app. C-2). Most methods for estimating tree productivity are poorly suited for use in the TSME series, as many of these sites are quite old and site index curves cannot be accurately applied (Henderson et al. 1992). Therefore, tree productivity data must be viewed with caution.

Site index			
Species	Base age	No. of trees	SI
ABAM	100	27	56
ABLA2	50	12	26
PIEN	50	12	38
TSHE	50	2	50
TSME	50	24	49

Basal area (sq. ft./ac)	
Species	BA
ABAM	58
ABLA2	27
CHNO	6
PIAL	3
PIEN	24
PSME	5
THPL	1
TSHE	9
TSME	26
Total	157

Down Wood—

The overall amount of down woody material is moderate compared with the other tree series (app. C-3). Logs cover only 7 percent of the ground surface. This is commensurate with the moderate stand basal area, tree diameters and height, and site indices associated with these stands.

Definitions of log decomposition classes are on page 15.

	Down log attributes				
Log decomposition	Tons/ acre	Cu. ft./ acre	Linear ft./ acre	Sq. ft./ acre	% ground cover
Class 1	1.18	100	188	149	0.34
Class 2	8.48	905	686	794	1.82
Class 3	3.71	475	1,023	677	1.55
Class 4	1.98	636	849	760	1.74
Class 5	1.43	459	760	603	1.38
Total	16.78	2,575	3,506	2,983	6.83

Snags—

The TSME series supports a moderate number of snags (37 snags per acre) in comparison with other tree series (app. C-4). Only the ABGR, POTR, POTR2, and TSHE series have lower snag values. This again reflects harsh habitats that take long periods to grow large-diameter trees. The lower-elevation TSME/MEFE-VAAL and TSME/OPHO-VAAL associations have a greater abundance of large down wood owing to their more productive environments and greater tree species diversity.

Definitions of snag condition classes are on page 15.

	Snags/acre by d.b.h. class (inches)				
Snag condition	5–9.9	10–15.5	15.6–21.5	21.6+	Total
Class 1	0	2.4	1.6	1.1	5.1
Class 2	14.3	5.7	2.6	1.2	23.8
Class 3	2.2	2.8	.4	.4	5.8
Class 4	0	.7	.3	.1	1.1
Class 5	0	0	.4	.8	1.2
Total	16.5	11.6	5.3	3.6	37.0

Fire—

Mountain hemlock is low to moderate in its adaptation to fire (Fischer and Bradley 1987). Its relatively thick bark provides some protection; however, its shallow roots, low-hanging branches, highly flammable foliage, and tendency to grow in dense stands make it very susceptible to fire injury. The lichen-covered branches further increase its susceptibility to fire (Franklin and Dyrness 1973). Even light ground fires are damaging because the shallow roots scorch. Additional mortality is caused by fungal infection of the fire wounds. Despite these disadvantages, TSME sites are typically moist, making fire occurrence low. Fires generally occur as infrequent stand-replacement fires at 400- to 800-year intervals (Atzet and Wheeler 1982).

In all, 81 trees were sampled for age in the TSME series. The average tree age (188 years breast height) is high compared with other forest series. Most stands appeared to be between 100 and 400 years old. Two trees were over 400 years old, 14 were 300 to 399 years old, 21 were 200 to 299 years old, 19 were 100 to 199 years old, and 25 were less than 100 years old. The two oldest trees were both mountain hemlocks at 410 and 579 years old. Both of these trees were measured in a TSME/RHAL-VAME association. The percentage (46 percent) of trees greater than 199 years old is the highest percentage of any forest series. These data suggest that fires usually are large, stand-replacing fires and that the average fire-return interval in the TSME series sites probably exceeds 200 years, and may be greater than 400 years on some sites. Although lightning strikes are common at higher elevations, fires started by lightning strikes appear to be infrequent or to burn small areas.

Animals—

Livestock. There are few grazing allotments within the TSME series in eastern Washington. In general, these cool, moist to wet sites have little utility for domestic livestock, with low forage value and relatively short growing seasons. Most areas are covered in snow and unavailable until early or mid summer. In addition, many areas are located at high elevations or in wilderness areas with very rugged topography, eliminating any potential livestock use. Forage potential may be fair in early successional stages but is generally poor in late-successional stages. Owing to the lack of suitable forage, these sites primarily represent sources of water and shade. In general, these sites are susceptible to trampling owing to moist, fine-textured soils.

Livestock grazing is not usually a problem, if present at all. However, if sites have been grazed too heavily, modifying the grazing system coupled with close monitoring of wildlife often allows the remnant shrub and herb population to sprout and reinvade the stand. The ability to easily reestablish desired shrubs and herbs may be lost when the vegetation has been eliminated because of overgrazing and when the water table has been lowered owing to streambed downcutting or lateral erosion. (For more information on forage palatability see app. B-1. For potential biomass production, see app. B-5.)

Wildlife. Riparian zones in the TSME series provide good hiding and thermal cover for wildlife species (Atzet et al. 1984, Lanner 1983). However, these sites are characterized by long, cold, wet winters with heavy snowpacks in steep, rugged terrain. Because of these characteristics, the TSME series is not as heavily used by wildlife as some of the other forest series. Most use by wildlife is limited to mid to late summer when conditions are more favorable, often in the subalpine parklands. These sites provide important summer and fall range for elk and mule deer (Pfister et al. 1977). Mountain goats may be observed in mountain hemlock stands and surrounding habitat during most seasons of the year. Black bears forage in these sites, especially on the many berry-producing shrubs that are used in late summer and fall. Grizzly bears, although rare, may select these areas for summer foraging and winter denning. Various small mammals such as bats, red tree vole, red squirrels, and American marten will use hollow trees, snags, and logs for feeding, dens, or rest sites (Hansen et al. 1995). Conifer cones are harvested and cached for winter use by squirrels and chipmunks.

Late-seral stand structures at many of these sites serve as important habitat for a variety of bird species. These include the northern spotted owl, great horned owl, great gray owl, pileated and hairy woodpeckers, chickadees, nuthatches, kinglets, and warblers. Blue grouse use these sites even in winter. Ptarmigan use surrounding heath meadows and alpine sites. Birds eat the seed of mountain hemlock and other conifers. (For more information on thermal or feeding cover values, see apps. B-2 and B-3. For information on food values or degree of use, see apps. B-2 and B-4.)

Fish. Riparian zones in the TSME series play important roles in watershed function and hydrologic regimes. Watershed values are high. Many of these sites are located in high-elevation cirque basins where winter snowpacks are the largest and most pronounced on the eastern slope of the Cascade Range. These areas serve an important function by acting as hydrologic reservoirs, helping maintain streamflows and runoff during the warm summer months. In addition, owing to windthrow and disease, many mountain hemlock sites have moderate amounts of large woody debris in and alongside the stream channels. This woody debris, primarily large-diameter logs, provides good stream channel stabilization particularly during peak flows associated with spring runoff (for more information see app. B-5, erosion control potential). Many of these locations are too high in elevation, and channels are too steep and small for good fisheries habitat. However, the large tree canopies provide shade for the small streams, helping to regulate stream water temperatures and promoting good fisheries habitat in downstream locations. Managers may wish to maintain healthy, vigorous stands of TSME and associated series on fluvially active locations. These buffer strips of erosion-resistant plant species help stabilize streambanks and nearby terraces and swales, provide a barrier to sedimentation from nearby slopes, and provide a source of large down wood for the stream and nearby fluvial surfaces.

Recreation—

Most of these sites are not well suited for recreation uses owing to often inaccessible locations, high water tables, and sensitive soils. Soils are susceptible to compaction, and vegetation is easily trampled. Many of the heaths, heathers, and huckleberries found on these sites are very sensitive to trampling damage. In addition, most of these sites are plagued by overabundant mosquito and fly populations during summer. Most recreation use is limited to wilderness areas where horseback riders, backpackers, and day hikers pass through riparian zones and uplands along established trails.

Insects and Disease—

The most common pathogens found on these sites are various species of decay fungi. Mountain hemlock is very susceptible to laminated root rot (Dickman and Cook 1989, Means 1990). This fungus spreads from centers of infection along tree roots so that all trees are killed in an expanding circle. Annosus root disease is another common decay, particularly in mature stands, that infects the root and butt of both Pacific silver fir and mountain hemlock as well as subalpine fir, Engelmann spruce, and western hemlock (Lillybridge et al. 1995). Other fungal and parasitic pests include Indian paint fungus and dwarf mistletoe.

Insect pests include mountain pine beetle, spruce beetle, western spruce budworm, and fir engraver (Lillybridge et al. 1995). Potential problems with insects usually are minimal at these sites. However, outbreaks of the silver fir beetle are possible on Pacific silver fir trees. Pacific silver fir also may be susceptible to the balsam woolly adelgid. Both mountain hemlock and Pacific silver fir may be affected by the western black-headed budworm.

Estimating Vegetation Potential on Disturbed Sites—

Estimating potential on disturbed sites is generally not needed on these conifer-dominated sites. Clearcutting in riparian areas is unusual, at least on FS lands. Wetter types in the SALIX, MEADOW, and ALSI series separate many mountain hemlock stands from active flood zones. Currently, FS riparian zones are buffered and not managed for timber management. For young stands, similar valley segments in nearby drainages can indicate the potential natural vegetation.

Sensitive Species—

Sensitive plants were not found on any of the ecology plots (app. D).

ADJACENT SERIES

The TSME series occupies some of the highest forested sites found in the stronger maritime climates of the Cascade Range. At its highest elevation it often grades quickly into a mountain hemlock-dominated subalpine parkland along the crest of the Cascade Range (Lillybridge et al. 1995). However, the LALY, ABLA2, or PIAL series can be found at the upper fringe of the TSME series on some sites (especially those transitional to continental climate). At lower elevations, the TSME series grades into the ABAM series.

RELATIONSHIPS TO OTHER CLASSIFICATIONS

This is the first riparian/wetland classification of the TSME series for eastern Washington. Many of the associations described in this classification also were recognized in the upland forest classification for the Wenatchee NF (Lillybridge et al. 1995). In the context of this study, they occur near water. Only TSME/OPHO-VAAL represents a newly classified association.

Plant associations belonging to the TSME series have been described by numerous authors, either as unique types or sometimes included in the ABAM series in the Cascade Range (Brockway et al. 1983, Diaz et al. 1997, Franklin et al. 1988, Hemstrom and Franklin 1982, Hemstrom et al. 1987, Henderson et al. 1992, John et al. 1988, Lillybridge et al. 1995, Williams and Lillybridge 1983); northeastern Washington, northern Idaho, and Montana (Cooper et al. 1991, Daubenmire and Daubenmire 1968, Pfister et al. 1977, Williams et al. 1995); and northeastern Oregon (Johnson and Simon 1987). Meidinger and Pojar (1991) described mountain hemlock-dominated sites for British Columbia.

U.S. DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE WETLANDS CLASSIFICATION

System:	palustrine
Class:	forested wetland
Subclass:	needle-leaved evergreen
Water regime:	(nontidal) intermittently saturated

KEY TO THE MOUNTAIN HEMLOCK (*TSUGA MERTENSIANA*) PLANT ASSOCIATIONS

1. Devil's club (*Oplopanax horridum*) ≥5 percent canopy coverage .... **Mountain hemlock/devil's club (TSME/OPHO-VAAL) association**

2. Moss-heathers (*Cassiope* spp.), mountain-heaths (*Phyllodoce* spp.), and/or Cascade huckleberry (*Vaccinium deliciosum*) ≥5 percent canopy coverage .... **Mountain hemlock/red mountain-heath–Cascade huckleberry (TSME/PHEM-VADE) association**

3. Rusty menziesia (*Menziesia ferruginea*) ≥5 percent canopy coverage, Alaska (*Vaccinium alaskaense*) or oval-leaf huckleberry (*V. ovalifolium*) usually present .... **Mountain hemlock/rusty menziesia-Alaska huckleberry (TSME/MEFE-VAAL) association**

4. Cascade azalea (*Rhododendron albiflorum*) ≥5 percent canopy coverage, big huckleberry (*Vaccinium membranaceum*) usually present .... **Mountain hemlock/Cascade azalea-big huckleberry (TSME/RHAL-VAME) association**

Table 1—Constancy and mean cover of important plant species in the TSME plant associations

		TSME/MEFE-VAAL 5 plots		TSME/OPHO-VAAL 4 plots		TSME/PHEM-VADE 5 plots		TSME/RHAL-VAME 11 plots	
Species	Code	CON[a]	COV[b]	CON	COV	CON	COV	CON	COV
Tree overstory:									
Pacific silver fir	ABAM	100	30	75	20	40	15	100	23
subalpine fir	ABLA2	—	—	—	—	80	9	55	12
Alaska yellow-cedar	CHNO	—	—	—	—	20	5	9	30
Engelmann spruce	PIEN	—	—	—	—	—	—	82	9
whitebark pine	PIAL	—	—	—	—	20	3	18	8
western redcedar	THPL	40	9	25	5	—	—	—	—
western hemlock	TSHE	80	13	25	20	—	—	—	—
mountain hemlock	TSME	100	17	100	29	80	7	100	13
Tree understory:									
Pacific silver fir	ABAM	100	11	100	6	80	14	100	10
subalpine fir	ABLA2	—	—	—	—	80	21	64	5
Alaska yellow-cedar	CHNO	—	—	25	1	20	20	9	Tr[c]
Engelmann spruce	PIEN	—	—	—	—	40	7	27	1
western hemlock	TSHE	60	1	75	2	—	—	—	—
mountain hemlock	TSME	80	1	75	8	100	10	100	6
Shrubs:									
Sitka alder	ALSI	20	5	75	23	—	—	9	2
bearberry honeysuckle	LOIN	—	—	25	6	—	—	27	1
rusty menziesia	MEFE	100	17	50	14	20	33	9	5
devil's club	OPHO	80	1	100	15	—	—	—	—
Cascade azalea	RHAL	—	—	50	15	60	25	100	36
stink currant	RIBR	—	—	25	5	—	—	9	3
Hudsonbay currant	RIHU	—	—	50	5	20	15	9	Tr[c]
salmonberry	RUSP	60	3	100	16	—	—	9	3
undergreen willow	SACO2	—	—	—	—	20	5	—	—
Piper's willow	SAPI	—	—	—	—	20	35	—	—
scarlet elderberry	SARA	—	—	—	—	20	12	—	—
Cascade mountain-ash	SOSC2	60	2	50	5	60	13	18	8
Sitka mountain-ash	SOSI	—	—	25	10	40	3	27	3
Douglas spiraea	SPDO	—	—	—	—	20	15	—	—
Alaska huckleberry	VAAL	100	13	100	37	20	18	9	5
big huckleberry	VAME	80	9	75	4	80	13	100	33
Low shrubs and subshrubs:									
bunchberry dogwood	COCA	40	5	25	Tr	—	—	—	—
Labrador tea	LEGL	—	—	—	—	20	3	27	1
red mountain-heath	PHEM	—	—	—	—	100	16	64	2
dwarf bramble	RULA	100	3	50	1	20	8	45	7
five-leaved bramble	RUPE	100	6	75	3	40	3	55	5

Table 1—Constancy and mean cover of important plant species in the TSME plant associations (continued)

Species	Code	TSME/MEFE-VAAL 5 plots		TSME/OPHO-VAAL 4 plots		TSME/PHEM-VADE 5 plots		TSME/RHAL-VAME 11 plots	
		CON	COV	CON	COV	CON	COV	CON	COV
Cascade huckleberry	VADE	—	—	—	—	80	41	36	2
low huckleberry	VAMY	20	6	—	—	20	30	9	1
Perennial forbs:									
deerfoot vanilla-leaf	ACTR	—	—	50	3	—	—	—	—
sharptooth angelica	ANAR	—	—	75	2	20	Tr	27	1
mountain arnica	ARLA	20	2	25	Tr	40	3	82	2
queencup beadlily	CLUN	100	11	100	2	—	—	—	—
false saxafrage	LEPY	—	—	—	—	60	4	27	1
bigleaf lupine	LUPO	—	—	—	—	20	1	18	Tr
lupine species	LUPIN	—	—	—	—	—	—	9	Tr
northern bluebells	MEPAB	—	—	25	Tr	—	—	9	Tr
miterwort species	MITEL	—	—	50	1	60	1	9	1
sidebells pyrola	PYSE	20	1	75	2	20	Tr	73	1
arrowleaf groundsel	SETR	—	—	25	Tr	60	1	55	1
starry solomonplume	SMST	60	4	—	—	—	—	9	Tr
claspleaf twisted-stalk	STAM	—	—	100	2	20	2	45	Tr
rosy twisted-stalk	STRO	40	5	50	Tr	20	3	55	4
coolwort foamflower	TITRU	80	5	75	3	—	—	36	3
Sitka valerian	VASI	60	3	25	Tr	80	4	73	3
American false hellebore	VEVI	—	—	50	Tr	40	2	27	1
pioneer violet	VIGL	—	—	50	Tr	40	Tr	27	1
Ferns and fern allies:									
lady fern	ATFI	20	1	75	18	20	3	9	Tr
deer fern	BLSP	—	—	50	4	—	—	—	—
common horsetail	EQAR	—	—	25	Tr	60	1	9	Tr
oak fern	GYDR	60	10	50	5	—	—	9	Tr

[a] CON = percentage of plots in which the species occurred.
[b] COV = average canopy cover in plots in which the species occurred.
[c] Tr = trace cover, less than 1 percent canopy cover.

PACIFIC SILVER FIR SERIES

Abies amabilis

ABAM N = 62

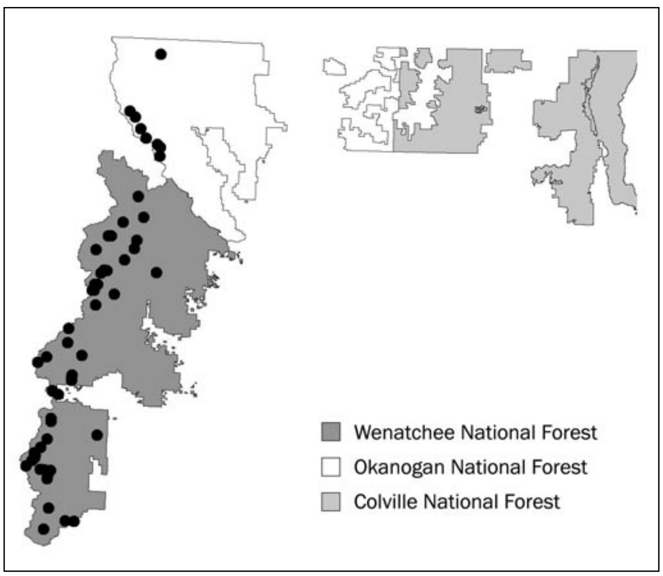


Figure 8—Plot locations for the Pacific silver fir series.

THE RANGE OF Pacific silver fir[1] extends from extreme southeastern Alaska south through western British Columbia and the Cascade Range of Washington and Oregon to northwestern California (Hitchcock and Cronquist 1973). Pacific silver fir is usually associated with uplands, but within its range, it is also prominent in riparian zones on fluvial surfaces such as streambanks and terraces.

Pacific silver fir is one of the most shade-tolerant and environmentally restricted conifers in eastern Washington. The ABAM series is found only in areas of strong maritime influence, usually in climatic zones within 10 miles of the Cascade crest (Lillybridge et al. 1995). This maritime influence is particularly strong and extensive in the mountain pass corridors on the Wenatchee NF. The ABAM series also is found on the western extreme of the Okanogan NF, generally west of a line formed by Washington Pass, Harts Pass, and Reynolds Peak. Most of this land lies west of the Cascade crest on lands once administered by the Mount Baker NF but now administered by the Okanogan NF. The ABAM series is not found on the Colville NF.

CLASSIFICATION DATABASE

The ABAM series includes all forest stands potentially dominated by silver fir at climax. The series was sampled on the Okanogan and Wenatchee NFs (fig. 8). Stands are common on all ranger districts of the Wenatchee NF and the extreme west end of the Methow Valley RD on the Okanogan NF. Thirty riparian and wetland plots were sampled in the ABAM series. Data from an additional 32 plots from other ecology samples were included to augment species composition, distribution, and elevation data for the series. From this database, seven major and two minor plant associations are described. For the most part, these samples were located in late-seral and climax Pacific silver fir stands.

[1] See appendix A for a cross reference for all species codes and common and scientific names used in this document.

Pacific silver fir plant associations

	Scientific name	Common name	Ecoclass code	Plots
Major associations:				
ABAM/ACTR-WEN	*Abies amabilis/Achlys triphylla*-Wenatchee	Pacific silver fir/deerfoot vanilla-leaf–Wenatchee	CFF254	6
ABAM/ATFI	*Abies amabilis/Athyrium filix-femina*	Pacific silver fir/lady fern	CFF621	7
ABAM/GYDR	*Abies amabilis/Gymnocarpium dryopteris*	Pacific silver fir/oak fern	CFF622	9
ABAM/MEFE-WEN	*Abies amabilis/Menziesia ferruginea-*Wenatchee	Pacific silver fir/rusty menziesia-Wenatchee	CFS542	8
ABAM/OPHO	*Abies amabilis/Oplopanax horridum*	Pacific silver fir/devil's club	CFS351	15
ABAM/TITRU	*Abies amabilis/Tiarella trifoliata* var. *unifoliata*	Pacific silver fir/coolwort foamflower	CFF162	6
ABAM/VAME/CLUN-WEN	*Abies amabilis/Vaccinium membranaceum-*Wenatchee	Pacific silver fir/big huckleberry-Wenatchee	CFS233	5
Minor associations:				
ABAM/ACCI	*Abies amabilis/Acer circinatum*	Pacific silver fir/vine maple	CFS621	2
ABAM/RHAL-VAME-WEN	*Abies amabilis/Rhododendron albiflorum-Vaccinium membranaceum*-Wenatchee	Pacific silver fir/Cascade azalea-big huckleberry-Wenatchee	CFS556	4

VEGETATION CHARACTERISTICS

Mature stands in the ABAM series characteristically have two or more tree canopies, with species such as Douglas-fir and Engelmann spruce forming a tall canopy above a layer of more shade-tolerant and slower growing species such as Pacific silver fir, western hemlock, and western redcedar (Lillybridge et al. 1995). Late-seral stands have an overstory dominated by Pacific silver fir, with some large, remnant western redcedar and western hemlock. Common seral tree species include Engelmann spruce, western hemlock, western redcedar, western white pine, and Douglas-fir. Subalpine fir and Alaska yellow-cedar are common seral species in the three high-elevation types (ABAM/RHAL-VAME-WEN, ABAM/TITRU, and ABAM/VAME/CLUN-WEN). Mountain hemlock may be scattered in cold, high-elevation stands on sites transitional to the TSME series. The tree understory is usually dominated by Pacific silver fir and western hemlock regeneration, with lesser amounts of western redcedar. Pacific silver fir is extremely shade tolerant and will survive for decades in sapling form, releasing rapidly when the overstory is opened by logging, disease, or windthrow.

Shrub and herb layers are floristically rich and varied. Heavily shaded stands often support little understory plant cover (depauperate). Very deep litter and low light levels at the forest floor appear to reduce the number and cover of shrubs and herbs. Inspection of adjacent stands or use of relative cover data may be needed to correctly identify the type. Shrubs dominate many types in open stands and include vine maple, big huckleberry, rusty menziesia, dwarf bramble, and Cascade azalea on relatively drier sites; devil's club, prickly currant, and salmonberry on wetter sites. Common herbs include queencup beadlily, deerfoot vanilla-leaf, sidebells pyrola, rosy twisted-stalk, and coolwort foamflower. Lady fern and oak fern are prominent on wetter sites.

PHYSICAL SETTING

Elevation—

The majority of ABAM series plots are between 3,000 and 5,000 feet. Okanogan NF plots are over 600 feet higher than Wenatchee NF plots. The Okanogan NF has a relatively weak maritime climate compared with the Wenatchee NF. Therefore, ABAM series sites are located at elevations high enough to provide the precipitation and snowpack needed to support the ABAM series. The highest plot on the Wenatchee NF is located at the extreme eastern extension of the range of Pacific silver fir and, like the Okanogan plots, occurs at higher elevation in zones of heavier precipitation and snowpack.

	Elevation (feet)			
Forest	Minimum	Maximum	Average	N
Okanogan	3,190	4,900	4,250	8
Wenatchee	2,380	5,520	3,623	54
Series	2,380	5,520	3,704	62

Additional insight is gained by looking at individual associations. The average elevations for ABAM/RHAL-VAME-WEN, ABAM/VAME/CLUN-WEN, and ABAM/TITRU associations are much higher compared with the other associations, but ranges still overlap for many associations. The limited data and the author's own observations suggest that ABAM/ACCI is the lowest elevation plant association.

	Elevation (feet)			
Plant association	Minimum	Maximum	Average	N
ABAM/RHAL-VAME-WEN	4,400	5,500	5,002	4
ABAM/VAME/CLUN-WEN	3,620	5,520	4,824	5
ABAM/TITRU	3,190	4,850	4,422	6
ABAM/ATFI	2,380	4,460	3,653	7
ABAM/GYDR	2,450	4,920	3,519	9
ABAM/MEFE-WEN	2,900	3,760	3,318	8
ABAM/ACTR-WEN	2,500	3,680	3,292	6
ABAM/OPHO	2,610	4,200	3,290	15
ABAM/ACCI	3,040	3,050	3,045	2
Series	2,380	5,520	3,704	62

Valley Geomorphology—

The ABAM series is found in various valley width and gradient classes. Approximately 65 percent of the plots are located in moderate to very narrow valleys (less than 330 feet) with moderate to very high gradients (greater than 4 percent). However, some sites also are located in very broad (greater than 990 feet), low gradient (less than 3 percent) valleys. In many cases these later plots are associated with lake basins or along cold air drainages in large valleys such as the Chiwawa River. The variety of valley width and gradient classes likely indicates that maritime climate is more important than valley geomorphology in determining the distribution of the ABAM series (with the exception of cold air drainages).

	Valley gradient					
Valley width	Very low	Low	Moderate	Steep	Very steep	N
Very broad	6	2	1	0	0	9
Broad	0	0	0	0	0	0
Moderate	0	2	2	1	1	6
Narrow	0	2	4	0	7	13
Very narrow	0	0	0	0	2	2
Series total	6	6	7	1	10	30

The limited valley data do not show a clear pattern for individual ABAM associations, as each association can be found across a variety of valley width and gradient classes. ABAM/ACCI, ABAM/ATFI, ABAM/MEFE-WEN, ABAM/OPHO, ABAM/RHAL-VAME-WEN, and ABAM/VAME/CLUN-WEN occur more often in moderate to very narrow valleys. Only ABAM/ACTR-WEN and ABAM/TITRU indicate a preference for broader valleys. ABAM/ACCI, ABAM/ACTR-WEN, ABAM/ATFI, and ABAM/GYDR appear to occur on very low to moderate gradient valleys, whereas the ABAM/OPHO, ABAM/RHAL-VAME-WEN, and ABAM/VAME/CLUN-WEN occur in steeper valleys.

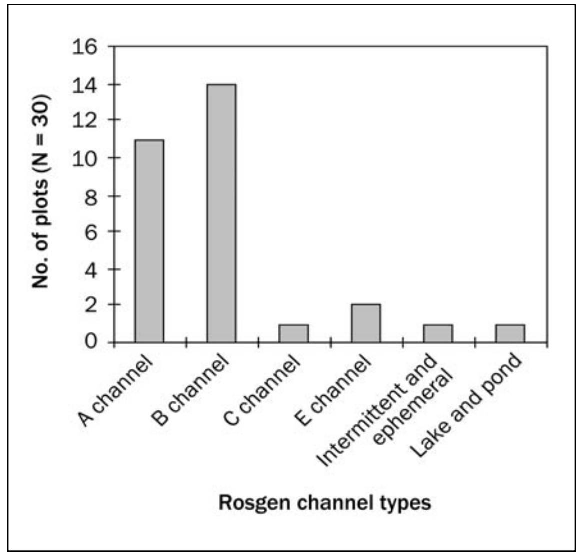
	Valley width					
Plant association	Very broad	Broad	Moderate	Narrow	Very narrow	N
ABAM/ACCI	0	0	0	1	0	1
ABAM/ACTR-WEN	2	0	1	0	0	3
ABAM/ATFI	0	0	3	2	0	5
ABAM/GYDR	2	0	0	2	0	4
ABAM/MEFE-WEN	0	0	1	1	1	3
ABAM/OPHO	1	0	0	3	0	4
ABAM/TITRU	2	0	1	0	0	3
ABAM/RHAL-VAME-WEN	1	0	0	2	0	3
ABAM/VAME/CLUN-WEN	1	0	0	2	1	4
Series total	9	0	6	13	2	30

	Valley gradient					
Plant association	Very low	Low	Moderate	Steep	Very steep	N
ABAM/ACCI	0	0	1	0	0	1
ABAM/ACTR-WEN	2	1	0	0	0	3
ABAM/ATFI	0	1	3	0	1	5
ABAM/GYDR	2	0	2	0	0	4
ABAM/MEFE-WEN	0	2	0	1	0	3
ABAM/OPHO	1	0	0	0	3	4
ABAM/TITRU	0	1	1	1	0	3
ABAM/RHAL-VAME-WEN	1	0	0	0	2	3
ABAM/VAME/CLUN-WEN	0	1	0	0	3	4
Series total	6	6	7	1	10	30

Channel Types—

The limited data suggest the moderate to narrow width, moderate to very steep gradient valleys associated with many plots in the ABAM series usually support A and B Rosgen channel types. Fewer plots are associated with C channels, E channels, and lakes or ponds in larger, lower gradient valleys. These sites tend to get too wet for Pacific silver fir; therefore, the ABAM series gives way to wetter riparian and wetland series and associations.

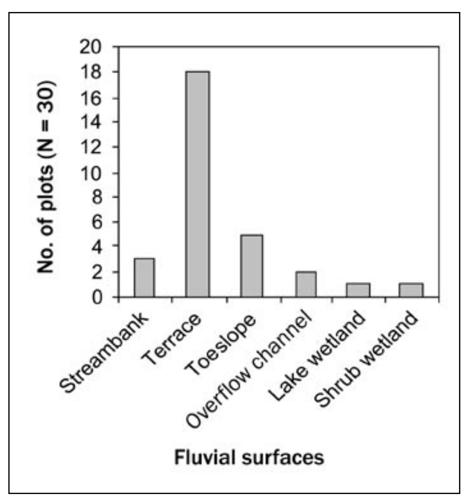
Data for individual associations support these observations, as most are located along A and B channels. Only ABAM/ACCI and ABAM/ACTR-WEN seem to have an affinity for other channel types (C and E channels), but data to support this observation are very limited.



	Rosgen channel types						
Plant association	A	B	C	E	Intermittent/ ephemeral	Lake/ pond	N
ABAM/ACCI	0	0	0	1	0	0	1
ABAM/ACTR-WEN	0	1	1	1	0	0	3
ABAM/ATFI	2	3	0	0	0	0	5
ABAM/GYDR	2	2	0	0	0	0	4
ABAM/MEFE-WEN	0	2	0	0	1	0	3
ABAM/OPHO	2	2	0	0	0	0	4
ABAM/TITRU	1	2	0	0	0	0	3
ABAM/RHAL-VAME-WEN	1	1	0	0	0	1	3
ABAM/VAME/CLUN-WEN	3	1	0	0	0	0	4
Series total	11	14	1	2	1	1	30

Fluvial Surfaces—

The ABAM series is most prominent in riparian zones on streambanks, overflow channels, terraces, and toeslopes. The vast majority of plots (76 percent) are on terraces and toeslopes. Only two plots are found on the dry margins (xeroriparian) of lakes and ponds associated with wetlands.

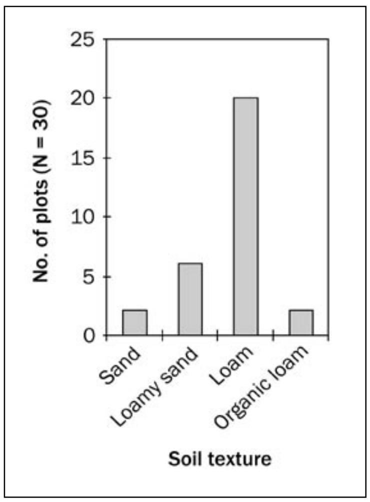


Little additional insight into fluvial location is gained by looking at individual plant associations. All eight associations are found primarily on riparian zone fluvial surfaces, especially terraces. ABAM/GYDR is the only plant association located in largely filled-in overflow channels. ABAM/ACTR-WEN and ABAM/RHAL-VAME-WEN are occasionally located on the dry margins of wetlands.

	Fluvial surfaces					
Plant association	Stream-bank	Terrace	Toe-slope	Overflow channel	Wetlands	N
ABAM/ACTR-WEN	0	2	0	0	1	3
ABAM/ATFI	1	3	1	0	0	5
ABAM/GYDR	0	3	0	2	0	5
ABAM/MEFE-WEN	0	1	2	0	0	3
ABAM/OPHO	2	2	0	0	0	4
ABAM/RHAL-VAME-WEN	0	2	0	0	1	3
ABAM/TITRU	0	3	0	0	0	3
ABAM/VAME/CLUN-WEN	0	2	2	0	0	4
Series total	3	18	5	2	2	30

Soils—

Mineral soils predominate in the ABAM series. Loamy sand and loam soils are the most common soil texture classes. Two plots with recent flood overflow and deposition have sandy soils. A few soils in the wettest types (ABAM/GYDR and ABAM/ATFI) were classified organic loam.



Little additional information about soil texture is gained by looking at individual plant associations. As with the ABAM series in general, most stands are associated with loam soils. ABAM/ACTR-WEN and ABAM/VAME/CLUN-WEN are the only associations with sandy (flood deposition) soils, whereas the wet ABAM/ATFI and ABAM/GYDR associations occasionally grow on organic soils.

	Soil texture				
Plant association	Sand	Loamy sand	Loam	Organic loam	N
ABAM/ACCI	0	0	1	0	1
ABAM/ACTR-WEN	1	1	1	0	3
ABAM/ATFI	0	1	3	1	5
ABAM/GYDR	0	0	3	1	4
ABAM/MEFE-WEN	0	1	2	0	3
ABAM/OPHO	0	0	4	0	4
ABAM/RHAL-VAME-WEN	0	1	2	0	3
ABAM/TITRU	0	1	2	0	3
ABAM/VAME/CLUN-WEN	1	1	2	0	4
Series total	2	6	20	2	30

Water tables were sampled on only seven plots, where they averaged 28 inches below the soil surface. There is no discernable pattern between plant associations and water tables, perhaps owing to the low sample size. Similarly, few plots had soil surface water present at the time of sampling. ABAM/OPHO, ABAM/ATFI, and ABAM/GYDR are the plant associations most likely to be partially flooded at snowmelt.

Soil temperature data are available for 29 plots. Generally, higher elevation plant associations had the coldest soil temperatures; however, data are limited and should be viewed with caution.

	Soil temperature (°F)			
Plant association	Minimum	Maximum	Average	N
ABAM/ACCI	55	55	55	1
ABAM/MEFE-WEN	47	55	53	3
ABAM/GYDR	45	58	52	4
ABAM/OPHO	48	54	49	4
ABAM/ATFI	43	51	47	4
ABAM/TITRU	43	47	46	3
ABAM/VAME/CLUN-WEN	43	47	46	4
ABAM/ACTR-WEN	42	48	45	3
ABAM/RHAL-VAME-WEN	40	46	43	3
Series	40	58	48	29

ECOSYSTEM MANAGEMENT

Natural Regeneration of Pacific Silver Fir—

Pacific silver fir reproduces only from seed (Lane 1959) and begins seed production at 20 to 30 years of age. Good seed crops are produced every 2 to 3 years, although intervals between good seed production may be as long as 6 years. The largeness of the seed limits the distance it can be dispersed by wind. Seed germination occurs in the spring on a variety of substrates, such as litter, rotten wood, moss, and both organic and mineral soils. Cool, moist sites are optimal for germination, whereas full sunlight is needed for maximum new growth. Under optimal conditions, Pacific silver fir saplings reach a height of 5 feet in 9 years, but under dense canopies, it may take 80 years or longer. Information about natural and artificial establishment of other tree species that may be found in ABAM series stands is found in descriptions for other tree series.

Artificial Establishment of Pacific Silver Fir and Associated Shrubs and Firs—

Nursery-grown bare-root and container stock of Pacific silver fir are widely planted in the Pacific Northwest. Both establish best on bare mineral soil, although broadcast slash burning has been shown to slow the success of regeneration. When using selection-harvest methods in riparian zones, it is probably better to rely on the release of natural seedlings and saplings for regeneration of Pacific silver fir.

Many of the shrubs used to characterize the ABAM series are well adapted to planting on disturbed sites. Devil's club can be established from seed or cuttings, or by layering, although establishment is slow. Prickly currant, salmonberry, and western thimbleberry can be easily grown from seed. Five-leaved bramble, dwarf bramble, twinflower, and other trailing plants can be easily propagated from root runners. Huckleberry species can be established from seed, but its growth from seed is slow. Huckleberry cuttings root poorly. Rusty menziesia and Cascade azalea, like all ericaceous plants, can propagate from seed or cuttings. However, the seed is small and the seedlings need two or three transplantings before being outplanted. Deerfoot vanilla-leaf, oak fern, and lady fern are easily propagated from rhizomes. (For more information on the short- and long-term revegetation potential of selected riparian wetland plant species, see app. B-5.)

Stand Management—

The ABAM series supports many tree species. Pacific silver fir, Engelmann spruce, western redcedar, and western hemlock are dominant, and six other eastern Washington trees are well represented. Only ponderosa pine, Oregon white oak, mountain hemlock, subalpine larch, and whitebark pine are not suited to ABAM series environments. Douglas-fir and, in some cases, western redcedar and western hemlock, are not well suited to higher, colder associations such as ABAM/VAME/CLUN-WEN and ABAM/RHAL-VAME-WEN.

Although tree productivity is quite high on these sites, tree harvesting and associated management activities need to be carefully planned in riparian zones. Some sites, such as those that occur in ABAM/OPHO and ABAM/ATFI associations, are swampy and, although tree growth is rapid, are difficult to manage for timber production (Lillybridge et al. 1995). Loam soils are prevalent and are susceptible to compaction during most of the growing season. Many larger trees have extensive heart rot and also are susceptible to blowdown. Timber harvesting in these sites or adjacent upslope sites may cause water tables to rise and increase the risk of blowdown. Regeneration may be particularly difficult on the wettest sites, such as ABAM/OPHO and ABAM/ATFI, where Pacific silver fir and western hemlock will only establish themselves on down logs or root wads.

Although overstory removal is a viable harvest option in uplands, riparian zones are best suited to single-tree or small-group selection to open the canopy and increase understory production, as well as to protect streams and other riparian-dependent resources. After release by logging or blowdown, suppressed Pacific silver fir will respond with substantial growth. Tree harvesting should occur during late summer/fall or during winter, over snow, to minimize soil disturbance. Commercial rotations are seldom longer than 110 years, but a period of 150 to 200 years is more suited to riparian sites. Wetland sites should be avoided entirely. Provisions for future supplies of large down wood are essential for riparian sites.

Tree Growth and Yield—

Cool average annual temperatures and heavy snowpacks are the main limitations to tree growth in the ABAM series (Lillybridge et al. 1995). However, favorable summer growing conditions that include moist soils and occasional summer rains more than make up for the relatively short growing season. The ABAM series is one of the more productive series in eastern Washington, exhibiting high basal area (281 square feet per acre) and site index values. The high basal area value is one of the highest for any of the tree series (apps. C-1a and C-1b). Only the PSME, THPL, and TSHE series are comparable. Similarly, the average site index for individual species (feet) is generally high compared with other series (app. C-2). Tree productivity data are limited and should be viewed with caution.

Site index			
Species	Base age	No. of trees	SI
ABAM	100	63	97
ABGR	5	3	104
ABLA2	50	10	56
ABPR	100	3	118
CHNO	100	3	75
PIEN	50	39	78
PSME	50	6	86
THPL	100	11	85
TSHE	50	13	65
TSME	50	2	56

Basal area (sq. ft./ac)	
Species	BA
ABAM	100
ABGR	2
ABPR	1
ABLA2	28
CHNO	18
LAOC	2
PICO	1
PIEN	49
PIMO	1
POTR2	2
PSME	13
THPL	27
TSHE	35
TSME	2
Total	281

Down Wood—

Overall, the amount of down wood on ABAM sites is high compared to other tree series sites (app. C-3), with logs covering 12 percent of the ground. This reflects cool, moist, productive conditions that support large-diameter trees and, hence, large-diameter logs. These environmental conditions then slow the decomposition of the down wood. ABAM sites usually carry less down wood than the THPL series (e.g., 31.37 tons per acre compared with 66.32 tons per acre) probably because ABAM sites have far fewer decay-resistant western redcedar trees and logs.

	Down log attributes				
Log decomposition	Tons/ acre	Cu. ft./ acre	Linear ft./ acre	Sq. ft./ acre	% ground cover
Class 1	3.14	265	182	222	0.50
Class 2	4.30	724	605	534	1.20
Class 3	11.87	1,519	1,012	1,288	3.00
Class 4	5.00	1,604	1,487	1,585	3.60
Class 5	7.06	2,261	1,302	1,771	4.10
Total	31.37	6,373	4,588	5,400	12.40

Definitions of log decomposition classes are on page 15.

Snags—

Similarly, the ABAM series has more snags (53.5 snags per acre) than other forest series (app. C-4) except the ABLA2 series (54.3 snags per acre). It also has a greater number of snags in larger size classes (16.3 snags per acre larger than 15.5 inches diameter at breast height (d.b.h.) than other tree series. However, nearly 70 percent of snags are less than 15.5 inches in diameter, and nearly 60 percent are class 1 or 2. Most tree mortality is caused by overstory suppression or losses to insects and diseases in smaller diameter classes.

Definitions of snag condition classes are on page 15.

	Snags/acre by d.b.h. class (inches)				
Snag condition	5–9.9	10–15.5	15.6–21.5	21.6+	Total
Class 1	5.1	3.1	3.2	2.3	13.7
Class 2	9.2	4.4	2.0	1.0	16.6
Class 3	.7	5.0	1.2	.9	7.8
Class 4	1.0	4.3	1.0	1.5	7.8
Class 5	2.3	2.1	1.2	2.0	7.6
Total	18.3	18.9	8.6	7.7	53.5

Fire—

Fire in Pacific silver fir stands is infrequent owing to the relatively short summers, high humidity, and high precipitation associated with this zone (Houston and Scott 1992). Fire intervals are reported to be as long as 500 years. Pacific silver fir's distribution and dominance are directly dependent on long fire-return intervals because its thin bark and shallow roots are extremely fire sensitive. When they do occur, fires are extremely intense owing to the buildup of natural fuels. The intense fires replace the stands of Pacific silver fir.

A total of 179 site index trees were sampled for age data. These trees averaged 183 years in age at breast height. Four trees were at least 400 years old, 7 were 300 to 399 years old, 59 were 200 to 299 years old, and 66 were 100 to 199 years old. Sixty-three percent of the site index trees were found to be greater than 150 years old. These age data suggest that stand-replacing fire intervals in the ABAM series in riparian areas on the east side of the Cascade Range generally range from 150 to 400 years (Agee 1993).

Animals—

Livestock. There are few grazing allotments within the ABAM series in eastern Washington, and livestock grazing is not usually a problem. In general, these cold, wet sites have little utility for domestic livestock. Forage potential may be fair in early successional stages but becomes poor as stands mature. Because of the lack of suitable forage, these sites represent sources of water and shade. However, when grazed, trampling can damage the moist, fine-textured soils on these sites. As a result of limiting grazing and monitoring of wildlife, remnant shrub and herb populations will reoccupy the stand; however, the opportunity to quickly reestablish shrubs is lost when they are eliminated by overgrazing or when the water table is dramatically lowered by streambed downcutting. (For more information on forage palatability, see app. B-1. For potential biomass production, see app. B-5.)

Wildlife. Riparian zones in the ABAM series provide valuable habitat for a variety of wildlife species. Multiple shrub and tree layers associated with most stands provide considerable habitat diversity. In general, ABAM series sites offer cover, forage, and water. Late-seral and climax stand structures at many sites serve as important habitat for old-growth-dependent species. These more mature stands include old, large western hemlock and Pacific silver fir with extensive heart rot decay, which results in large trees, snags, and logs with hollow centers. In addition, many sites have abundant berry-producing shrubs, an important food source for many animals.

Large ungulates such as mule deer and elk forage in these sites during summer and fall. Elk do not usually browse on Pacific silver fir but are known to favor vine maple and devil's club as forage plants and also will eat deerfoot vanilla-leaf. ABAM sites also provide good habitat for mountain goats, as long as other critical habitat such as rocks and cliffs are nearby (Young 1989). Black bears forage in these sites during late summer and fall, especially on the abundant berry-producing shrubs. Grizzly bears, although rare, may select these sites for summer foraging and winter denning. Bears, squirrels, bats, and American marten will use hollow logs for dens and resting sites. Mammals that prefer old-growth stands include fisher and western red-backed vole. Squirrels and other rodents eat the seeds of Pacific silver fir and other conifers. Pacific silver fir stands provide little habitat for beavers.

Woodpeckers and Vaux's swift use hollow trees and snags for roosting. Woodpeckers forage them for ants. Mature stands are important habitat for the northern spotted owl and goshawks. Birds eat the seeds of Pacific silver fir and other conifers. (For more information on thermal or feeding cover values, see apps. B-2 and B-3. For information on food values or degree of use, see apps. B-2 and B-4.)

Fish. The ABAM series plays an important role in the maintenance of good fish habitat. The sites are very productive and provide ample amounts of large woody debris, primarily large-diameter logs that enhance stream structure. Most Pacific silver fir sites are located along A and B channels, which tend to be steeper in gradient. Thus, the contribution of large woody debris from ABAM stands helps maintain channel stability, particularly during peak flows. (For more information, see app. B-5, erosion control potential.) In addition, the large tree canopies provide shade for the stream and help regulate stream water temperatures. Maintaining healthy, vigorous stands of Pacific silver fir and associated series along riparian zones helps to stabilize streambanks and nearby terraces and swales, form barriers to sedimentation from nearby slopes, and provide large down wood for the stream and nearby fluvial surfaces.

Recreation—

Late-seral and old-growth stands of Pacific silver fir have high recreational value owing to the attractiveness of the big trees. Other than fishing opportunities in nearby streams, stands in the ABAM/TITRU, ABAM/ATFI, ABAM/GYDR, and ABAM/OPHO associations are not well suited for recreation owing to moist soils, high water tables, and seeps and springs. The prevalent loam soils are highly susceptible to compaction. The shrub layers of some associations, such as ABAM/ACCI, may be dense and tangled in open conifer stands and thus hard to access. The herbaceous vegetation in ABAM/ACCI is easily trampled if the shrub layer is opened. Construction and maintenance of campgrounds and trails is not recommended on wetter associations. If access is necessary, it may require boardwalks. Campsites can be constructed in associations such as ABAM/ACTR-WEN and ABAM/VAME/CLUN-WEN where they occur on well-drained terraces well away from flood zones. However, campground managers should be aware that these sites are prone to windthrow owing to seasonally wet soils, shallow rooting systems, and heart and root rot.

Insects and Disease—

The most common pathogens found on these sites are decay fungi (Henderson and Peter 1982). Annosus root disease is the most serious disease of the ABAM series, causing root, butt, and stem decay of Pacific silver fir and western hemlock. Armillaria root rot kills mostly suppressed and diseased trees. Laminated root rot also occurs in some stands. Other fungal diseases include yellow root rot, red ring rot, rust red stringy rot, and long pocket rot. Brown trunk rot and brown cubical rot are particular problems with Douglas-fir. Natural or human-caused wounds to trees often result in increased damage from decay fungi. Brown felt blight (snow mold) might occur on Pacific silver fir, especially at higher elevations. White pine blister rust may occur on western white pine.

Insect pests include the silver fir beetle, mountain pine beetle, spruce beetle, western spruce budworm, and fir engraver (Lillybridge et al. 1995). Of these, only the silver fir beetle and mountain pine beetle have the potential to reach epidemic populations in the ABAM series. The silver fir beetle can kill thousands of trees in areas with extensive, mature Pacific silver fir. The mountain pine beetle can cause extensive damage within limited areas dominated by lodgepole pine. The Douglas-fir tussock moth and western spruce budworm attack mainly Douglas-fir and grand fir.

Estimating Vegetation Potential on Disturbed Sites—

Because many ABAM stands are protected by wilderness status and all FS riparian zones are buffered, it is generally not necessary to estimate potential vegetation for this series. Conifers and the understory vegetation usually reestablished quickly on these sites where clearcut in the past. Additionally, many stands lie in wilderness areas and are separated from active flood zones by wetter associations belonging to the SALIX, MEADOW, and ALSI series. In young stands or in the event of recent wildfire, managers can look at nearby stands or in similar valley segments of nearby watersheds to help determine the potential natural vegetation.

Sensitive Species—

No sensitive species were found on ABAM series ecology plots. However, sensitive plants have been found in ABAM series environments on the Wenatchee NF and elsewhere in the Northwest (Lillybridge 1998). (See app. D.)

ADJACENT SERIES

The TSME series occurs on colder, harsher sites at higher elevations than the ABAM series. The TSHE series usually replaces ABAM on warmer and drier sites. Wetter sites in ALSI, SALIX, and MEADOW series often occur on more fluvially active surfaces and separate the ABAM series from the direct influence of streams except, perhaps, during very high floods.

RELATIONSHIPS TO OTHER CLASSIFICATIONS

This is the first riparian/wetland classification of the ABAM series in eastern Washington. Many of the riparian plant associations described in the ABAM series represent relatively wet stand conditions for Pacific silver fir plant associations previously described for uplands on the Wenatchee NF by Lillybridge et al. (1995). Only the ABAM/ATFI and ABAM/GYDR associations are newly classified. The ABAM/ATFI association represents a slightly warmer component of the ABAM/OPHO association described in Lillybridge et al. (1995). ABAM/GYDR represents a wetter component of several other associations described by Lillybridge et al. (1995). ABAM/VAME/CLUN-WEN is very similar to Lillybridge's ABAM/VAME/CLUN and ABAM/VAME-PYSE associations, but this study does not include sufficient plots to differentiate the two.

Plant associations belonging to the ABAM series have been described in the Cascade Range (Brockway et al. 1983, Franklin et al. 1988, Hemstrom et al. 1982, Hemstrom et al. 1987, Henderson et al. 1992, John et al. 1988, Williams and Lillybridge 1983). These are primarily upland classifications. Meidinger and Pojar (1991) described similar stands for British Columbia, although these are classified primarily in their "Mountain Hemlock Zone."

U.S. DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE WETLANDS CLASSIFICATION

System:	palustrine
Class:	forested wetland
Subclass:	needle-leaved evergreen
Water regime:	(nontidal) temporarily saturated to intermittently flooded

KEY TO THE PACIFIC SILVER FIR (*ABIES AMABILIS*) PLANT ASSOCIATIONS

1. Devil's club (*Oplopanax horridum*) ≥5 percent canopy cover .... **Pacific silver fir/devil's club (ABAM/OPHO) association**
2. Lady fern (*Athyrium filix-femina*) ≥5 percent canopy coverage .... **Pacific silver fir/lady fern (ABAM/ATFI) association**
3. Vine maple (*Acer circinatum*) ≥5 percent canopy coverage .... **Pacific silver fir/vine maple (ABAM/ACCI) association**
4. Oak fern (*Gymnocarpium dryopteris*) ≥5 percent canopy coverage .... **Pacific silver fir/oak fern (ABAM/GYDR) association**
5. Rusty menziesia (*Menziesia ferruginea)* ≥5 percent canopy coverage .... **Pacific silver fir/rusty menziesia-Wenatchee (ABAM/MEFE-WEN) association**
6. Cascade azalea (*Rhododendron albiflorum*) ≥5 percent canopy coverage, big huckleberry (*Vaccinium membranaceum*) usually present .... **Pacific silver fir/Cascade azalea-big huckleberry-Wenatchee (ABAM/RHAL-VAME-WEN) association**
7. Deerfoot vanilla-leaf (*Achlys triphylla*) ≥2 percent canopy coverage .... **Pacific silver fir/deerfoot vanilla-leaf–Wenatchee (ABAM/ACTR-WEN) association**
8. Coolwort foamflower (*Tiarella trifoliata* var. *unifoliata*), rosy twisted-stalk (*Streptopus roseus*) and/or false bugbane (*Trautvetteria caroliniensis*) ≥5 percent canopy coverage .... **Pacific silver fir/coolwort foamflower (ABAM/TITRU) association**
9. Big huckleberry (*Vaccinium membranaceum*) ≥5 percent canopy coverage .... **Pacific silver fir/big huckleberry/queencup beadlily-Wenatchee (ABAM/VAME/CLUN-WEN) association**

Table 2—Constancy and mean cover of important plant species in the ABAM plant associations

Species	Code	ABAM/ ACCI 2 plots		ABAM/ ACTR-WEN 6 plots		ABAM/ ATFI 7 plots		ABAM/ GYDR 9 plots		ABAM/ MEFE-WEN 8 plots		ABAM/ OPHO 15 plots		ABAM/RHAL-VAME-WEN 4 plots		ABAM/ TITRU 6 plots		ABAM/VAME/ CLUN-WEN 5 plots	
		CON[a]	COV[b]	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV
Tree overstory:																			
Pacific silver fir	ABAM	100	10	100	25	100	31	78	26	100	26	100	30	100	37	100	22	100	32
grand fir	ABGR	50	10	—	—	14	10	22	4	—	—	—	—	—	—	—	—	—	—
subalpine fir	ABLA2	50	10	50	23	29	7	33	20	25	3	—	—	25	8	67	13	40	23
Alaska yellow-cedar	CHNO	—	—	33	11	14	15	44	10	25	20	—	—	25	10	17	35	60	13
Engelmann spruce	PIEN	50	15	50	8	57	24	78	15	25	5	13	4	50	18	83	23	80	16
western white pine	PIMO	50	10	17	3	14	1	44	5	13	2	—	—	25	5	33	3	—	—
Douglas-fir	PSME	100	10	33	13	14	3	33	10	25	6	27	15	—	—	17	5	—	—
western redcedar	THPL	100	13	50	12	29	18	67	9	50	11	53	14	—	—	17	25	—	—
western hemlock	TSHE	100	18	67	17	43	13	100	15	88	29	93	25	—	—	33	11	40	23
mountain hemlock	TSME	—	—	—	—	14	Tr[c]	—	—	13	8	13	3	75	1	17	5	40	8
Tree understory:																			
Pacific silver fir	ABAM	50	5	100	12	100	6	89	13	100	12	100	9	100	16	100	17	100	13
grand fir	ABGR	50	6	—	—	14	1	—	—	—	—	—	—	—	—	—	—	—	—
subalpine fir	ABLA2	—	—	50	5	57	2	11	1	13	1	—	—	25	1	67	6	40	3
Alaska yellow-cedar	CHNO	—	—	50	12	14	5	56	6	25	12	—	—	25	Tr	17	5	60	4
Engelmann spruce	PIEN	50	2	17	1	14	1	11	1	—	—	7	1	25	1	67	4	40	1
western redcedar	THPL	100	6	33	5	14	1	44	4	38	3	53	2	—	—	17	8	—	—
western hemlock	TSHE	50	10	67	9	43	3	100	7	75	3	73	7	—	—	50	1	20	3
mountain hemlock	TSME	—	—	—	—	43	2	11	5	13	1	7	2	50	4	—	—	40	4
Shrubs:																			
vine maple	ACCI	100	55	—	—	14	2	—	—	—	—	27	11	—	—	—	—	—	—
Sitka alder	ALSI	—	—	17	2	29	10	11	2	13	20	20	7	25	10	17	8	—	—
California hazel	COCO	50	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
rusty menziesia	MEFE	—	—	17	1	43	6	44	5	100	19	47	7	—	—	33	1	20	2
devil's club	OPHO	—	—	17	1	43	1	56	2	—	—	100	34	—	—	17	1	—	—
Cascade azalea	RHAL	—	—	33	2	29	3	22	5	38	16	—	—	100	26	17	1	20	2
Hudsonbay currant	RIHU	—	—	—	—	29	4	22	Tr	—	—	13	8	—	—	—	—	—	—
prickly currant	RILA	—	—	50	3	57	2	67	2	—	—	33	1	—	—	50	7	60	2
western currant	RILA2	—	—	—	—	—	—	11	5	—	—	7	10	—	—	—	—	—	—
baldhip rose	ROGY	50	10	67	2	29	1	22	3	25	1	27	1	—	—	—	—	—	—
western thimbleberry	RUPA	50	1	50	5	29	3	44	1	—	—	60	5	—	—	17	4	—	—
salmonberry	RUSP	—	—	33	4	57	5	33	10	63	2	60	7	—	—	—	—	20	1
Alaska huckleberry	VAAL	—	—	67	5	—	—	22	4	38	9	53	4	25	5	—	—	40	3
big huckleberry	VAME	50	2	100	16	86	23	89	4	88	12	67	5	100	16	83	18	100	19
oval-leaf huckleberry	VAOV	—	—	—	—	14	Tr	33	17	—	—	—	—	—	—	—	—	—	—
Low shrubs and subshrubs:																			
Cascade hollygrape	BENE	50	35	17	6	—	—	11	3	25	3	—	—	—	—	17	1	—	—
western prince's-pine	CHUMO	50	10	—	—	—	—	33	2	50	1	—	—	—	—	17	2	—	—
bunchberry dogwood	COCA	50	20	83	14	29	1	67	10	38	10	20	26	—	—	17	2	—	—
Labrador tea	LEGL	—	—	17	30	—	—	22	19	—	—	—	—	—	—	—	—	—	—
twinflower	LIBOL	50	35	67	7	14	Tr	78	4	63	8	40	3	—	—	—	—	20	Tr
dwarf bramble	RULA	—	—	67	3	57	5	78	7	75	1	67	4	50	5	50	13	60	Tr
five-leaved bramble	RUPE	—	—	33	3	57	4	33	8	50	2	33	7	25	7	17	3	40	4
low huckleberry	VAMY	—	—	—	—	—	—	33	1	13	15	20	1	—	—	17	4	—	—
grouse huckleberry	VASC	—	—	17	5	—	—	22	2	13	2	—	—	—	—	—	—	40	3

Table 2—Constancy and mean cover of important plant species in the ABAM plant associations (continued)

		ABAM/ ACCI 2 plots		ABAM/ ACTR-WEN 6 plots		ABAM/ ATFI 7 plots		ABAM/ GYDR 9 plots		ABAM/ MEFE-WEN 8 plots		ABAM/ OPHO 15 plots		ABAM/RHAL-VAME-WEN 4 plots		ABAM/ TITRU 6 plots		ABAM/VAME/ CLUN-WEN 5 plots	
Species	Code	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV
Perennial forbs:																			
deerfoot vanilla-leaf	ACTR	50	10	100	15	43	22	56	16	38	3	27	16	—	—	—	—	—	—
baneberry	ACRU	50	Tr	17	2	57	1	56	1	—	—	67	1	—	—	—	—	—	—
pathfinder	ADBI	100	1	—	—	14	2	22	3	—	—	40	3	—	—	—	—	—	—
Oregon anemone	ANOR	—	—	17	Tr	14	Tr	33	1	—	—	7	5	—	—	—	—	—	—
sharptooth angelica	ANAR	—	—	17	Tr	43	Tr	33	Tr	—	—	—	—	25	1	—	—	60	Tr
mountain arnica	ARLA	—	—	17	18	29	4	11	1	13	Tr	7	Tr	50	4	83	6	20	2
wild ginger	ASCA3	50	5	—	—	14	1	11	4	—	—	53	5	—	—	—	—	—	—
alpine leafybract aster	ASFO	—	—	—	—	—	—	—	—	—	—	—	—	—	—	17	5	—	—
queencup beadlily	CLUN	100	6	83	4	57	9	78	4	100	4	100	9	50	3	33	7	40	Tr
Hooker fairy-bells	DIHO	50	Tr	17	Tr	14	3	11	Tr	—	—	40	2	—	—	—	—	—	—
sweetscented bedstraw	GATR	—	—	17	Tr	43	2	56	1	—	—	73	2	—	—	17	3	—	—
western rattlesnake plantain	GOOB	50	2	33	2	43	1	33	2	38	1	20	2	—	—	17	2	20	Tr
bigleaf lupine	LUPO	—	—	17	3	—	—	—	—	—	—	—	—	—	—	17	5	—	—
fivestamen miterwort	MIPE	—	—	—	—	29	Tr	11	Tr	—	—	—	—	25	Tr	50	4	40	Tr
three-parted mitewort	MITR2	—	—	—	—	—	—	11	6	—	—	—	—	—	—	17	1	—	—
broadleaved montia	MOCO	—	—	17	Tr	14	2	—	—	13	1	—	—	—	—	50	2	20	Tr
purple sweet-root	OSPU	—	—	—	—	43	Tr	22	Tr	—	—	—	—	25	1	50	1	20	Tr
sidebells pyrola	PYSE	50	2	83	2	71	2	89	1	88	2	60	3	100	1	67	2	100	1
western solomonplume	SMRA	50	Tr	—	—	57	3	22	2	—	—	27	2	—	—	33	2	—	—
starry solomonplume	SMST	50	7	50	1	29	5	67	3	25	3	60	6	—	—	33	1	—	—
rosy twisted-stalk	STRO	—	—	50	2	71	3	44	3	25	2	60	6	50	1	17	2	60	Tr
western meadowrue	THOC	—	—	17	1	29	1	11	Tr	—	—	20	1	—	—	50	1	—	—
coolwort foamflower	TITRU	50	2	83	3	86	9	78	3	50	2	93	11	50	7	83	7	—	—
false bugbane	TRCA3	—	—	50	4	14	1	44	4	—	—	7	5	—	—	33	23	—	—
broadleaf starflower	TRLA2	—	—	—	—	14	Tr	22	2	13	1	20	5	—	—	—	—	—	—
white trillium	TROV	50	Tr	50	2	57	1	56	2	38	1	80	2	—	—	50	1	40	Tr
Sitka valerian	VASI	—	—	17	3	71	1	67	3	25	1	20	3	50	5	67	13	80	Tr
pioneer violet	VIGL	50	Tr	17	Tr	86	1	56	1	—	—	73	3	—	—	83	3	40	Tr
round-leaved violet	VIOR2	—	—	17	4	—	—	89	1	25	4	27	4	—	—	33	2	—	—
Ferns and fern allies:																			
lady fern	ATFI	50	3	33	4	100	11	44	1	—	—	93	6	—	—	33	1	—	—
common horsetail	EQAR	50	15	33	2	29	1	11	Tr	13	1	—	—	—	—	—	—	40	Tr
oak fern	GYDR	50	3	—	—	86	11	100	12	25	1	100	14	25	4	33	2	—	—
sword fern	POMU	50	Tr	—	—	14	1	33	1	13	Tr	—	—	—	—	—	—	—	—

[a] CON = percentage of plots in which the species occurred.
[b] COV = average canopy cover in plots in which the species occurred.
[c] Tr = trace cover, less than 1 percent canopy cover.

WESTERN HEMLOCK SERIES

Tsuga heterophylla

TSHE N = 117

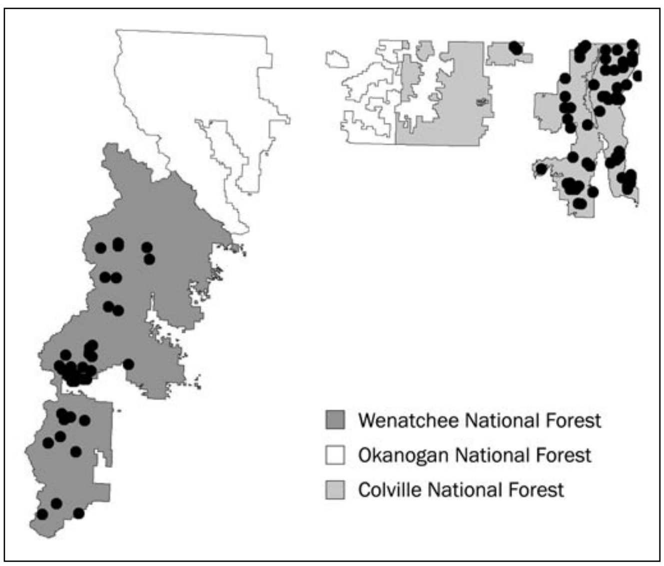


Figure 9—Plot locations for the western hemlock series.

THE DISTRIBUTION OF western hemlock[1] is similar to that of western redcedar, with disjunct coastal and interior populations (Williams et al. 1995). The interior distribution, which includes portions of the Colville NF, is closely correlated with the inland maritime climatic regime and extends from southeastern British Columbia to northeastern Washington, northern Idaho, and northwestern Montana (Hitchcock and Cronquist 1973, Parish et al. 1996). The coastal distribution, which includes portions of the Wenatchee and Okanogan NFs, extends from Alaska's Kenai Peninsula south into the coast ranges of northern California inland along the east side of the Cascade Range in Oregon and Washington. Within this range, western hemlock occurs on a variety of sites, including wetland, riparian, and upland sites.

Western hemlock is one of the most shade-tolerant and environmentally restricted conifers on the Colville, Wenatchee, and Okanogan NFs. The shade tolerance of western hemlock is outranked only by those of Pacific silver fir and mountain hemlock (Lillybridge et al. 1995). Like Pacific silver fir, mountain hemlock, and western redcedar, western hemlock develops in areas influenced by Pacific maritime and inland maritime climatic patterns. Average annual precipitation for the TSHE series is more than 25 inches, with highest averages along the Cascade crest and moderately high precipitation in northeastern Washington. Temperatures are moderate; summer drought is less severe than in areas of continental climate.

Therefore, the TSHE series occurs only on that part of the species' range beyond the environmental or geographic limits of the ABAM and TSME series, which prefer cooler, stronger maritime environments (Lillybridge et al. 1995). Riparian and wetland sites for the TSHE series are generally higher and presumably cooler, although not necessarily moister, than THPL series sites. The TSHE series occupies cooler maritime and inland maritime sites, whereas the THPL and ABGR series occupy slightly warmer and drier habitats (Williams et al. 1995). Under these restrictions, the TSHE series is limited to (but abundant in) the eastern half of the Colville NF (Williams et al. 1995), 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 on the Colville Indian Reservation (Clausnitzer and Zamora 1987). The best development of the TSHE series on the Wenatchee and Okanogan NFs is in areas within strong maritime climate but where Pacific silver fir and mountain hemlock are absent (Lillybridge et al. 1995). The TSHE series is most abundant south of the Entiat River on the west side of the Wenatchee NF (CleElum, Naches, Leavenworth, and Lake Wenatchee RDs). The TSHE series also is found in the western extremes of the Entiat and Lake Chelan RDs (Wenatchee NF). On the Okanogan NF, western hemlock sites are limited to areas west of Washington Pass near the North Cascades National Park.

CLASSIFICATION DATABASE

The TSHE series includes all closed-forest stands potentially dominated by western hemlock at climax. The series is found on all three NFs and to some extent on all but the Twisp and Republic RDs, where it is extremely rare. Fifty-five riparian and wetland plots were sampled on the

[1] See appendix A for a cross reference for all species codes and common and scientific names used in this document.

Western hemlock plant associations

	Scientific name	Common name	Ecoclass code	Plots
Major associations:				
TSHE/ACCI	*Tsuga heterophylla/Acer circinatum*	Western hemlock/vine maple	CHS226	19
TSHE/ACTR-WEN	*Tsuga heterophylla/Achlys triphylla*-Wenatchee	Western hemlock/deerfoot vanilla-leaf–Wenatchee	CHF223	14
TSHE/ARNU3	*Tsuga heterophylla/Aralia nudicaulis*	Western hemlock/wild sarsaparilla	CHF312	6
TSHE/ATFI	*Tsuga heterophylla/Athyrium filix-femina*	Western hemlock/lady fern	CHF421	15
TSHE/CLUN	*Tsuga heterophylla/Clintonia uniflora*	Western hemlock/queencup beadlily	CHF311	6
TSHE/GYDR	*Tsuga heterophylla/Gymnocarpium dryopteris*	Western hemlock/oak fern	CHF422	24
TSHE/OPHO	*Tsuga heterophylla/Oplopanax horridum*	Western hemlock/devil's club	CHS513	29
Minor associations:				
TSHE/ASCA3	*Tsuga heterophylla/Asarum caudatum*	Western hemlock/wild ginger	CHF313	2
TSHE/LYAM	*Tsuga heterophylla/Lysichiton americanus*	Western hemlock/skunk cabbage	CHM122	2

Colville and Wenatchee NFs (fig. 9). Data were added from an additional 62 plots from previous ecology sampling (Lillybridge et al. 1995, Williams et al. 1995) to help develop the classification, as well as to provide more data for species composition, distribution, and elevation. From this database, seven major and two minor plant associations are recognized. TSHE/ACCI, TSHE/ASCA3, TSHE/ACTR-WEN, and TSHE/LYAM associations are restricted to the Cascade Range. With the exception of a few plots, the TSHE/ARNU3, TSHE/ATFI, TSHE/CLUN, and TSHE/GYDR associations are restricted to northeastern Washington. The TSHE/OPHO association is found throughout the study area. The information presented for this series primarily represents mature stands in late-seral to climax conditions.

VEGETATION CHARACTERISTICS

Mature TSHE series stands are normally dominated by western hemlock and long-lived western redcedar, although a variety of other tree species may be present depending on plant association, past disturbance, and time since disturbance (Williams et al. 1995). Scattered large grand fir, Douglas-fir, western larch, and Engelmann spruce may be present. In the Cascade Range, mountain hemlock and Pacific silver fir, if present, are restricted to microsites or are clearly reproducing less successfully than western hemlock (Lillybridge et al. 1995). The understory of mature stands is also usually dominated by both western redcedar and western hemlock, with a few grand fir and Engelmann spruce. Stands usually are too shady to support Douglas-fir regeneration. Seral stands vary by association and stand history but usually include grand fir, Douglas-fir, and Engelmann spruce. Ponderosa pine occurs on warmer, drier sites, although it is very uncommon. Western larch may dominate stands that originated after stand replacement fire. Some dense, doghair western hemlock/western redcedar stands originated after the stand-replacement fires of the early 1900s.

The TSHE series exhibits high species diversity owing to its inherent site variability. One cause of community variety is that moister associations usually contain one set of plants, whereas drier ones have another. Primary indicator shrub species are vine maple and devil's club. Herbs characterize all other associations. Other medium and tall shrub species include Douglas maple, Utah honeysuckle, common snowberry, baldhip rose, big huckleberry, and western thimbleberry on mesic sites; and mountain alder, Sitka alder, and prickly currant on wetter sites. Low shrubs include Oregon and Cascade hollygrape, western prince's-pine, twinflower, myrtle pachistima, five-leaved bramble, and Pacific blackberry.

The herb composition is also rich and varied. Indicator herbs include deerfoot vanilla-leaf, wild sarsaparilla, wild ginger, lady fern, queencup beadlily, oak fern, and skunk cabbage. Other herbs include pathfinder, western rattlesnake plantain, sweetscented bedstraw, white trillium, sidebells pyrola, and starry solomonplume on mesic sites; and baneberry, claspleaf twisted-stalk, and coolwort foamflower on wet sites.

PHYSICAL SETTING

Elevation—

The TSHE series spans a moderate to moderately high range of elevations. Most plots are located between 2,500 and 4,500 feet. The average elevation for the plots on the Colville NF is about 850 feet higher than the Wenatchee NF. At the same elevations, Cascade Range sites receive higher precipitation compared with the Selkirk Mountains on the Colville NF. Therefore, in the Cascade Range, the ABAM and TSME series occupy mid to upper elevation sites, which (in the absence of TSME and ABAM) support TSHE on the Colville NF. For example, the TSHE/OPHO association averages about 2,700 feet in elevation on the Wenatchee NF but averages 3,350 feet on the Colville. The TSHE/CLUN and TSHE/GYDR associations also occur at lower levels on the Wenatchee NF compared with the Colville NF.

	Elevation (feet)			
Forest	Minimum	Maximum	Average	N
Colville	2,270	5,200	3,696	68
Wenatchee	2,080	4,720	2,854	49
Series	2,080	5,200	3,343	117

Additional insight is gained by looking at elevation distributions by plant association. The TSHE/ATFI, TSHE/GYDR, and TSHE/LYAM associations occur at higher elevations on average, although individual plot elevations overlap with plots in associations at lower elevations. TSHE/ARNU3, TSHE/ASCA3, and TSHE/ACCI are the lowest elevation associations.

	Elevation (feet)			
Plant association	Minimum	Maximum	Average	N
TSHE/ATFI	3,260	5,200	4,233	15
TSHE/GYDR	2,640	5,025	3,901	24
TSHE/LYAM	2,925	4,720	3,822	2
TSHE/CLUN	2,600	5,150	3,338	6
TSHE/ACTR-WEN	2,340	4,000	3,299	14
TSHE/OPHO	2,080	4,250	3,120	29
TSHE/ARNU3	2,270	3,150	2,817	6
TSHE/ASCA3	2,390	3,100	2,745	2
TSHE/ACCI	2,080	3,190	2,490	19
Series	2,080	5,200	3,343	117

Valley Geomorphology—

Plots in the TSHE series are located in a variety of valley width and gradient classes. Sixty-six percent of the plots occur in valleys of moderate, narrow, and very narrow width (less than 330 feet). Valley gradient is more variable, with most plots occurring in the low, moderate, and very steep classes (1 to more than 8 percent).

	Valley gradient					
Valley width	Very low	Low	Moderate	Steep	Very steep	N
Very broad	0	3	0	0	0	3
Broad	1	4	1	1	0	7
Moderate	0	3	3	3	0	9
Narrow	0	5	8	3	10	26
Very narrow	0	0	1	0	9	10
Series total	1	15	13	7	19	55

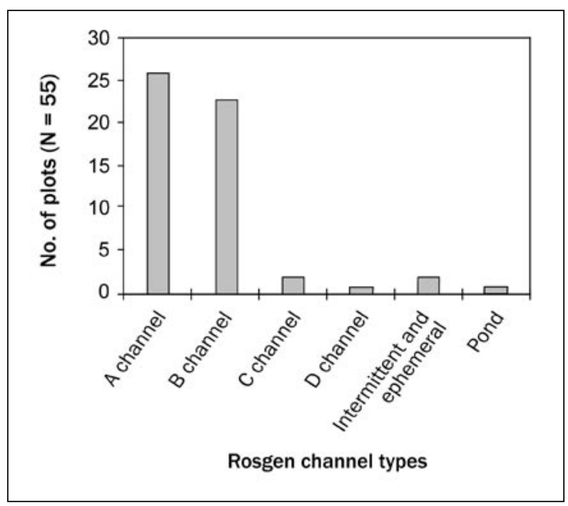
Little additional insight is gained by looking at the distribution of valley width and gradient classes according to associations. The trend follows that almost all associations are most common in moderate to very narrow width classes; and low, moderate, and very steep gradient classes. The TSHE/ATFI and TSHE/OPHO associations appear to favor narrower valleys but also occur over a wide range of valley gradients. The TSHE/GYDR association favors broad to narrow valley widths, but again, no particular valley gradient class. Other associations also occur in several valley configurations, but their sample size is too small for definitive conclusions. For the TSHE series, valley configuration seems less important for vegetation diversity than soil moisture and climate.

	Valley width					
Plant association	Very broad	Broad	Moderate	Narrow	Very narrow	N
TSHE/ACCI	0	1	0	3	0	4
TSHE/ACTR-WEN	0	1	1	1	0	3
TSHE/ARNU3	0	1	0	2	0	3
TSHE/ATFI	0	1	1	5	4	11
TSHE/CLUN	1	0	1	0	1	3
TSHE/GYDR	0	2	3	4	0	9
TSHE/OPHO	1	1	3	11	5	21
Series total	3	7	9	26	10	54

	Valley gradient					
Plant association	Very low	Low	Moderate	Steep	Very steep	N
TSHE/ACCI	0	1	0	2	1	4
TSHE/ACTR-WEN	0	1	2	0	0	3
TSHE/ARNU3	1	1	1	0	0	3
TSHE/ATFI	0	2	3	1	5	11
TSHE/CLUN	0	1	1	0	1	3
TSHE/GYDR	0	3	2	1	3	9
TSHE/OPHO	0	5	4	3	9	21
Series total	1	14	13	7	19	54

Channel Types—

The TSHE series plots are located along a variety of channel types. Given the lack of broad to very broad valley widths and very low valley gradient; primarily straight, well-entrenched Rosgen A and B channel types predominate (89 percent). Few plots are located along very low gradient C channels, intermittent streams, ephemeral draws, or lakes and ponds. E channels were not sampled.

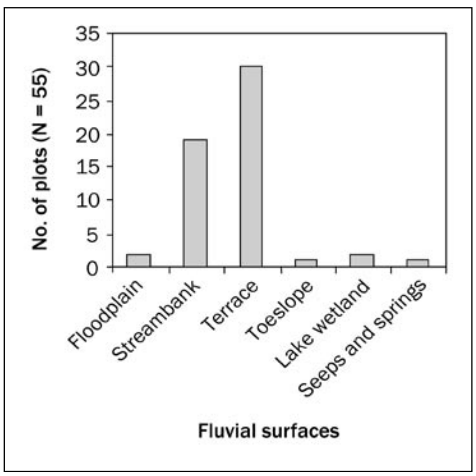


Little additional insight is gained by looking at the distribution of channel types by plant associations. All associations other than TSHE/ARNU3 show a preference for A or B channels. The TSHE/ARNU3 association is the only association found along intermittent streams, ephemeral draws, or the dry margins of a pond wetland. However, this association is also common on well-drained sites along A and B channels.

Plant association	Rosgen channel types A	B	C	D	Intermittent and ephemeral	Pond	N
TSHE/ACCI	1	3	0	0	0	0	4
TSHE/ACTR-WEN	0	2	1	0	0	0	3
TSHE/ARNU3	0	0	0	0	2	1	3
TSHE/ATFI	8	3	0	0	0	0	11
TSHE/CLUN	2	1	0	0	0	0	3
TSHE/GYDR	4	4	1	0	0	0	9
TSHE/LYAM	0	1	0	0	0	0	1
TSHE/OPHO	11	9	0	1	0	0	21
Series total	26	23	2	1	2	1	55

Fluvial Surfaces—

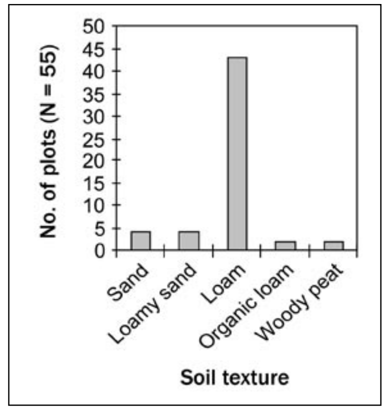
Most TSHE series plots (89 percent) are located in riparian zones on well-drained streambanks and terraces. Smaller percentages are found on wet floodplains, the dry margins of wetlands, or near seeps and springs (11 percent).



The same pattern holds for individual plant associations. No single association shows a preference for fluvial surfaces other than streambanks or terraces.

Plant association	Fluvial surfaces Flood-plain	Stream-bank	Terrace	Toe-slope	Lake wetland	Seeps/springs	N
TSHE/ACCI	0	1	3	0	0	0	4
TSHE/ACTR-WEN	0	0	3	0	0	0	3
TSHE/ARNU3	0	1	1	0	1	0	3
TSHE/ATFI	0	6	5	0	0	0	11
TSHE/CLUN	0	1	2	0	0	0	3
TSHE/GYDR	0	2	5	1	1	0	9
TSHE/LYAM	0	0	1	0	0	0	1
TSHE/OPHO	2	8	10	0	0	1	21
Series total	2	19	30	1	2	1	55

Soils—



The TSHE series plots are dominated by mineral soils with loam textures (78 percent). Sand and loamy sand textures are uncommon and presumably occur on more active fluvial surfaces such as streambanks and floodplains. In most plots the soil surface is covered with a thick layer of duff and logs.

Like the TSHE series, most individual plant associations grow on loam soil. Two soils in the wettest associations (TSHE/LYAM and TSHE/ATFI) were classified as organic loams. The two wood peat soils in TSHE/OPHO probably represent crew error where they placed the soil auger on a log with condition class 5. Loam soil likely occurred beneath the log.

Plant association	Soil texture Sand	Loamy sand	Loam	Organic loam	Woody peat	N
TSHE/ACCI	1	0	3	0	0	4
TSHE/ACTR-WEN	0	0	3	0	0	3
TSHE/ARNU3	0	0	3	0	0	3
TSHE/ATFI	0	1	9	1	0	11
TSHE/CLUN	0	0	3	0	0	3
TSHE/GYDR	1	3	5	0	0	9
TSHE/LYAM	0	0	0	1	0	1
TSHE/OPHO	2	0	17	0	2	21
Series total	4	4	43	2	2	55

Water table depth at the time of sampling could only be measured on two associations: TSHE/OPHO and TSHE/ATFI. Measurements for TSHE/LYAM are not available, but it is easily as wet as TSHE/OPHO and TSHE/ATFI. The remaining associations are generally restricted to well-drained streambanks and terraces with water tables that were not often reached with a soil auger.

Plant association	Water table (inches) Minimum	Maximum	Average	N
TSHE/OPHO	-35	-2	-15	15
TSHE/ATFI	-28	-5	-16	9
Series	-75	-3	-22	49

The TSHE/OPHO and TSHE/ATFI series also are the only sites that had surface water present at the time of sampling and they, along with TSHE/LYAM, are probably partially flooded at spring runoff. Data are limited and no table is shown. Soil temperature data are available for 52 plots. With some exceptions, higher elevation associations such as

TSHE/ATFI and TSHE/GYDR had cold soil temperatures, whereas low-elevation associations (TSHE/ACCI) had warm soil temperatures.

	Soil temperature (°F)			
Plant association	Minimum	Maximum	Average	N
TSHE/ACCI	50	62	56	4
TSHE/ACTR-WEN	46	52	49	3
TSHE/CLUN	42	56	48	3
TSHE/OPHO	36	62	47	19
TSHE/ARNU3	43	50	46	3
TSHE/ATFI	31	47	42	10
TSHE/GYDR	34	49	41	9
Series	31	62	46	52

ECOSYSTEM MANAGEMENT

Natural Regeneration of Western Hemlock—

Western hemlock reproduces from seed and vegetatively (Owens and Molder 1984, Packee 1990, Ruth 1974). Trees in open-grown stands can begin producing seeds at 20 years, but good cone crops do not usually occur until stands are 25 to 35 years old. Some cones are produced every year, but good crops occur every 3 or 4 years. Seeds are small and light, with large wings. They generally fall within 2,000 feet of the parent tree; however, strong winds can carry them as far as 4,000 feet, and in denser stands they fall much closer to the base of the parent. Western hemlock seeds require 3 to 4 weeks of cold stratification to improve germination. Seed remains viable only through the first growing season after it falls. Germination can occur on a variety of soils, including undisturbed duff and litter, rotten wood, or bare mineral soil (Williamson 1976). Most seedling mortality occurs in the first 2 years. Seedlings are shade tolerant but grow best in partial shade. However, germination may fail on heavily shaded sites owing to slow root penetration in drying duff. Western hemlock seedlings also are sensitive to heat, drought, frost, and wind (Owens and Molder 1984). Seedlings grow slowly; at 2 years a seedling may be only 8 inches tall. Once established, those in full sunlight may average 24 inches height growth annually. Suppressed seedlings and saplings release well following removal of competing overstory and understory vegetation.

Western hemlock can occasionally reproduce vegetatively by layering of live branches or rooting of broken branches (Packee 1990). Seedlings that die back to the soil surface may sprout from buds near the root collar.

Artificial Establishment of Western Hemlock—

Western hemlock is a valued timber species that is strong, even grained, and uniform in color. It is widely used for lumber, doors, windows, flooring, stairways, and molding (Parish et al. 1996). Although widely planted, it is difficult to grow in outdoor nurseries (Klinka et al. 1984) so natural regeneration is preferred over planting stock. Artificial regeneration is suitable on sites ranging from mineral soils to well-decomposed organic material. Nursery-grown container stock appears to perform better than bare rootstock. Direct seeding is possible where bare mineral soil is available. Western hemlock also grafts readily, and the growth of grafted material is often better than that of rooted material. When using selection-cutting methods in riparian zones, it is probably better to rely on natural seeding.

Many of the shrubs that characterize the TSHE series are well adapted to planting on disturbed sites. Red-osier dogwood, vine maple, Sitka alder, mountain alder, myrtle pachistima, and devil's club can be established from nursery stock or seed. Layering or cuttings can establish red-osier dogwood and vine maple. Prickly currant, western thimbleberry, salmonberry, dwarf bramble, five-leaved bramble, and Pacific blackberry can be easily grown from seed. These and other trailing plants can be easily propagated from root runners. Although growth is slow, huckleberries can be established from seed. Common snowberry can be established from stem or root cuttings, nursery stock, or seed. Oak fern, lady fern, and horsetail species can be easily propagated from rhizomes. (For more information on the short- and long-term revegetation potential of selected riparian wetland plant species, see app. B-5.)

Stand Management—

Western hemlock forests are among the most productive forests in the world, especially on the Pacific coast. The TSHE series supports a variety of seral tree species, including western redcedar, grand fir, Engelmann spruce, western larch, and Douglas-fir. Ponderosa pine does not perform well on TSHE sites. Except for western redcedar and Engelmann spruce, regeneration of these tree species will be difficult in the wettest sites owing to high water and competition from a rich variety of shrubs and herbs. Heavy browsing of western redcedar regeneration by snowshoe hares is a potential problem. Despite its high growth and yield, the TSHE series is vulnerable to a variety of perturbations, and management activities must be carefully planned.

The TSHE sites can be regenerated by using various harvest methods (Weetman and Vyse 1990). Overstory removal will favor seral species such as Douglas-fir and western larch. A common problem after overstory removal is overtopping vegetation, especially by shrubs such as vine maple, Sitka alder, and Scouler's willow, which tend to form dense thickets and exclude conifer regeneration. Shelterwood and single-tree cutting will reduce shrub competition, as well as favor shade-tolerant conifers such as western hemlock and western redcedar. Management options in riparian zones appear to be limited to single-tree selection or small-group selection with the objective of opening the canopy to increase understory production for other resources. Scheduling management activity during late summer and early fall or during winter on snowpack will minimize soil disturbance. High water tables and the presence of seeps and springs on wetter sites such as TSHE/ATFI and TSHE/OPHO preclude many timber management activities. Other associations also have seasonably high water tables. Many larger trees have extensive heart rot, and trees on wetter sites are often susceptible to blowdown. Timber harvest upslope of these or adjacent sites may raise water tables and increase the risks of blowdown. A clearcut within or adjacent to riparian zones could result in blowdown in the riparian zone.

Western hemlock, western redcedar, Engelmann spruce, and grand fir may require down logs or root wads to establish in mature stands, especially on wetter sites. Coarse, compaction-resistant soils are unusual in these sites, except on frequently flooded floodplains and streambanks. Loam soils predominate, with sensitive organic soils only in the wetter associations (TSHE/ATFI and TSHE/OPHO). Machinery and livestock easily compact or otherwise damage these soils, especially when water tables are high (Hansen et al. 1995). Roads and trails generally should be located on the adjacent upland. Poorly drained sites, streamside locations, or sites with organic soils warrant special concern.

Tree Growth and Yield—

The TSHE series is one of the most productive forested series in eastern Washington, as indicated by high basal area and site index values. Perhaps this is because of its moderate to moderately high elevations, cool temperatures, and high moisture levels (Williams et al. 1995). Another factor helping explain high productivity is the variability and the number of tree species on TSHE sites. Large, old-growth trees characterize some of the wetter associations, such as TSHE/ATFI, TSHE/LYAM, and TSHE/OPHO. Basal area averaged 263 square feet per acre (apps. C-1a and C-1b). Only the ABAM, PSME, and THPL series were higher. Similarly, average site index for individual species (feet) is high compared with other series (app. C-2). Note that tree productivity data are limited and should be used with caution.

Site index			
Species	Base age	No. of trees	SI
ABGR	50	32	77
ABLA2	50	14	65
CHNO	100	2	58
LAOC	50	37	75
PICO	100	3	109
PIEN	50	31	71
PIMO	50	6	69
PIPO	100	4	129
PSME	50	41	82
THPL	100	81	76
TSHE	50	45	60

Basal area (sq. ft./ac)	
Species	BA
ABAM	1
ABGR	25
ABLA2	6
BEPA	Tr
CHNO	Tr
LAOC	14
PICO	3
PIEN	19
PIMO	6
PIPO	Tr
POTR2	1
PSME	23
THPL	103
TSME	62
Total	263

Down Wood—

The overall amount of down woody material is generally high for forest series (app. C-3). Logs cover 13 percent of the ground surface, a measure second only to the THPL series. This reflects the cool, moist (to wet) environment of TSHE series sites, which tends to support large-diameter trees and logs.

Definitions of log decomposition classes are on page 15.

	Down log attributes				
Log decomposition	Tons/ acre	Cu. ft./ acre	Linear ft./ acre	Sq. ft./ acre	% ground cover
Class 1	2.33	213	456	304	0.7
Class 2	3.53	374	659	498	1.14
Class 3	15.22	1,931	3,473	1,803	4.14
Class 4	5.86	1,606	1,639	1,592	3.65
Class 5	5.54	1,776	1,352	1,584	3.64
Total	32.48	5,900	7,579	5,781	13.27

Snags—

The TSHE series supports a moderate number of snags (27.5 per acre) compared with other forest series (app. C-4). The POTR2 series is the only forest series with fewer snags (8.1 per acre). This is surprising, as the TSHE series is in other ways (site index, basal area, and logs) one of the most productive series. Possible explanations are (1) conditions for decomposition are ideal, and (2) high heart rot causes rapid snag fall. Approximately 74 percent of the snags were in the 5- to 15-inch diameter range, distributed fairly well through all condition classes.

Definitions of snag condition classes are on page 15.

	Snags/acre by d.b.h. class (inches)				
Snag condition	5–9.9	10–15.5	15.6–21.5	21.6+	Total
Class 1	5.5	1.9	1.1	0.4	8.9
Class 2	0	1.2	.3	1.0	2.5
Class 3	1.1	3.8	1.3	.2	6.4
Class 4	2.9	1.9	1.2	.1	6.1
Class 5	1.8	.2	1.0	.6	3.6
Total	11.3	9.0	4.9	2.3	27.5

Fire—

Fire-return intervals are infrequent, as all but the most severe wildfires do not take hold on the TSHE series' cool, moist sites (Davis et al. 1980, Ruth 1976). Fire frequencies are reported to be as long as 150 to 400 years in the Pacific Northwest (Parminter 1983). Intervals tend to be longer in riparian and wetland zones compared with adjacent uplands.

Western hemlock's thin bark, shallow roots, highly flammable foliage, and low branching habit make it vulnerable to fire (Davis et al. 1980, Parminter 1983). Lichen-covered branches further increase this susceptibility. Even light ground fires are damaging because of scorching of its shallow roots (Packee 1990). Additional mortality can be caused by fungal infection of fire wounds (Fischer and Bradley 1987). Although old stands support heavy fuel loads, much of this material is moist, deep duff, and rotting wood. Because this organic material does not burn easily, these sites may act as firebreaks. Fires in older stands tend to be slow moving and to do little damage (although western hemlock appears to be more vulnerable than western redcedar). Once ignited, however, such fuels could support long-lasting fires, especially during severe drought.

Three hundred sixty-six trees were measured for age in the TSHE series. They averaged 188 years old at breast height. One hundred and nine trees were less than 100 years old, 170 were 100 to 199, 54 were 200 to 299, 7 were 400 to 499, and 2 trees were 500 to 599 years old. Over half of the site index trees were over 100 years old, and nearly 17 percent were over 200 years old. Most stands appear to be between 75 and 250 years old based on site index trees. This seems to suggest that stand-replacing fire-return intervals in eastern Washington generally range from 100 to 250 years. Stands in the wetter TSHE/OPHO, TSHE/ATFI, and TSHE/GYDR associations contain older trees, and nearly all site index trees older than 200 years were located in these three associations. Fire-return intervals in wet associations may be greater than 200 years, whereas drier associations are probably characterized by shorter fire-return intervals of 100 to 200 years. Furthermore, most trees in the TSHE series over 200 years old were located on the Colville NF. This suggests that fire-free intervals in western hemlock sites in the inland maritime area are longer than on the east slope of the Cascade Range.

The fire regime of surrounding upland stands also affects how often riparian sites burn. In eastern Washington, riparian zones in the TSHE series are surrounded by drier Douglas-fir or grand fir uplands on southerly slopes, which historically burned more frequently during the late summer fire season. The ABLA2 associations on upper slopes of all aspects usually bound TSHE series sites in the vicinity of the Selkirk Mountains. Many of these burned in the early 1900s, and it is reasonable to presume that many adjacent western hemlock uplands and bottoms also burned during these intense fires. Such TSHE sites may reflect shorter fire-return intervals compared with riparian zones adjacent to moister western redcedar/western hemlock uplands. It is thought, therefore, that those vast, early 1900s fires influence present stand ages in the TSHE series.

Animals—

Livestock. In general, these cool, moist to wet sites have little forage for domestic livestock, except in early successional stages when forage production may be high (in the absence of shrubs). With forage potential generally poor, sites in mid- to late-successional stages primarily present sources of water and shade. Regeneration of conifers has been poor in some cattle grazing allotments that were clearcut (generally, the 1990s saw a moratorium on clearcutting). Where water tables are high and soils moist or wet, sites are vulnerable to trampling. In addition, where grazing is particularly heavy, shrub and herb composition may be altered over the years, with a trend toward dominance by increaser and invader species such as Kentucky bluegrass and white clover.

Because forage is poor for livestock, grazing is not usually a problem. However, the ability to easily reestablish desired shrubs and herbs may be lost when they have been eliminated owing to the combination of clearcutting, fire, or overgrazing, and if the water table has been lowered because of stream downcutting (rare on eastern Washington NFs) or lateral erosion. If sites have not been grazed too heavily, modification of the grazing system and close monitoring of wildlife often allow the remnant shrub and herb population to sprout and reestablish in the stand. (For more information on forage palatability, see app. B-1, and for potential biomass production, see app. B-5.)

Wildlife. The mosaic of riparian and wetland associations within and adjacent to the TSHE series provides valuable habitat for a variety of wildlife species. In general, these sites offer sources of cover, forage, and water. Late-seral stand structures on many sites serve as important habitat for old-growth-dependent species. These stands include older western hemlock and western redcedar trees with extensive heart rot, resulting in large trees, snags, and logs with hollow interiors. During summer and fall, large ungulates such as mule deer, white-tailed deer, and elk will forage in these sites on the rich variety of shrubs and herbs. They may browse western hemlock (Packee 1990). Elk are known to favor devil's club as forage. In the Selkirk Mountains, caribou forage in lower elevation western hemlock stands during summer and move into mature, high-elevation western hemlock and subalpine fir stands in winter and early spring to feed on lichens. Bears will use hollow logs for dens and rest sites. Black bears and grizzly bears are known to forage in these sites (Layser 1978). Various small mammals such as bats, flying squirrels, red tree voles, red squirrels, and American marten will use hollow trees, snags, and logs for feeding, dens, or rest sites (Anthony et al. 1987, Thomas 1979). Squirrels and chipmunks cache western hemlock and other conifer cones for winter feeding. Beaver are important only where stands are located along lower gradient channels. They may occasionally use conifer limbs for nearby dam construction, and they have been observed eating western redcedar and grand fir bark, probably as a food of last resort.

Various woodpeckers, yellow-bellied sapsuckers, and Vaux's swifts use hollow trees and snags on these sites for nesting, feeding, and roosting (McClelland 1980). Woodpeckers forage for ants. The northern spotted owl can be found in forest dominated by large western hemlock on the Wenatchee NF and near Ross Lake. These stands also serve as important habitat for barred owls and goshawks

(Allen 1987). (For more information on thermal or feeding cover values, see apps. B-2 and B-3. For information on food values or degree of use, see apps. B-2 and B-4.)

Fish. The TSHE series play important roles in maintaining good fisheries habitat. The high tree productivity associated with most of these sites provides ample amounts of large woody debris, primarily large-diameter logs, which provide good fish habitat (structure) in streams. Most TSHE sites are located along high-energy Rosgen A and B channels, and the contribution of large woody debris helps maintain channel and streambank stability, particularly during peak flows. (For more information, see app. B-5, erosion control potential.) In addition, the tree canopy provides shade for the streams, helping regulate water temperatures. If managers maintain healthy, vigorous stands of TSHE and associated series along streams, these buffer strips help stabilize streambanks, form a barrier to sedimentation from nearby slopes, and provide large down wood for the stream and nearby fluvial surfaces.

Recreation—

Old-growth stands of western hemlock and western redcedar are valued for their big trees and general attractiveness (Hansen et al. 1995). Despite this, many are not well suited for recreation owing to high water tables or seeps and springs. Loamy textures and low gravel content, and organic soils in some cases, make most sites highly susceptible to foot or vehicle compaction, especially when soil moisture is high. Wetter sites may require wood boardwalks to prevent trampling of vegetation and soils. Construction and maintenance of campgrounds, roads, and trails is not recommended except on well-drained terraces. TSHE sites also are prone to windthrow of western redcedar, western hemlock, grand fir, and Engelmann spruce owing to shallow rooting systems, wet soils, and root rot infestations.

Insects and Disease—

The most common pathogens found on TSHE sites are decay fungi. Large trees with root, butt, and trunk rot are common. Hessburg et al. (1994) noted four diseases as primary influences in both historical and current forests: laminated root rot, armillaria root rot, annosus root disease, and brown cubical rot. Laminated root rot was especially common in early- and mid-seral stands dominated by Douglas-fir and grand fir, where trees of all ages were killed. Western hemlock shows little effect until maturity, when butt defects develop. Dwarf mistletoe can be a major cause of mortality in western larch, particularly where western larch is a major component of the stand.

Potential problems with insects usually are minimal on TSHE sites, but they do exist. Western hemlock hosts a variety of insect pests, such as the Steremnius weevil, western larch borer, western black-headed budworm, western hemlock looper, green striped forest looper, saddleback looper, and hemlock sawfly (Packee 1990). The western hemlock looper, a potential defoliator, has caused more mortality of western hemlock than any other insect pest. Drier sites supporting Douglas-fir may be prone to attack by budworm and Douglas-fir beetle.

Estimating Vegetation Potential on Disturbed Sites—

Estimating vegetation potential on disturbed sites is generally not needed as these sites are seldom disturbed. Wetter associations in the SALIX, COST, ALSI, and ALIN series often isolate TSHE stands from active flood zones and associated disturbance. Past clearcutting in riparian areas has been unusual on FS lands in eastern Washington. Even when clearcut, western redcedar, western hemlock, grand fir, Douglas-fir, Engelmann spruce, and other conifers often rapidly regenerated on these productive sites. Riparian zones on NF lands are currently protected from management-created disturbances by buffers and not managed for timber. Estimation to help determine the potential in young stands can be gauged by comparison with similar valley segments in nearby drainages.

Sensitive Species—

Black snake-root was found on two TSHE/ASCA3 association plots on the Colville NF. No other sensitive species were found on TSHE series plots, although *Botrychium* species have been found on the dense duff below mature western hemlock/western redcedar stands. (For more information, see app. D.)

ADJACENT SERIES

The ABAM and TSME adjoin the TSHE series at higher elevations (colder, wetter sites) on the Wenatchee and Okanogan NFs, and ABLA2 series adjoins it on the Colville NF. The TSHE, ABGR, or PSME series usually adjoin it on warmer sites at lower elevations. The ALIN, ALSI, and SALIX series often separate the TSHE series from the nearby stream.

RELATIONSHIPS TO OTHER CLASSIFICATIONS

Kovalchik (1992c) described many of the riparian/wetland plant associations in the TSHE series in the draft classification for northeast Washington. Riparian plant associations described in the TSHE series represent relatively wet stand conditions for western hemlock plant associations previously described for uplands on the Wenatchee NF by Lillybridge et al. (1995) and the Colville NF by Williams et al. (1995). They focused on upland environments but included several plant associations located primarily in riparian and wetland zones. Some of the associations in this classification derived from Lillybridge et al. (1995) and Williams et al. (1995)

include: TSHE/ACTR-WEN, TSHE/ARNU3, TSHE/CLUN, and TSHE/GYDR. The TSHE/ACCI association represents parts of the Wenatchee NF's TSHE/ACCI/CLUN, TSHE/ACCI/ACTR, and TSHE/ACCI/ASCA3 associations. The TSHE/ATFI and TSHE/OPHO associations are both included within THPL/OPHO in the forest classifications by Lillybridge et al. (1995) and Williams et al. (1995). The TSHE/OPHO and THPL/OPHO series were separately classified in this document to discriminate between sites dominated at climax by both western redcedar and western hemlock and those supporting just western redcedar. The TSHE/ATFI series is very similar to the THPL/ATFI habitat type described by Cooper et al. (1991) for northern Idaho.

The TSHE series has been described in the Washington Cascade Range (Diaz and Mellen 1996, Henderson et al. 1989, Henderson et al. 1992, Lillybridge et al. 1995, and Topik et al. 1986); in northeastern Washington, northern Idaho, and Montana (Cooper et al. 1991, Daubenmire and Daubenmire 1968, Hansen et al. 1988, Hansen et al. 1995, Pfister et al. 1977, and Williams et al. 1995); and in British Columbia (Braumandl and Curran 1992, Lloyd et al. 1990, and Meidinger and Pojar 1991).

U.S. DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE WETLANDS CLASSIFICATION

System:	palustrine
Class:	forested wetland
Subclass:	needle-leaved evergreen
Water regime:	(nontidal) intermittently saturated to intermittently flooded

KEY TO THE WESTERN HEMLOCK *(TSUGA HETEROPHYLLA)* PLANT ASSOCIATIONS

1. Skunk cabbage (*Lysichiton americanus*) ≥5 percent canopy coverage .... **Western hemlock/skunk cabbage (TSHE/LYAM) association**
2. Devil's club (*Oplopanax horridum*) ≥5 percent canopy coverage .... **Western hemlock/devil's club (TSHE/OPHO) association**
3. Lady fern (*Athyrium filix-femina)* ≥5 percent canopy coverage .... **Western hemlock/lady fern (TSHE/ATFI) association**
4. Oak fern (*Gymnocarpium dryopteris)* and/or five-leaved bramble (*Rubus pedatus*) ≥5 percent canopy coverage; sites located east of the Okanogan River .... **Western hemlock/oak fern (TSHE/GYDR) association**
5. Vine maple (*Acer circinatum*) ≥5 percent canopy coverage .... **Western hemlock/vine maple (TSHE/ACCI) association**
6. Wild ginger (*Asarum caudatum*) and lady fern (*Athyrium filix-femina*) ≥1 percent canopy coverage; site located west of the Okanogan River .... **Western hemlock/wild ginger (TSHE/ASCA3) association**
7. Deerfoot vanilla-leaf (*Achlys triphylla*) ≥2 percent canopy coverage .... **Western hemlock/deerfoot vanilla-leaf (TSHE/ACTR) association**
8. Wild sarsaparilla (*Aralia nudicaulis*) and/or wild ginger (*Asarum caudatum*) ≥2 percent canopy coverage; site located east of the Okanogan River .... **Western hemlock/wild sarsaparilla (TSHE/ARNU3) association**
9. Queencup beadlily (*Clintonia uniflora*), myrtle pachistima (*Pachistima myrsinites*) and/or round-leaved violet (*Viola orbiculata*) ≥1 percent canopy coverage .... **Western hemlock/queencup beadlily (TSHE/CLUN) association**

Table 3—Constancy and mean cover of important plant species in the TSHE plant associations

		TSHE/ACCI 19 plots		TSHE/ACTR-WEN 14 plots		TSHE/ARNU3 6 plots		TSHE/ASCA3 2 plots		TSHE/ATFI 15 plots		TSHE/CLUN 6 plots		TSHE/GYDR 24 plots		TSHE/LYAM 2 plots		TSHE/OPHO 29 plots	
Species	Code	CON[a]	COV[b]	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV
Tree overstory:																			
Pacific silver fir	ABAM	—	—	—	—	—	—	50	5	7	1	—	—	—	—	50	3	—	—
grand fir	ABGR	63	19	79	21	67	24	50	10	33	16	50	22	50	12	—	—	62	10
subalpine fir	ABLA2	11	10	—	—	33	4	—	—	40	6	50	9	29	4	50	3	21	2
western larch	LAOC	21	11	50	8	17	25	—	—	13	2	33	23	25	11	50	2	7	5
Engelmann spruce	PIEN	11	1	36	14	33	1	—	—	73	10	33	9	54	11	100	17	24	9
lodgepole pine	PICO	16	8	21	6	17	1	—	—	—	—	17	5	4	30	—	—	7	2
western white pine	PIMO	37	5	43	5	17	20	—	—	13	5	83	2	33	3	50	2	10	2
Douglas-fir	PSME	89	19	93	21	33	13	50	35	13	4	67	8	25	8	—	—	45	9
western redcedar	THPL	74	21	71	18	100	38	100	43	87	28	83	24	92	32	100	21	93	32
western hemlock	TSHE	84	21	86	17	100	13	100	18	100	28	100	24	100	29	100	23	100	25
Tree understory:																			
Pacific silver fir	ABAM	16	1	21	2	—	—	50	3	—	—	—	—	—	—	50	1	7	1
grand fir	ABGR	68	6	86	7	83	4	50	1	33	2	50	4	50	4	50	Tr[c]	41	1
subalpine fir	ABLA2	16	4	14	8	—	—	—	—	40	1	33	3	17	3	100	2	10	1
Engelmann spruce	PIEN	16	2	21	5	—	—	—	—	33	2	—	—	25	2	50	Tr	14	Tr
western redcedar	THPL	89	4	71	8	100	12	50	1	87	4	83	14	88	7	100	6	83	6
western hemlock	TSHE	79	5	93	4	83	7	50	6	93	9	100	9	100	5	100	4	93	5
Shrubs:																			
vine maple	ACCI	100	23	21	1	—	—	50	2	—	—	—	—	—	—	—	—	28	18
Douglas maple	ACGLD	16	4	—	—	67	7	—	—	13	2	67	3	25	2	—	—	28	1
mountain alder	ALIN	—	—	—	—	17	3	—	—	7	5	17	Tr	4	1	50	6	17	3
Sitka alder	ALSI	5	1	7	10	—	—	—	—	27	9	17	4	4	3	—	—	7	1
red-osier dogwood	COST	16	13	7	Tr	33	2	—	—	20	1	—	—	4	2	—	—	24	2
Utah honeysuckle	LOUT	—	—	—	—	50	1	—	—	53	2	83	2	63	2	—	—	31	Tr
rusty menziesia	MEFE	—	—	7	1	—	—	50	1	40	6	—	—	33	6	50	7	10	1
devil's club	OPHO	16	2	—	—	33	1	100	1	13	2	17	Tr	25	1	50	Tr	100	15
Cascade azalea	RHAL	—	—	—	—	—	—	—	—	20	7	17	Tr	13	4	50	Tr	—	—
prickly currant	RILA	11	4	43	2	33	2	—	—	47	2	33	2	33	2	50	6	66	1
baldhip rose	ROGY	74	3	93	4	83	2	—	—	13	3	67	3	21	2	50	2	31	1
western thimbleberry	RUPA	42	2	50	1	83	2	—	—	60	3	83	2	42	4	50	1	41	1
salmonberry	RUSP	21	1	7	2	—	—	—	—	—	—	—	—	—	—	50	2	21	2
common snowberry	SYAL	—	—	36	2	67	2	—	—	7	Tr	17	4	13	1	—	—	14	2
big huckleberry	VAME	53	3	93	2	50	2	50	2	87	5	67	2	67	4	100	1	55	1
Low shrubs and subshrubs:																			
Oregon hollygrape	BEAQ	—	—	14	4	50	2	—	—	—	—	50	2	—	—	—	—	7	Tr
Cascade hollygrape	BENE	79	6	79	11	—	—	100	2	7	4	17	3	—	—	100	1	21	2
little prince's-pine	CHME	32	2	21	1	—	—	50	1	—	—	17	2	4	1	—	—	10	2
western prince's-pine	CHUMO	63	3	71	2	50	2	50	1	20	1	67	3	4	Tr	100	2	24	1
bunchberry dogwood	COCA	37	12	21	4	83	2	50	1	13	2	33	2	8	11	—	—	17	1
slender wintergreen	GAOV	37	1	29	3	—	—	100	2	—	—	17	Tr	—	—	100	3	3	5
twinflower	LIBOL	68	12	86	7	100	6	100	6	47	4	83	8	75	5	100	4	59	1
myrtle pachistima	PAMY	68	7	86	4	33	3	100	3	53	1	83	2	50	2	50	2	48	1
dwarf bramble	RULA	21	3	36	1	—	—	50	10	—	—	—	—	—	—	50	4	10	1
five-leaved bramble	RUPE	—	—	—	—	—	—	—	—	60	7	—	—	38	7	—	—	17	Tr
Pacific blackberry	RUUR	63	3	43	3	—	—	—	—	—	—	—	—	—	—	—	—	10	2

Table 3—Constancy and mean cover of important plant species in the TSHE plant associations (continued)

		TSHE/ACCI 19 plots		TSHE/ACTR-WEN 14 plots		TSHE/ARNU3 6 plots		TSHE/ASCA3 2 plots		TSHE/ATFI 15 plots		TSHE/CLUN 6 plots		TSHE/GYDR 24 plots		TSHE/LYAM 2 plots		TSHE/OPHO 29 plots	
Species	Code	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV
Perennial forbs:																			
deerfoot vanilla-leaf	ACTR	63	8	100	22	—	—	—	—	7	45	—	—	—	—	—	—	14	6
baneberry	ACRU	11	1	21	1	50	1	—	—	40	1	50	Tr	25	1	100	1	55	1
pathfinder	ADBI	37	1	64	2	50	2	—	—	40	2	50	1	42	3	—	—	52	1
wild sarsaparilla	ARNU3	—	—	—	—	83	18	—	—	—	—	—	—	13	2	—	—	14	1
heartleaf arnica	ARCO	—	—	29	2	17	1	—	—	—	—	—	—	4	1	50	7	3	Tr
wild ginger	ASCA3	26	2	14	1	67	3	100	2	13	Tr	—	—	38	5	—	—	69	4
queencup beadlily	CLUN	74	5	79	6	83	3	50	3	100	2	83	3	92	5	50	Tr	93	3
Hooker's fairy-bells	DIHO	21	1	7	1	50	1	—	—	33	3	33	Tr	50	2	—	—	48	1
sweetscented bedstraw	GATR	32	1	21	2	83	2	—	—	67	1	67	Tr	67	1	50	Tr	83	1
western rattlesnake plantain	GOOB	84	2	86	2	33	2	50	2	33	2	83	1	58	2	—	—	45	1
skunk cabbage	LYAM	5	3	—	—	17	Tr	—	—	—	—	—	—	4	1	100	13	14	1
arctic butterbur	PEFR2	5	2	—	—	—	—	—	—	—	—	—	—	—	—	50	25	—	—
pink wintergreen	PYAS	42	2	29	1	33	2	50	1	20	4	—	—	17	3	50	1	28	1
sidebells pyrola	PYSE	47	1	79	2	—	—	50	2	33	3	67	2	42	2	50	2	34	1
arrowleaf groundsel	SETR	—	—	14	2	—	—	—	—	47	1	17	Tr	25	1	50	Tr	31	1
starry solomonplume	SMST	58	2	50	2	83	4	100	1	60	2	50	3	63	4	100	2	62	3
claspleaf twisted-stalk	STAM	11	Tr	7	6	33	Tr	—	—	87	1	33	1	58	2	50	Tr	76	1
rosy twisted-stalk	STRO	16	2	7	Tr	—	—	—	—	13	2	17	Tr	4	1	50	Tr	7	1
coolwort foamflower	TITRU	32	2	57	2	83	4	50	6	100	5	67	2	96	5	100	3	97	3
false bugbane	TRCA3	5	2	21	1	—	—	—	—	27	1	—	—	21	2	50	Tr	14	3
broadleaf starflower	TRLA2	53	4	21	4	—	—	—	—	—	—	—	—	—	—	—	—	7	8
white trillium	TROV	84	2	93	2	83	1	50	2	67	1	33	1	75	1	100	1	72	1
Sitka valerian	VASI	—	—	7	1	—	—	50	2	—	—	—	—	—	—	50	30	—	—
pioneer violet	VIGL	16	1	36	1	—	—	50	1	33	2	—	—	25	2	—	—	34	2
round-leaved violet	VIOR2	21	2	21	3	50	2	50	5	33	4	50	4	71	3	—	—	17	1
Grasses or grasslike:																			
brome species	BROMU	5	1	14	1	33	2	—	—	27	2	17	2	4	5	—	—	3	Tr
soft-leaved sedge	CADI	—	—	—	—	—	—	—	—	13	Tr	—	—	—	—	50	3	—	—
tall mannagrass	GLEL	—	—	—	—	—	—	—	—	—	—	—	—	—	—	50	1	7	1
Ferns and fern allies:																			
lady fern	ATFI	11	2	14	2	33	3	50	2	100	13	33	Tr	79	2	100	18	90	7
oak fern	GYDR	26	1	7	1	17	2	—	—	100	11	—	—	100	14	—	—	79	6
sword fern	POMU	21	1	7	5	17	1	—	—	13	Tr	17	Tr	17	1	—	—	34	1
western brackenfern	PTAQ	68	2	29	3	17	Tr	—	—	—	—	17	Tr	4	1	50	2	14	1

[a] CON = percentage of plots in which the species occurred.
[b] COV = average canopy cover in plots in which the species occurred.
[c] Tr = trace cover, less than 1 percent canopy cover.

WESTERN REDCEDAR SERIES

Thuja plicata

THPL N = 89

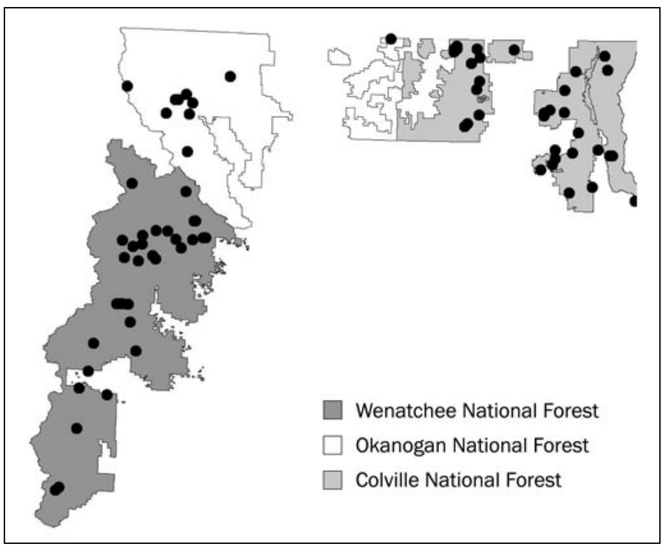


Figure 10—Plot locations for the western redcedar series.

WESTERN REDCEDAR[1] is a long-lived conifer that can reach 800 to 1,000 years in age (Williams et al. 1995). The species has two separate coastal and interior distributions. The coastal distribution occurs along the Pacific coast from the Alaska Panhandle south through British Columbia, western Washington, western Oregon, and the redwood forests of California. Inland areas extend in a continuous band along the east side of the Cascade Range from southern British Columbia to northern central Oregon (Arno and Hammerly 1984, Minore 1990). A disjunct population occurs much farther inland along the west slopes of the Rocky Mountains from Prince George, British Columbia, to northeast Washington, northern Idaho, and western Montana. Within this range, western redcedar occurs on a variety of sites, including wetland, riparian, and upland sites.

Western redcedar ranks second only to western hemlock as the most shade-tolerant conifer on the Colville NF (Williams et al. 1995). The shade tolerance of western redcedar is outranked by mountain hemlock, Pacific silver fir, and western hemlock on the Wenatchee NF (Lillybridge et al. 1995). Like mountain hemlock, Pacific silver fir, and western hemlock, the distribution of western redcedar is dependent on maritime and inland maritime climatic patterns. Average annual precipitation at western redcedar sites is generally greater than 25 inches per year.

Therefore, the THPL series (where redcedar is the indicated climax dominant) occurs only on that part of the species' range that is beyond the environmental or geographic range of mountain hemlock, Pacific silver fir, and western hemlock. Only minor amounts of mountain hemlock, Pacific silver fir, and western hemlock are acceptable in the THPL series. On the Colville NF, western redcedar tolerates warmer temperatures and both wetter and drier conditions compared with sites dominated by western hemlock (Minore 1979). The THPL series can be said to occupy sites that are marginal or beyond the environmental or geographic range of the TSHE series (Williams et al. 1995). The THPL series also has a bimodal moisture distribution on the Colville NF. At one end it characterizes sites too dry to support the TSHE series but which are somewhat moister than the ABGR series. Root penetration of western redcedar is better than that of western hemlock, perhaps allowing it to survive in somewhat warmer, drier locations (Burns and Honkala 1990). The THPL series also tolerates moderately wet sites where western hemlock is usually, but not always, a climax codominant. The upland forest classification for the Colville NF (Williams et al. 1995) follows Daubenmire and Daubenmire (1968) and Pfister et al. (1977) in assigning these wet habitats to the THPL/OPHO association, which is part of the THPL series. However, this study added additional plots to the database and elected to distinguish between sites clearly successional to western redcedar climax versus those successional to western hemlock (with western redcedar as a co-climax species). Thus associations such as THPL/OPHO (Williams et al. 1995) have been split into both THPL/OPHO and TSHE/OPHO associations based on the authors' interpretation of climax overstory potential.

The requirements for the THPL series are somewhat different on the Wenatchee and Okanogan NFs. Western redcedar is one of the most shade-tolerant yet environmentally restricted conifers on these NFs. Few plots attributable to western redcedar climax were available in the previous classifications for upland forests (Lillybridge et al. 1995); thus that guide collapsed the few plots dominated by western

[1] See appendix A for a cross reference for all species codes and common and scientific names used in this document.

Western redcedar plant associations

	Scientific name	Common name	Ecoclass code	Plots
Major associations:				
THPL/ACCI	*Thuja plicata/Acer circinatum*	Western redcedar/vine maple	CCS511	6
THPL/ARNU3	*Thuja plicata/Aralia nudicaulis*	Western redcedar/wild sarsaparilla	CCF222	14
THPL/ATFI	*Thuja plicata/Athyrium filix-femina*	Western redcedar/lady fern	CCF121	13
THPL/GYDR	*Thuja plicata/Gymnocarpium dryopteris*	Western redcedar/oak fern	CCF224	13
THPL/OPHO	*Thuja plicata/Oplopanax horridum*	Western redcedar/devil's club	CCS211	17
THPL/PAMY/CLUN	*Thuja plicata/Pachistima myrsinites/ Clintonia uniflora*	Western redcedar/myrtle pachistima/ queencup beadlily	CCS312	11
Minor associations:				
THPL/ACTR	*Thuja plicata/Achlys triphylla*	Western redcedar/deerfoot vanilla-leaf	CCF212	2
THPL/ALIN	*Thuja plicata/Alnus incana*	Western redcedar/mountain alder	CCS411	3
THPL/ASCA3	*Thuja plicata/Asarum caudatum*	Western redcedar/wild ginger	CCF223	3
THPL/CLUN	*Thuja plicata/Clintonia uniflora*	Western redcedar/queencup beadlily	CCF221	2
THPL/EQUIS	*Thuja plicata/Equisetum* species	Western redcedar/horsetail species	CCM411	3
THPL/VAME	*Thuja plicata/Vaccinium membranacium*	Western redcedar/big huckleberry	CCS311	2

redcedar into its closest relative, the TSHE series. However, additional data indicate the THPL series clearly exists and should be separately recognized for riparian and wetland zones on the Okanogan and Wenatchee NFs. The best development of the THPL series is in areas of maritime climate where Pacific silver fir, mountain hemlock, and western hemlock are poorly represented or absent. Here, just as on the Colville NF, the THPL series usually lies in an environmental position intermediate between the TSHE and ABGR series. The TSME and ABAM series prefer much stronger maritime environments. In addition, western hemlock, Pacific silver fir, and mountain hemlock are largely absent in the extensive continental climate zones found north of the Entiat River and east of the Cascade crest (to the Kettle Mountain crest). Within this zone, scattered stands belonging to the THPL series are found on a limited number of riparian sites, usually within uplands dominated by the PSME and ABLA2 series.

CLASSIFICATION DATABASE

The THPL series includes all closed-forest stands potentially dominated by western redcedar at climax. The THPL series was sampled on all three NFs and all RDs in eastern Washington (fig. 10). Sixty-four riparian and wetland plots were sampled in the THPL series. Data from an additional 25 plots from previous ecology sampling were included to increase the data set for the THPL series, help facilitate classification, and provide additional information for species composition, distribution, and elevation. From this database, six major and six minor plant associations are recognized. The THPL/ACCI, THPL/ASCA3, THPL/ACTR, and THPL/PAMY/CLUN associations are limited to the Cascade Range, whereas the THPL/CLUN and THPL/ARNU3 associations are only found well east of the Okanogan River. The remaining associations are found throughout the study area. Two potential one-plot associations (THPL/COST and THPL/MEFE) are not used in the data nor described in this classification. However, the THPL/MEFE association is described in the upland forest classification for the Colville NF (Williams et al. 1995). For the most part, the samples used in the THPL series represent mature stands in late-seral to climax conditions.

VEGETATION CHARACTERISTICS

The THPL series exhibits high species diversity owing to its inherent site amplitude. Mature stands are dominated by large, long-lived western redcedar. More shade-tolerant trees such as mountain hemlock, Pacific silver fir, or western hemlock are absent or accidental and, if present, are clearly reproducing less successfully than western redcedar. Grand fir, Douglas-fir, western larch, and Engelmann spruce may be present as scattered large individuals in old stands. The understory of mature stands is usually dominated by western redcedar, with lesser amounts of grand fir, Douglas-fir, and Engelmann spruce. The composition of seral stands varies by association and stand history (especially fire history) but usually includes grand fir, Douglas-fir, and Engelmann spruce. Ponderosa pine, although unusual, may be seral on warmer sites, whereas western larch often dominates stands originating after stand-replacement fire. Also, dog hair western redcedar stands originated after the fires of the early 1900s.

Shrubs are common. Their composition and abundance vary by association. The primary indicator species are vine maple, mountain alder, devil's club, myrtle pachistima, and big huckleberry. Other common shrubs include Saskatoon serviceberry, common snowberry, twinflower, Douglas maple, baldhip rose, and western thimbleberry on moist sites; Sitka alder and prickly currant on wetter sites.

Indicator herbs include deerfoot vanilla-leaf, wild sarsaparilla, wild ginger, lady fern, oak-fern, horsetails (especially common horsetail), and queencup beadlily. Other herbs include sweetscented bedstraw, sidebells pyrola, and starry solomonplume on moist sites; baneberry, claspleaf twistedstalk, and coolwort foamflower on wetter sites.

PHYSICAL SETTING

Elevation—

The THPL series occurs at moderately low to moderate elevations in eastern Washington. Elevation differences between NFs are insignificant and range from 1,760 to 4,650 feet (2,845 feet average), although the majority of riparian sites are below 3,000 feet. This contrasts with the TSHE series, where the majority of samples are above 3,000 feet. Thus, riparian sites in the THPL series are generally lower in elevation and presumably warmer, although not necessarily drier, than sites in the TSHE series. As mentioned before, the THPL series is associated with moderate maritime or inland maritime climates. Precipitation is moderately high, temperatures are moderate, and summer drought is less severe compared with areas of continental climate.

	Elevation (feet)			
Forest	Minimum	Maximum	Average	N
Colville	2,200	4,650	2,880	40
Okanogan	1,850	4,360	2,991	15
Wenatchee	1,760	4,120	2,740	34
Series	1,760	4,650	2,845	89

The major exceptions to the 3,000-foot rule are the THPL/ACTR, THPL/ATFI, THPL/GYDR, and THPL/VAME associations.

	Elevation (feet)			
Plant association	Minimum	Maximum	Average	N
THPL/VAME	3,630	4,360	3,995	2
THPL/GYDR	2,320	4,050	3,176	13
THPL/ACTR	2,200	4,140	3,170	2
THPL/ATFI	2,300	4,650	3,061	13
THPL/PAMY/CLUN	2,020	3,400	2,844	11
THPL/ASCA3	2,200	3,400	2,793	3
THPL/OPHO	1,850	3,630	2,775	17
THPL/EQUIS	2,550	2,950	2,767	3
THPL/ARNU3	2,200	3,300	2,592	14
THPL/ACCI	1,960	3,130	2,582	6
THPL/CLUN	2,240	2,500	2,370	2
THPL/ALIN	1,760	2,280	2,060	3
Series	1,760	4,650	2,859	89

Valley Geomorphology—

Plots in the THPL series are located in a variety of valley width and valley gradient classes. The most common valley landforms are broad to narrow valleys with low to moderate valley gradient. Still, no patterns are clear for the THPL series as a whole.

	Valley gradient					
Valley width	Very low	Low	Moderate	Steep	Very steep	N
Very broad	3	3	0	0	0	6
Broad	2	9	1	0	0	12
Moderate	1	9	5	5	3	23
Narrow	0	4	6	2	3	15
Very narrow	0	0	0	2	6	8
Series total	6	25	12	9	12	64

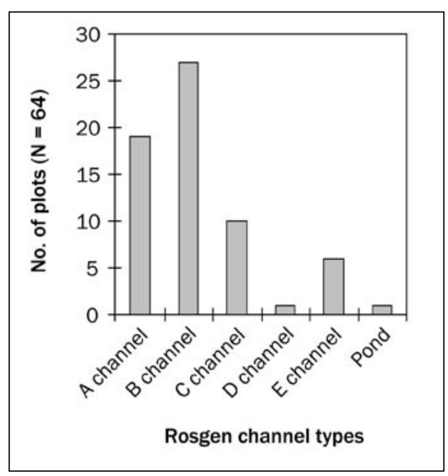
Looking at valley configuration by individual associations is not very helpful. The THPL/ACCI, THPL/ALIN, and THPL/EQUIS associations appear to favor relatively wide and gentle valleys. However, three plots per association is not a satisfactory sample size for making these conclusions. The other associations have more plots but still occur on a variety of valley landforms. Apparently valley configuration is less important than site location, climate, or hydrology.

	Valley width					
Plant association	Very broad	Broad	Moderate	Narrow	Very narrow	N
THPL/ACCI	2	0	1	0	0	3
THPL/ACTR	0	0	1	0	0	1
THPL/ALIN	1	1	0	1	0	3
THPL/ARNU3	1	1	3	1	0	6
THPL/ATFI	0	3	3	1	3	10
THPL/CLUN	0	0	1	0	1	2
THPL/EQUIS	0	2	0	1	0	3
THPL/GYDR	1	2	5	2	2	12
THPL/OPHO	1	2	5	5	0	13
THPL/PAMY/CLUN	0	0	4	4	2	10
THPL/VAME	0	1	0	0	0	1
Series total	6	12	23	15	8	64

	Valley gradient					
Plant association	Very low	Low	Moderate	Steep	Very steep	N
THPL/ACCI	1	1	1	0	0	3
THPL/ACTR	0	0	1	0	0	1
THPL/ALIN	0	2	1	0	0	3
THPL/ARNU3	1	2	2	0	1	6
THPL/ATFI	1	3	1	1	4	10
THPL/CLUN	0	0	0	2	0	2
THPL/EQUIS	2	1	0	0	0	3
THPL/GYDR	0	5	2	3	2	12
THPL/OPHO	1	5	4	1	2	13
THPL/PAMY/CLUN	0	5	0	2	3	10
THPL/VAME	0	1	0	0	0	1
Series total	6	25	12	9	12	64

Channel Types—

The THPL series plots are located along a variety of channel types. Rosgen A, B, and C channels predominate, which is typical for valleys with low to steep gradients. A few wetland plots are located in low-gradient valleys with E channels, lakes, and ponds.

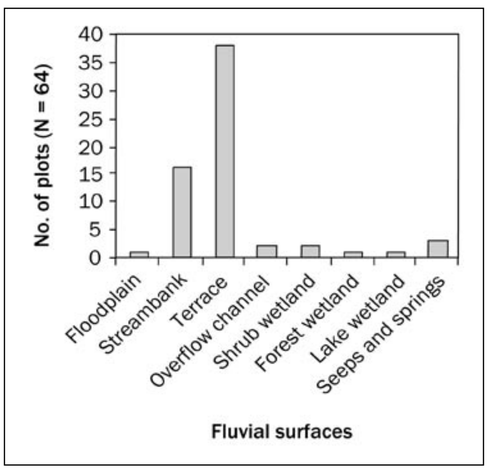


Additional insight can be gained by looking at the distribution of Rosgen channel types by plant association. With the exception of the THPL/EQUIS and THPL/OPHO associations, most associations are near Rosgen A, B, or C channels. Five of six E channels are associated with very low gradient valleys and wet associations (THPL/ATFI, THPL/OPHO, and THPL/EQUIS).

Plant association	Rosgen channel types						N
	A	B	C	D	E	Pond	
THPL/ACCI	0	2	1	0	0	0	3
THPL/ACTR	0	1	0	0	0	0	1
THPL/ALIN	1	1	1	0	0	0	3
THPL/ARNU3	1	3	1	0	1	0	6
THPL/ATFI	4	5	0	0	1	0	10
THPL/CLUN	2	0	0	0	0	0	2
THPL/EQUIS	0	0	1	0	1	1	3
THPL/GYDR	5	7	0	0	0	0	12
THPL/OPHO	2	6	1	1	3	0	13
THPL/PAMY/CLUN	4	2	4	0	0	0	10
THPL/VAME	0	0	1	0	0	0	1
Series total	19	27	10	1	6	1	64

Fluvial Surfaces—

Eighty percent of the THPL series plots are located in riparian zones on moist, well-drained streambanks and terraces. A small percentage of sites are located on wetter floodplains, overflow channels, wetlands, seeps, and springs.

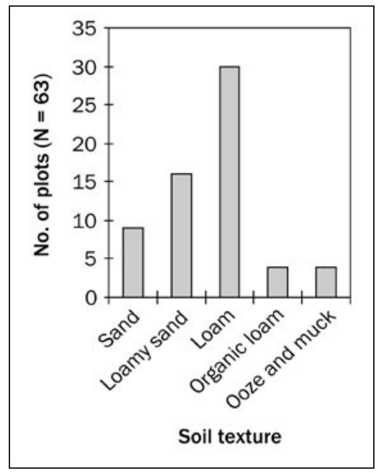


Additional insight can be gained by looking at the distribution of fluvial surfaces by plant associations. Most associations are best represented on streambanks and terraces. However, in the case of the THPL/ATFI, THPL/EQUIS, and THPL/OPHO associations, some sites are located on wetlands. The THPL/ALIN association occurs on active fluvial surfaces such as overflow channels, floodplains, and streambanks that are subject to periodic flooding.

Plant association	Fluvial surfaces					N
	Streambank	Terrace	Overflow channel	Seeps/springs	Other	
THPL/ACCI	0	3	0	0	0	3
THPL/ACTR	0	1	0	0	0	1
THPL/ALIN	2	1	0	0	0	3
THPL/ARNU3	1	4	0	0	1	6
THPL/ATFI	4	4	0	1	1	10
THPL/CLUN	1	1	0	0	0	2
THPL/EQUIS	0	1	0	0	2	3
THPL/GYDR	4	8	0	0	0	12
THPL/OPHO	2	7	2	1	1	13
THPL/PAMY/CLUN	2	7	0	1	0	10
THPL/VAME	0	1	0	0	0	1
Series total	16	38	2	3	5	64

Soils—

The THPL series plots are dominated by mineral soils with loamy sand and loam textures. Sand textures are less common, presumably occurring on active fluvial surfaces such as streambanks, floodplains, and overflow channels. A few wet sites had organic loam and muck soils.



Additional insight is gained by looking at soil texture by plant association. Some soils in the wettest associations (THPL/OPHO, THPL/EQUIS, and THPL/ATFI) are classified as organic loams, ooze, or muck. However, most associations are found on loam and loamy sand-textured soils. The frequently flooded THPL/ALIN association is most common on sand-textured soils.

Plant association	Soil texture					N
	Sand	Loamy sand	Loam	Organic loam	Ooze/muck	
THPL/ACCI	0	2	1	0	0	3
THPL/ACTR	0	1	0	0	0	1
THPL/ALIN	2	0	1	0	0	3
THPL/ARNU3	1	2	3	0	0	6
THPL/ATFI	0	1	6	2	1	10
THPL/CLUN	0	0	2	0	0	2
THPL/EQUIS	0	0	1	0	2	3
THPL/GYDR	2	3	6	1	0	12
THPL/OPHO	1	3	6	1	1	12
THPL/PAMY/CLUN	3	3	4	0	0	10
THPL/VAME	0	1	0	0	0	1
Series total	9	16	30	4	4	63

Water table measurements at the time of sampling were variable, depending on association. The THPL/EQUIS and THPL/ATFI associations are easily the wettest sites, with THPL/OPHO a close third. The data associated with THPL/ALIN are due to the sample season as these sites may be temporarily saturated or even flooded at peak runoff (before sampling). The rest of the associations are generally restricted to well-drained terraces and deeper water tables. Water table depths are not available for the THPL/CLUN, THPL/ACCI, and THPL/VAME associations.

	Water table (inches)			
Plant association	Minimum	Maximum	Average	N
THPL/EQUIS	-20	-3	-9	3
THPL/ATFI	-28	0	-11	10
THPL/OPHO	-35	-9	-17	10
THPL/GYDR	-35	-12	-23	7
THPL/ARNU3	-35	-20	-26	3
THPL/PAMY/CLUN	-77	-7	-33	5
THPL/ALIN	-47	-22	-35	2
Series	-77	0	-20	40

Soil temperature at the time of sampling (degrees Fahrenheit) also varies by association. The THPL/ALIN sites are warm because the young, open stands of alder allow the sun to directly strike sand, gravel, and cobble soil surfaces. The causal effects creating the other average soil temperatures are unknown. The higher elevation associations appear to be cooler.

	Soil temperature (°F)			
Plant association	Minimum	Maximum	Average	N
THPL/ALIN	58	67	62	3
THPL/ACCI	52	60	56	3
THPL/PAMY/CLUN	47	65	55	10
THPL/EQUIS	53	56	54	3
THPL/OPHO	43	57	51	11
THPL/GYDR	44	55	51	10
THPL/ATFI	36	63	48	9
THPL/ARNU3	42	52	47	3
Series	36	67	52	52

ECOSYSTEM MANAGEMENT

Natural Regeneration of Western Redcedar—

Western redcedar reproduces from seed and vegetatively (Arno and Hammerly 1984, Edwards and Leadem 1988, Habeck and Mutch 1973). Vegetative regeneration may occur by layering; rooting of live, fallen branches that have been torn off by wind or snow; and rooting along the trunks of fallen, living trees. Seed production begins at about 10 years of age in open stands and 20 to 30 years in closed stands (Turner 1985). Poor cone crops are rare, and large seed crops are produced every 3 to 4 years. The seeds are small, light, and wind dispersed, but generally fall within 400 feet of the parent tree. The seed germinates well without stratification and, with proper warehouse storage, remains viable for at least 7 years (Minore 1990). Germination occurs on a variety of sites, including heavily shaded duff seedbeds, rotten wood, and burned surfaces (Graham et al. 1988).

Seedling survival is low because of various factors such as fungi, birds, insects, and smothering by fallen leaves (Arno and Hammerly 1984, Krasowski and Owens 1991, Minore 1990). Drought and high soil temperatures will damage seedlings in full sunlight. Seedlings grow best in partial shade, although they may fail on heavily shaded sites because of slow root penetration. Seedlings grow very slowly; early annual height growth ranges from less than 1 inch in dense stands to more than 7 inches in partially shaded stands (Graham et al. 1988). They release well following removal of competing vegetation. Vegetative reproduction by layering is favored by closed stands, especially old-growth stands where the soil or rotten wood substrate is moist throughout the growing season (Fischer and Bradley 1987, Habeck 1963, Habeck and Mutch 1973).

Artificial Establishment of Western Redcedar and Associated Shrubs and Herbs—

Western redcedar is a valued timber species (Parish et al. 1996) and can be planted on disturbed sites within its range. It is suitable for planting on a variety of sites, ranging from mineral soils in mesic uplands to well-decomposed organic material on lowland sites (Hawkes et al. 1990). Nursery-grown container stock appears to perform better than bare rootstock (Graham et al. 1988). Direct seeding is possible where bare mineral soil is available. It is probably better to rely on the release of natural seedlings and saplings when using selection-cutting methods in riparian zones.

Many of the shrubs that characterize the THPL series are well adapted to planting on disturbed sites. Red-osier dogwood, mountain alder, myrtle pachistima, vine maple, and devil's club can be established from nursery stock, seed, cuttings, or layering. Prickly currants, Nootka and baldhip rose, and western thimbleberry can be easily grown from seed. Five-leaved bramble, bunchberry dogwood, and other trailing plants can be propagated from root runners. Huckleberry cuttings root poorly but can be established from seed although growth is slow. Common snowberry can be established from stem or root cuttings, nursery stock, or seed. Oak fern, lady fern, and horsetail species can be easily propagated from rhizomes. (For more information on the short- and long-term revegetation potential of selected riparian wetland plant species, see app. B-5.)

Stand Management—

Although tree productivity is high on these sites, tree harvesting and associated management activities need to be carefully planned. The high water tables and the presence of seeps and springs on wetter sites such as THPL/ATFI and THPL/OPHO preclude many timber management activities. Periodic flooding and scouring is a problem on THPL/ALIN sites or other associations that lie on active fluvial surfaces. Loam soils are very susceptible to compaction during most of the growing season. Many large western redcedar have extensive heart rot. Wetter sites also are susceptible to windthrow. Timber harvesting on these sites or adjacent sites that are upslope may increase the risk of windthrow and rising water tables. A clearcut adjacent to a small riparian zone could result in blowdown in the riparian zone.

The THPL series supports a variety of seral tree species including grand fir, Engelmann spruce, western larch, and Douglas-fir. Ponderosa pine may perform well on warmer associations such as THPL/CLUN, THPL/ARNU3, THPL/ASCA3, and THPL/ACTR. With the exception of Engelmann spruce, regeneration of these tree species will be difficult on the wettest sites owing to seasonally high water and competition from a variety of shrubs and herbs. Also, heavy browsing of western redcedar regeneration by snowshoe hares is a potential problem. Management options appear to be limited to single-tree or small-group selection with the objective of opening the canopy to increase understory production for other resources. It is preferable to schedule any management activity during late summer, early fall, or winter (on snowpack) to minimize soil disturbance.

Coarse-textured, compaction-resistant soils are unusual, except on more active fluvial sites such as THPL/ALIN. Loam soils predominate and are subject to compaction. Very sensitive organic soils are occasionally associated with the wetter associations. Machinery and livestock easily displace or otherwise damage these soils during periods of excessive soil moisture (Hansen et al. 1995). Poorly drained sites, streamside locations, or sites with organic soils should warrant special concern. Roads and trails generally should be located on the adjacent upland.

Tree Growth and Yield—

Moderate elevation, mild temperatures, and moderately high precipitation characterize the THPL series (Williams et al. 1995). Large, old-growth trees characterize some of the wetter associations. The THPL series is one of the most productive forested series in eastern Washington as indicated by high basal area (square feet per acre) and site index values. Basal area averages 286 square feet per acre, which is the highest value for any of the tree series (apps. C-1a and C-1b). Only the ABAM, PSME, and TSHE series are comparable. Similarly, average site index (feet) is high compared with other series (app. C-2). Tree productivity data are limited and should be viewed with caution.

Site index			
Species	Base age	No. of trees	SI
ABGR	50	22	75
ABLA2	50	4	65
LAOC	20	12	76
PIEN	20	51	78
PIPO	100	3	122
POTR2	80	2	142
PSME	50	53	77
THPL	100	86	87

Basal area (sq. ft./ac)	
Species	BA
ABGR	20
ABLA2	6
ACMA	Tr
ALRU	1
BEPA	1
LAOC	5
PICO	1
PIEN	48
PIMO	Tr
PIPO	4
POTR	1
POTR2	7
PSME	31
THPL	162
TSHE	1
Total	288

Down Wood—

The overall amount of down woody material on THPL sites is the highest of any forested tree series (app. C-3). Logs cover 14 percent of the ground surface. This reflects both the warm, moist (to wet) environment, which tends to support large-diameter trees and logs, and the prevalence of heart rot in western redcedar trees.

Definitions of log decomposition classes are on page 15.

	Down log attributes				
Log decomposition	Tons/ acre	Cu. ft./ acre	Linear ft./ acre	Sq. ft./ acre	% ground cover
Class 1	1.21	109	301	182	0.42
Class 2	7.62	837	1,018	850	1.95
Class 3	20.82	2,735	2,862	2,697	6.19
Class 4	3.15	799	1,033	938	2.15
Class 5	33.52	1,753	916	1,269	2.91
Total	66.32	6,233	6,130	5,936	13.62

Snags—

Similarly, the THPL series supports a high number of snags (40.9 snags per acre) compared with other tree series (app. C-4). Only the ABAM, ABLA2, and PIEN series, with 53.5, 54.3, and 41.3 snags per acre, respectively, exceed it. Most snags are between 5 and 15.5 inches in diameter and in condition classes 1 and 2.

Definitions of snag condition classes are on page 15.

	Snags/acre by d.b.h. class (inches)				
Snag condition	5–9.9	10–15.5	15.6–21.5	21.6+	Total
Class 1	4.4	2.6	1.2	0.5	8.7
Class 2	13.3	1.8	.5	.2	15.8
Class 3	.1	.8	1.4	.4	2.7
Class 4	3.8	4.5	0	1.1	9.4
Class 5	1.6	2.3	0	.4	4.3
Total	23.2	12.0	3.1	2.6	40.9

Fire—

Western redcedar has low to moderate resistance to fire (Fischer and Bradley 1987). Its susceptibility comes from its thin bark, shallow root system, low branching habit, and highly flammable foliage. Yet the frequency of fire in western redcedar stands tends to be low, especially in river bottoms (Boggs et al. 1990, Turner 1985). In riparian and wetland zones, the mean fire interval is generally considered greater than 200 years. Trees in younger stands are easily damaged by fire, whereas the large trees associated with mature stands tolerate it quite well as evidenced by deep multiple fire scars on cedar trees in older stands.

Although old-age stands support heavy fuel loads, much of this material is in the form of moist, deep duff and rotting wood. Riparian stringers may often act as firebreaks because the moist duff does not easily burn. Therefore, fires in older stands tend to be slow moving and do little damage to the cedars. However, once ignited, such fuels could support long-lasting fires, especially during severe drought periods.

Fire-return intervals on THPL riparian sites in eastern Washington are not well documented. However, western redcedar stands appear to be younger than stands in the TSHE, ABAM, and TSME series. Two hundred fifty-three site index trees were measured for age in the THPL series. These trees averaged 123 years in age at breast height. One hundred four trees were less than 100 years old, 117 were 100 to 199 years old, 20 were 200 to 299 years old, 9 were 300 to 399 years old, 2 were 500 to 599 years old, and 1 western redcedar was 600 years old. Of the 32 trees that were older than 199 years, 18 trees were western redcedar. Most stands appear to be less than 200 years old based on ages of site index trees. These data suggest that stand-replacing fire-return intervals in eastern Washington generally range from 100 to 199 years. Return intervals are likely longer for THPL stands in stronger maritime and inland maritime climates or in the wetter THPL associations. However, these data and interpretations may be misleading owing to the large number of stands that originated after the huge stand-replacing fires of the early 1900s. Natural fire-return intervals may actually be longer. In general, it is reasonable to expect that the present stand ages associated with the THPL series are more a reflection of the vast acres associated with the early 1900s fires. This is supported by the large numbers of large logs observed in these stands as well as the size of trees in stands that escaped the fires (and logging).

The fire regime of surrounding upland forests also may affect how often these riparian sites burn. In eastern Washington, riparian zones in the THPL series are quite often surrounded by drier Douglas-fir or grand fir uplands, at least on southerly aspects. These sites historically burned more frequently during the late-summer fire season. In the vicinity of the Kettle River Range, the THPL series is usually bound by the ABLA2 series on mid and upper north slopes. Most of these subalpine fir stands burned in the early 1900s and are presently dominated by lodgepole pine. It is reasonable to expect that these fires burned into adjacent western redcedar uplands and bottoms. These western redcedar sites may reflect shorter fire-return intervals than riparian zones that are adjacent to moister western redcedar/western hemlock uplands in maritime and inland maritime zones.

Animals—

Livestock. Both cattle and sheep browse western redcedar and can cause considerable damage to western redcedar regeneration (Minore 1983). However, in most cases, these cool, wet sites have little utility for domestic livestock except for shade or where forage production is high in early successional stages. Regeneration of conifers in clearcuts (before 1990) in riparian areas with cattle grazing allotments has been poor. In addition, shrub and herb composition has been highly altered, with a trend toward dominance by increaser and invader species such as Kentucky bluegrass and white clover. Cattle also graze and damage the streamside areas within the clearcuts. Sites are susceptible to trampling owing to high water tables and moist or wet soils. If grazed, modification of the grazing system, coupled with close monitoring of wildlife, often allows the remnant shrub and herb population to sprout and reinvade the stand. The ability to easily reestablish desired shrubs and herbs may be lost when they have been eliminated owing to overgrazing and the water table has been lowered because of streambed downcutting or lateral erosion. (For more information on forage palatability, see app. B-1. For potential biomass production, see app. B-5.)

Wildlife. Riparian zones in the THPL series provide valuable habitat for a variety of wildlife species. In general, these sites offer sources of cover, forage, and water. Multiple shrub and tree layers provide structural diversity for wildlife. Late-seral stand structures serve as important habitat for old-growth-dependent species. These stands include older western redcedar, grand fir, and Engelmann spruce trees with extensive heart rot decay, resulting in large trees, snags, and logs with hollow interiors.

Western redcedar is a major winter food for big game in the northern Rocky Mountains (Minore 1983). Some sites may have an abundance of berry-producing shrubs, providing food for wildlife. Large ungulates such as mule deer and elk will forage in these sites during summer and fall. Elk are known to favor devil's club as a forage plant and also will eat deerfoot vanilla-leaf. Black bears may remove cedar bark and feed on the exposed sapwood (Minore 1990). Black bears use hollow logs for dens and rest sites. Grizzly bears also are known to use heavily timbered western redcedar forests (Layser 1978). Flying squirrels, bats, skunks, raccoons, and red squirrels use western redcedar stands for hiding and thermal cover and cedar cavities for dens (Arno and Hammerly 1984). American marten use hollow logs and snags for dens and rest sites. Beaver have been observed eating cedar bark, probably as a food of last resort. They also may use conifer limbs for dam construction.

Western redcedar is used as a nest tree by cavity-nesting birds such as woodpeckers, yellow-belied sapsuckers, tree swallows, chestnut-backed chickadees, and Vaux's swift (McClelland 1980). These sites also may serve as important habitat for the northern spotted owl, barred owl, and goshawk. Woodpeckers also forage these trees for bark beetles and ants, especially Engelmann spruce. (For more information on thermal or feeding cover values, see apps. B-2 and B-3. For information on food values or degree of use, see apps. B-2 and B-4.)

Fish. Riparian associations in the THPL series play important roles in the maintenance of good fish habitat. The high tree productivity associated with most of these sites provides ample amounts of large woody debris, primarily large-diameter logs, which provide good fish habitat (structure). In addition, most THPL sites are located along A and B channels with steep gradients. The contribution of large woody debris helps to maintain channel and streambank stability, particularly during peak flows. (For more information, see app. B-5, erosion control potential.) The large tree canopies provide shade for the stream, which helps to regulate stream water temperatures.

Maintaining healthy, vigorous stands of THPL and associated series along streams will create buffer strips of erosion-resistant plant species to help stabilize streambanks, nearby terraces, and swales; form barriers to sedimentation from nearby slopes; and provide a source of large down wood for the stream and nearby fluvial surfaces.

Recreation—

Old-growth stands of western redcedar have high recreational value owing to their attractiveness, scarcity, and big trees (Hansen et al. 1995). However, many riparian and wetland sites are not well suited for recreation purposes on account of high water tables or seeps and springs. Low gravel content and loamy textures (in some cases organic soils) make most sites highly susceptible to compaction and trampling when soil moisture conditions are high. Many wetter sites would require boardwalks so forest visitors would not trample vegetation and soils. Construction and maintenance of campgrounds, trails, and roads are not recommended except on well-drained terraces. The THPL sites also are prone to windthrow of western redcedar, grand fir, and Engelmann spruce owing to wet soil, these species' shallow rooting system, and weakness from root rot.

Insects and Disease—

Western redcedar is relatively free of major problems associated with insects and disease (Hessburg et al. 1994, Williams et al. 1995), although more than 200 fungi are found on it (Minore 1990). Trees with trunk, butt, and root rots are common. Laminated root rot caused by *Phellinus* (*Poria*) *weirii* is the most important trunk rot in eastern Washington. Trunk, butt, and root rots also affect other trees in the THPL series, such as Douglas-fir, grand fir, and Engelmann spruce. Armillaria root rot is very common throughout the series and is found in most stands (McDonald et al. 1987b). Annosus root disease is a common decay in western redcedar and grand fir, particularly in old-growth stands. Indian paint fungus is very common in old grand fir. Natural or human-caused wounding of trees will generally increase damage from decay fungi.

Although, western redcedar is a host for a variety of insect species, it seems to suffer little damage from them. The cedar gall midge reduces cedar seed crops (Minore 1990). Weevils damage seedlings and the western cedar borer causes degradation resulting in cull of lumber. Drier THPL associations that support seral Douglas-fir and grand fir are prone to some activity by Douglas-fir beetle, western spruce budworm, or fir engraver.

Estimating Vegetation Potential on Disturbed Sites—

Estimating vegetation potential on disturbed sites is generally not needed on these conifer-dominated sites, as they are seldom greatly disturbed. Clearcutting in riparian areas is unusual, at least on FS land. Wetter associations in the SALIX, COST, MEADOW, and ALIN series often separate THPL stands from active flood zones. Currently, the FS places buffer strips along riparian and wetland zones and does not manage them for wood production. Even where clearcut in the past, western redcedar, grand fir, Engelmann spruce, and other conifers regenerate rapidly on these productive sites. Similar valley segments in nearby drainages can help determine the potential natural vegetation for young stands.

Sensitive Species—

No sensitive plants were found on THPL series plots. However, old western redcedar stands often contain various *Botrychium* species on the thick accumulation of duff (Lillybridge 1998). (See app. D for more information.)

ADJACENT SERIES

In maritime and inland maritime zones, the TSHE series and the ABGR series normally bound the THPL series on cooler and warmer sites, respectively. Within continental climates, the THPL series is replaced by the ABLA2 series on colder sites and PSME series on warmer sites.

RELATIONSHIPS TO OTHER CLASSIFICATIONS

Kovalchik (1992c) described many of the plant associations in the THPL series in the draft classification for northeastern Washington. The THPL/ARNU3 and THPL/OPHO associations are described in the upland classifications by Lillybridge et al. (1995) and Williams et al. (1995). The THPL/ACCI and THPL/PAMY/CLUN associations have not been previously described.

Daubenmire and Daubenmire (1968) incorporated climax western redcedar stands into the TSHE series and did not explicitly recognize a THPL series. Plant associations belonging to the THPL series are similarly lumped into the TSHE series in other classifications for the Washington Cascade Range (e.g., Henderson et al. 1992, Lillybridge et al. 1995). The THPL plant associations (THPL/OPHO, THPL/ATFI, and THPL/GYDR) have been described for northeastern Washington, northern Idaho, and Montana (Cooper et al. 1991, Hansen et al. 1995, Pfister et al. 1977, and Williams et al. 1995). The western redcedar series also occurs in the southern interior of British Columbia (Braumandl and Curran 1992).

U.S. DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE WETLANDS CLASSIFICATION

System:	palustrine
Class:	forested wetland
Subclass:	needle-leaved evergreen
Water regime:	(nontidal) temporarily flooded to saturated

KEY TO THE WESTERN REDCEDAR (*THUJA PLICATA*) PLANT ASSOCIATIONS

1. Devil's club (*Oplopanax horridum*) ≥5 percent canopy coverage .... **Western redcedar/devil's club (THPL/OPHO) association**
2. Lady fern (*Athyrium filix-femina*) ≥5 percent canopy coverage .... **Western redcedar/lady fern (THPL/ATFI) association**
3. Oak fern (*Gymnocarpium dryopteris*) ≥5 percent canopy coverage .... **Western redcedar/oak fern (THPL/GYDR) association**
4. Common horsetail (*Equisetum arvense*) and/or soft-leaved sedge (*Carex disperma*) ≥10 percent canopy coverage .... **Western redcedar/common horsetail (THPL/EQUIS) association**
5. Vine maple (*Acer circinatum*) ≥5 percent canopy coverage .... **Western redcedar/vine maple (THPL/ACCI) association**
6. Mountain alder (*Alnus incana*) ≥25 percent canopy coverage .... **Western redcedar/mountain alder (THPL/ALIN) association**
7. Deerfoot vanilla-leaf (*Achlys triphylla*) ≥2 percent canopy coverage .... **Western redcedar/deerfoot vanilla-leaf (THPL/ACTR) association**
8. Wild ginger (*Asarum caudatum*) ≥2 percent canopy coverage; site west of Okanogan River .... **Western redcedar/wild ginger (THPL/ASCA3) association**
9. Myrtle pachistima (*Pachistima myrsinites*) ≥5 percent canopy coverage; site west of the Okanogan River .... **Western redcedar/myrtle pachistima/queencup beadlily (THPL/PAMY/CLUN) association**
10. Wild sarsaparilla (*Aralia nudicaulis*), wild ginger (*Asarum caudatum*) or baneberry (*Actaea rubra*) ≥2 percent canopy coverage; sites east of the Okanogan River .... **Western redcedar/wild sarsaparilla (THPL/ARNU3) association**
11. Big huckleberry (*Vaccinium membranaceum*) ≥5 percent canopy coverage; sites east of the Okanogan River .... **Western redcedar/big huckleberry (THPL/VAME) association**
12. Queencup beadlily (*Clintonia uniflora*) ≥1 percent canopy coverage; sites east of the Okanogan River.......... **Western redcedar/queencup beadlily (THPL/CLUN) association**

Table 4—Constancy and mean cover of important plant species in the THPL plant associations

Species	Code	THPL/ ACCI 6 plots		THPL/ ACTR 2 plots		THPL/ ALIN 3 plots		THPL/ ARNU3 14 plots		THPL/ ASCA3 3 plots		THPL/ AFTI 13 plots		THPL/ CLUN 2 plots		THPL/ EQUIS 3 plots		THPL/ GYDR 13 plots		THPL/ OPHO 17 plots		THPL/ PAMY/CLUN 12 plots		THPL/ VAME 2 plots	
		CON[a]	COV[b]	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV
Tree overstory:																									
grand fir	ABGR	83	15	100	8	67	4	64	21	100	20	46	11	100	6	—	—	23	2	41	23	17	4	—	—
subalpine fir	ABLA2	—	—	—	—	—	—	—	—	—	—	23	3	—	—	33	5	23	3	12	23	8	Tr[c]	100	3
red alder	ALRU	17	2	—	—	33	10	—	—	—	—	8	25	—	—	—	—	—	—	12	18	—	—	—	—
western larch	LAOC	17	10	50	5	—	—	57	8	67	8	31	4	—	—	—	—	31	4	6	Tr	—	—	—	—
Engelmann spruce	PIEN	33	8	—	—	33	20	79	17	67	11	77	14	50	Tr	100	35	69	19	41	17	58	16	100	45
western white pine	PIMO	50	5	—	—	—	—	14	3	33	7	15	3	—	—	—	—	8	Tr	—	—	8	8	—	—
ponderosa pine	PIPO	—	—	50	5	33	55	7	35	33	10	—	—	50	5	—	—	8	Tr	—	—	—	—	—	—
black cottonwood	POTR2	—	—	100	5	—	—	14	1	—	—	31	3	—	—	33	3	8	10	35	8	25	13	—	—
Douglas-fir	PSME	50	15	100	24	33	Tr	93	15	100	19	38	12	50	35	67	8	38	8	47	18	67	21	50	5
western redcedar	THPL	100	44	100	19	100	25	93	30	100	30	100	43	100	90	100	22	100	58	94	38	100	50	100	12
Tree understory:																									
grand fir	ABGR	50	3	100	4	67	1	50	6	67	1	62	3	100	4	—	—	38	2	24	3	25	4	—	—
Engelmann spruce	PIEN	17	5	—	—	—	—	43	3	—	—	38	4	—	—	67	13	54	2	18	2	25	2	—	—
Douglas-fir	PSME	17	1	50	1	33	Tr	43	2	—	—	8	Tr	50	1	—	—	8	Tr	12	1	50	1	—	—
western redcedar	THPL	67	9	50	7	100	4	93	9	100	12	100	9	100	14	67	23	100	12	100	8	92	9	100	24
western hemlock	TSHE	17	1	—	—	33	2	7	2	67	1	23	1	—	—	—	—	—	—	18	2	—	—	—	—
Shrubs:																									
vine maple	ACCI	100	41	—	—	33	2	—	—	—	—	15	5	—	—	—	—	—	—	41	16	—	—	—	—
Douglas maple	ACGLD	—	—	100	4	—	—	100	3	33	1	38	7	50	1	—	—	54	9	35	4	50	6	—	—
mountain alder	ALIN	17	1	50	5	100	35	—	—	—	—	46	12	—	—	100	3	38	3	18	3	50	4	—	—
Sitka alder	ALSI	—	—	100	4	33	1	14	3	33	2	23	4	—	—	—	—	23	1	18	4	25	3	—	—
Saskatoon serviceberry	AMAL	33	1	50	2	—	—	71	1	33	1	23	1	100	1	—	—	38	1	24	Tr	50	Tr	50	1
red-osier dogwood	COST	—	—	50	10	33	17	29	1	—	—	54	4	50	3	100	4	54	3	41	8	50	2	50	2
bearberry honeysuckle	LOIN	17	Tr	—	—	—	—	—	—	—	—	8	Tr	—	—	33	Tr	8	3	6	1	—	—	50	1
rusty menziesia	MEFE	—	—	—	—	—	—	—	—	33	1	15	2	—	—	—	—	8	2	24	5	8	Tr	50	1
devil's club	OPHO	—	—	—	—	—	—	—	—	—	—	23	1	—	—	33	Tr	38	2	100	22	—	—	50	1
prickly currant	RILA	17	2	—	—	—	—	36	2	33	1	69	1	50	1	33	2	92	3	59	2	67	1	100	3
baldhip rose	ROGY	50	2	100	3	67	3	100	3	67	2	54	1	100	1	33	3	54	1	29	1	50	1	50	Tr
Nootka rose	RONU	—	—	50	1	67	2	7	1	—	—	8	1	—	—	—	—	8	Tr	—	—	—	—	—	—
western thimbleberry	RUPA	50	4	100	2	—	—	71	5	67	1	62	4	50	2	33	Tr	62	7	82	9	67	3	100	2
Scouler's willow	SASC	—	—	50	2	33	3	—	—	—	—	—	—	—	—	—	—	8	2	—	—	25	2	—	—
Cascade mountain-ash	SOSC2	—	—	50	Tr	—	—	7	Tr	—	—	—	—	—	—	33	Tr	—	—	6	2	67	1	—	—
shiny-leaf spiraea	SPBEL	17	Tr	50	3	67	1	7	5	33	1	—	—	—	—	—	—	8	Tr	—	—	42	1	—	—
common snowberry	SYAL	—	—	50	2	33	3	64	3	33	2	54	2	50	Tr	33	2	46	4	12	5	33	1	—	—
big huckleberry	VAME	17	Tr	—	—	33	40	14	1	—	—	15	1	—	—	—	—	31	1	24	1	25	Tr	100	13
Low shrubs and subshrubs:																									
Oregon hollygrape	BEAQ	—	—	50	Tr	33	5	71	2	33	1	8	2	50	Tr	33	Tr	23	Tr	12	Tr	50	1	—	—
Cascade hollygrape	BENE	50	4	100	3	33	10	—	—	100	2	23	1	—	—	—	—	—	—	12	4	—	—	50	1
western prince's-pine	CHUMO	33	3	100	1	33	2	21	1	100	1	31	Tr	50	Tr	33	Tr	54	Tr	29	1	75	1	100	2
bunchberry dogwood	COCA	33	12	—	—	—	—	71	5	33	4	31	2	50	Tr	67	2	31	2	—	—	—	—	—	—
twinflower	LIBOL	50	7	50	2	—	—	93	10	33	4	77	2	100	2	33	15	77	7	35	6	—	—	100	11

Table 4—Constancy and mean cover of important plant species in the THPL plant associations (continued)

Species	Code	THPL/ ACCI 6 plots		THPL/ ACTR 2 plots		THPL/ ALIN 3 plots		THPL/ ARNU3 14 plots		THPL/ ASCA3 3 plots		THPL/ AFTI 13 plots		THPL/ CLUN 2 plots		THPL/ EQUIS 3 plots		THPL/ GYDR 13 plots		THPL/ OPHO 17 plots		THPL/ PAMY/CLUN 12 plots		THPL/ VAME 2 plots	
		CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV
myrtle pachistima	PAMY	67	4	50	7	67	2	50	1	67	2	38	1	—	—	33	Tr	31	1	29	1	100	12	50	2
five-leaved bramble	RUPE	—	—	—	—	—	—	—	—	—	—	15	6	—	—	33	5	—	—	6	Tr	—	—	—	—
low huckleberry	VAMY	—	—	—	—	33	3	7	2	33	1	8	Tr	—	—	—	—	23	1	—	—	17	1	—	—
Perennial forbs:																									
deerfoot vanilla-leaf	ACTR	17	1	100	18	—	—	—	—	33	2	—	—	—	—	—	—	—	—	12	4	—	—	—	—
baneberry	ACRU	—	—	50	2	—	—	71	1	33	2	69	1	100	Tr	—	—	54	1	65	3	8	Tr	—	—
pathfinder	ADBI	17	1	50	4	—	—	71	1	33	1	46	1	50	Tr	33	1	23	1	47	1	17	2	50	Tr
wild sarsaparilla	ARNU3	—	—	—	—	—	—	79	13	—	—	23	2	—	—	33	5	31	6	12	1	—	—	—	—
mountain arnica	ARLA	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8	Tr	—	—	8	Tr	50	Tr
wild ginger	ASCA3	33	13	—	—	—	—	43	2	100	6	46	12	—	—	33	1	15	2	65	5	—	—	—	—
enchanter's nightshade	CIAL	—	—	—	—	—	—	29	2	—	—	46	2	100	1	67	3	31	3	53	1	—	—	—	—
queencup beadlily	CLUN	50	11	50	1	—	—	86	4	100	2	100	2	100	3	—	—	77	2	41	2	—	—	50	2
Hooker's fairy-bells	DIHO	50	Tr	100	3	—	—	29	2	—	—	23	1	—	—	—	—	8	Tr	47	1	17	2	—	—
roughfruit fairy-bells	DITR	—	—	—	—	—	—	50	2	—	—	—	—	50	Tr	—	—	15	1	6	Tr	17	3	—	—
sweetscented bedstraw	GATR	33	1	50	1	—	—	79	2	33	1	92	1	100	1	67	2	38	1	53	2	17	Tr	50	Tr
western rattlesnake plantain	GOOB	67	1	50	Tr	33	2	43	1	100	1	31	1	50	1	33	Tr	46	Tr	41	1	50	1	100	1
fivestamen miterwort	MIPE	—	—	—	—	—	—	7	1	—	—	15	1	—	—	33	5	23	1	6	3	—	—	—	—
miterwort species	MITEL	—	—	—	—	—	—	21	1	—	—	23	1	100	Tr	33	2	31	2	12	1	—	—	—	—
smallflower miterwort	MIST2	—	—	—	—	—	—	—	—	—	—	8	5	—	—	—	—	—	—	—	—	—	—	—	—
mountain sweet-root	OSCH	—	—	50	1	—	—	57	2	—	—	23	2	50	Tr	—	—	23	1	24	1	25	1	50	Tr
western sweet-root	OSOC	—	—	50	2	—	—	—	—	—	—	—	—	—	—	—	—	8	Tr	6	2	—	—	—	—
purple sweet-root	OSPU	—	—	—	—	—	—	14	1	—	—	15	1	50	1	33	Tr	15	1	12	1	—	—	—	—
arctic butterbur	PEFR2	—	—	50	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
pink wintergreen	PYAS	33	2	50	1	—	—	—	—	67	2	31	2	50	Tr	33	2	46	Tr	24	3	17	3	100	14
sidebells pyrola	PYSE	17	1	50	Tr	33	Tr	36	2	67	1	46	1	50	Tr	33	Tr	46	1	35	1	92	1	100	3
arrowleaf groundsel	SETR	—	—	50	1	—	—	7	1	—	—	38	1	—	—	—	—	23	Tr	12	1	8	Tr	—	—
western solomonplume	SMRA	33	Tr	100	1	—	—	21	1	33	1	23	1	50	Tr	—	—	—	—	53	1	58	1	—	—
starry solomonplume	SMST	83	4	50	1	67	1	86	3	100	2	85	3	100	1	33	2	38	2	71	7	8	Tr	50	1
claspleaf twisted-stalk	STAM	—	—	—	—	—	—	50	1	—	—	85	1	50	1	—	—	77	2	65	2	25	1	50	Tr
rosy twisted-stalk	STRO	17	1	—	—	—	—	—	—	—	—	8	7	—	—	—	—	8	Tr	12	2		—	50	5
coolwort foamflower	TITRU	17	Tr	—	—	—	—	71	5	—	—	69	4	—	—	33	5	92	3	71	5	—	—	50	2
false bugbane	TRCA3	17	1	—	—	—	—	29	6	—	—	15	4	—	—	—	—	15	5	18	4	—	—	—	—
broadleaf starflower	TRLA2	17	1	50	1	—	—	—	—	100	1	15	2	—	—	—	—	—	—	29	3	—	—	—	—
white trillium	TROV	67	1	50	1	—	—	50	2	100	1	46	2	—	—	—	—	15	1	65	1	—	—	—	—
Canadian violet	VICA	—	—	50	2	—	—	14	3	—	—	8	1	—	—	—	—	8	2	—	—		—	—	—
pioneer violet	VIGL	—	—	50	1	—	—	29	2	33	1	62	3	100	2	33	Tr	54	1	76	2	25	1	50	Tr
round-leaved violet	VIOR2	33	1	—	—	—	—	29	2	—	—	—	—	—	—	—	—	8	Tr	6	2	25	2	—	—
Grass or grasslike:																									
soft-leaved sedge	CADI	—	—	—	—	—	—	7	3	—	—	46	1	50	Tr	67	14	15	Tr	6	5	8	Tr	—	—
smooth sedge	CALA	—	—	—	—	—	—	7	3	—	—	23	Tr	50	3	33	2	23	1	12	1	—	—	—	—
wood reed-grass	CILA2	—	—	—	—	—	—	—	—	—	—	38	1	50	Tr	67	2	46	1	41	1	17	Tr	—	—
western fescue	FEOC	—	—	50	Tr	—	—	29	1	—	—	—	—	—	—	—	—	8	Tr	—	—	—	—	—	—
tall mannagrass	GLEL	—	—	—	—	—	—	14	Tr	—	—	23	5	—	—	67	2	8	Tr	12	3	—	—	—	—

Table 4—Constancy and mean cover of important plant species in the THPL plant associations (continued)

		THPL/ ACCI 6 plots		THPL/ ACTR 2 plots		THPL/ ALIN 3 plots		THPL/ ARNU3 14 plots		THPL/ ASCA3 3 plots		THPL/ AFTI 13 plots		THPL/ CLUN 2 plots		THPL/ EQUIS 3 plots		THPL/ GYDR 13 plots		THPL/ OPHO 17 plots		THPL/ PAMY/CLUN 12 plots		THPL/ VAME 2 plots	
Species	Code	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV
Ferns and fern allies:																									
alpine lady fern	ATDI	—	—	—	—	—	—	—	—	—	—	8	7	—	—	—	—	—	—	—	—	—	—	—	—
lady fern	ATFI	17	Tr	—	—	—	—	43	1	—	—	92	13	50	3	33	1	77	2	82	21	17	Tr	—	—
common horsetail	EQAR	33	1	50	3	—	—	14	1	—	—	54	6	—	—	67	26	69	2	29	3	25	2	—	—
oak fern	GYDR	—	—	—	—	—	—	21	1	—	—	54	2	—	—	—	—	100	9	76	9	—	—	—	—
stiff clubmoss	LYAN	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8	Tr	—	—	—	—	—	—
western brackenfern	PTAQ	17	2	—	—	33	1	14	3	33	1	8	1	—	—	—	—	—	—	29	3	17	13	—	—

[a] CON = percentage of plots in which the species occurred.
[b] COV = average canopy cover in plots in which the species occurred.
[c] Tr = trace cover, less than 1 percent canopy cover.

SUBALPINE FIR SERIES

Abies lasiocarpa

ABLA2 N = 141

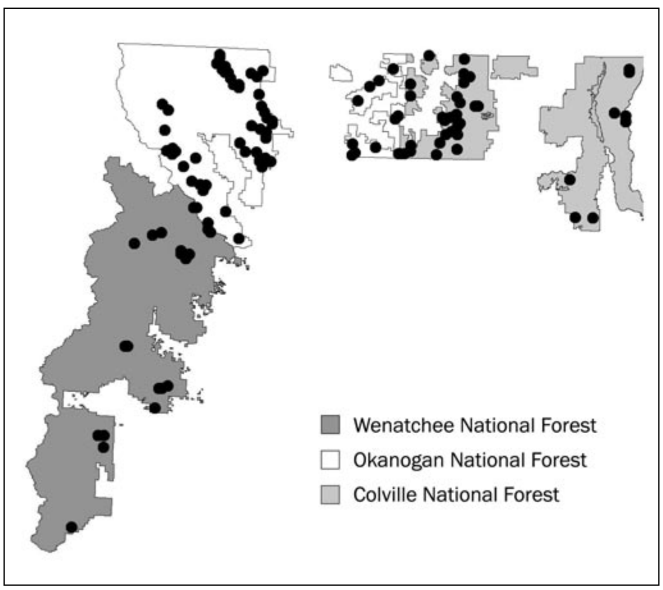


Figure 11—Plot locations for the subalpine fir series.

SUBALPINE FIR[1] is the most widely distributed true fir in North America (Alexander et al. 1984). The range of subalpine fir extends from near the northern tree line in the Yukon interior along the coast of southeastern Alaska, then south through western Alberta and British Columbia, to southern Colorado and the scattered mountain ranges of Arizona and New Mexico (Henderson and Peter 1982, Hitchcock and Cronquist 1973). It does not occur along the Coast Ranges of British Columbia, Washington, or Oregon; however, it does occur in the Olympic Mountains and on Vancouver Island. It occurs along both sides of the Cascade Range in Washington and is very prominent to the east, through the mountainous areas of north central and northeastern Washington into Idaho and Montana.

Subalpine fir is quite shade tolerant compared with Douglas-fir and ponderosa pine, but less so than grand fir, western redcedar, western hemlock, mountain hemlock, and Pacific silver fir. Therefore the ABLA2 series is best represented in areas characterized by relatively dry and cold continental climates where the more shade-tolerant species do not grow well. Although subalpine fir stands are less abundant in moister inland maritime and maritime climates, subalpine fir is found on sites too harsh (cold and dry) for the species listed above. The ABLA2 series is most abundant and widespread in the strong continental climate west of the Columbia River, east of the Okanogan Cascade crest, and north of the Entiat River. It is also prominent on high-elevation, relatively dry ridges in locations that usually are too dry for mountain hemlock and Pacific silver fir. These areas extend east from the Cascade crest and south of the Entiat River and include the Wenatchee Mountains, Table Mountain, and Manastash Ridge. Within its range, the ABLA2 series is present on a variety of sites, including riparian and upland sites, but is limited in wetlands owing to subalpine fir's intolerance to saturated soils and flooding.

CLASSIFICATION DATABASE

The ABLA2 series includes all stands potentially dominated by subalpine fir at climax and is found on all three NFs covered in this guide (fig. 11). Stands are common on all RDs. Ninety-six riparian and wetland sampling plots were measured in the ABLA2 series. Data from an additional 45 plots in other ecology databases were added to facilitate classification and provide additional data only for descriptions of species composition, distribution, and elevation. From this database, nine major and seven minor associations are recognized. Five of these associations (ABLA2/ARLA-POPU, ABLA2/LEGL-VASC, ABLA2/PAMY, ABLA2/RULA, and ABLA2/TRLA4) are limited to the Cascade Range. The remaining 11 associations are found throughout the study area. Two potential one-plot associations (ABLA2/VACA and ABLA2/VASC), occasionally found on drier terraces and benches, are not used in the data nor described in this classification. They are, however, found in upland forest classifications for eastern Washington (Lillybridge et al. 1995, Williams et al. 1995). For the most part, these samples represent late-seral to climax conditions. However, some mid-seral plots were located in extensive, mature lodgepole pine stands that originated in the widespread stand-replacing fires of the early 1900s.

[1] See appendix A for a cross reference for all species codes and common and scientific names used in this document.

Subalpine fir plant associations

	Scientific name	Common name	Ecoclass code	Plots
Major associations:				
ABLA2/ATFI	*Abies lasiocarpa/Athyrium filix-femina*	Subalpine fir/lady fern	CEF332	10
ABLA2/COCA	*Abies lasiocarpa/Cornus canadensis*	Subalpine fir/bunchberry dogwood	CEF423	21
ABLA2/GYDR	*Abies lasiocarpa/Gymnocarpium dryopteris*	Subalpine fir/oak fern	CEF342	19
ABLA2/LEGL-VASC	*Abies lasiocarpa/Ledum glandulosum-Vaccinium scoparium*	Subalpine fir/Labrador tea-grouse huckleberry	CES632	16
ABLA2/PAMY	*Abies lasiocarpa/Pachistima myrsinites*	Subalpine fir/myrtle pachistima	CES113	7
ABLA2/RHAL/SETR	*Abies lasiocarpa/Rhododendron albiflorum/Seniceo triangularis*	Subalpine fir/Cascade azalea/arrowleaf groundsel	CES214	10
ABLA2/STAMC	*Abies lasiocarpa/Streptopus amplexifolius* var. *chalazatus*	Subalpine fir/claspleaf twisted-stalk	CEF311	6
ABLA2/TRCA3	*Abies lasiocarpa/Trautvetteria caroliniensis*	Subalpine fir/false bugbane	CEF422	19
ABLA2/TRLA4	*Abies lasiocarpa/Trollius laxus*	Subalpine fir/globeflower	CEF425	12
Minor associations:				
ABLA2/ALSI	*Abies lasiocarpa/Alnus sinuata*	Subalpine fir/Sitka alder	CES142	3
ABLA2/ARLA-POPU	*Abies lasiocarpa/Arnica latifolia-Polemonium pulcherrimum*	Subalpine fir/mountain arnica-skunkleaf polemonium	CEF424	3
ABLA2/LIBOL	*Abies lasiocarpa/Linnaea borealis* var. *longiflora*	Subalpine fir/twinflower	CEF211	4
ABLA2/OPHO	*Abies lasiocarpa/Oplopanax horridum*	Subalpine fir/devil's club	CES711	3
ABLA2/RHAL/LUHI	*Abies lasiocarpa/Rhododendron albiflorum/Luzula hitchcockii*	Subalpine fir/Cascade azalea/smooth woodrush	CES213	2
ABLA2/RULA	*Abies lasiocarpa/Rubus lasiococcus*	Subalpine fir/dwarf bramble	CES423	2
ABLA2/VAME	*Abies lasiocarpa/Vaccinium membranaceum*	Subalpine fir/big huckleberry	CES342	2

VEGETATION CHARACTERISTICS

Mature stands in the ABLA2 series have a tree overstory that contains both subalpine fir and Engelmann spruce. In many stands they are codominant. Engelmann spruce is a larger, longer-lived species than subalpine fir. In some older stands it tends to dominate the overstory, with subalpine fir forming multiaged canopies in the understory. Engelmann spruce also tolerates both wetter and drier conditions and extends to lower elevations or wetter sites than subalpine fir. These sites lie outside the ecological amplitude of subalpine fir and are described in the PIEN series. The tree understory is usually characterized by a combination of subalpine fir and Engelmann spruce regeneration, with smaller amounts of Douglas-fir on drier associations. Other tree species, such as western hemlock, mountain hemlock, and subalpine larch, are generally not well represented except on sites transitional to series characterized by these species. Lodgepole pine is a common seral species in moderate to high-elevation associations such as ABLA2/LEGL-VASC and ABLA2/TRLA4, as well as young- to moderate-aged, fire-regenerated stands. Douglas-fir and western larch (east of the Okanogan River) are common seral species on lower elevation, warmer associations.

Because of the extreme environmental variation in the many associations represented in the ABLA2 series, understory vegetation is diverse. Species composition and cover varies from very rich in the wetter associations, such as ABLA2/ATFI, to little diversity in drier associations, such as ABLA2/LEGL-VASC. Common shrub species on drier associations include Labrador tea, bearberry, Utah honeysuckle, baldhip rose, western thimbleberry, grouse huckleberry, dwarf huckleberry, bunchberry dogwood, twinflower, and myrtle pachistima. Sitka alder, devil's club, and prickly currant are common on wetter associations. Common herbs include mountain arnica, skunkleaf polemonium, queencup beadlily, sweetscented bedstraw, and starry solomonplume. Lady fern, oak fern, claspleaf twisted-stalk, false bugbane, globeflower, coolwort foamflower, and arrowleaf groundsel are common on wetter sites. Smooth woodrush is found at high elevations.

PHYSICAL SETTING

Elevation—

The ABLA2 series spans a broad range of elevations, but the majority of sites are above 4,000 feet, with lower elevation sites usually in cold air drainages. Elevation differences of ABLA2 sites between NFs probably result from differences in climate and physical settings. The lower elevation boundary of the ABLA2 series is higher in continental climate zones and restricted to absent within strong maritime climates. Therefore, elevations in the ABLA2 series are generally higher on the Wenatchee and Okanogan NFs. The lower elevation ranges shown for the three NFs occur as the series extends down cold air drainages within continental climate zones.

	Elevation (feet)			
Forest	Minimum	Maximum	Average	N
Colville	3,000	6,250	4,402	40
Okanogan	2,875	6,900	4,883	73
Wenatchee	2,550	6,620	5,031	28
Series	2,550	6,900	4,775	141

Additional insight is gained by looking at the individual associations. The ABLA2/TRLA4, ABLA2/RHAL/SETR, ABLA2/LEGL-VASC, ABLA2/STAMC, ABLA2/TRCA3, ABLA2/ATFI, ABLA2/ARLA-POPU, ABLA2/ALSI, and ABLA2/RHAL/LUHI associations are the highest, usually located above 4,500 feet. However, all ABLA2 associations are at high elevations compared with the PIEN, TSHE, THPL, ABGR, and PSME series except where the ABLA2 series extends to lower elevations along cold air drainages.

	Elevation (feet)			
Plant association	Minimum	Maximum	Average	N
ABLA2/TRLA4	5,075	6,900	6,195	12
ABLA2/RHAL/LUHI	5,800	6,500	6,150	2
ABLA2/RHAL/SETR	4,950	6,620	5,878	10
ABLA2/LEGL-VASC	4,621	6,620	5,696	16
ABLA2/STAMC	4,500	4,500	5,450	6
ABLA2/ARLA-POPU	4,640	5,640	5,155	3
ABLA2/TRCA3	4,000	5,440	4,747	19
ABLA2/ATFI	4,225	5,225	4,608	10
ABLA2/ALSI	4,430	4,750	4,567	3
ABLA2/LIBOL	3,860	4,760	4,355	4
ABLA2/OPHO	3,460	5,475	4,212	3
ABLA2/GYDR	3,160	5,225	4,105	19
ABLA2/VAME	3,500	4,675	4,088	2
ABLA2/PAMY	2,875	4,520	3,912	7
ABLA2/COCA	3,000	4,570	3,852	21
ABLA2/RULA	2,550	4,600	3,575	2
Series	2,550	6,900	4,775	139

Valley Geomorphology—

The ABLA2 series is found in a variety of valley width and gradient classes, but most sample plots are in valleys of moderate to very narrow width (less than 330 feet) and moderate to very steep valley gradient (4 percent to greater than 8 percent). A smaller number of sample plots are in broader valleys with low to very low valley gradient (less than 4 percent).

	Valley gradient					
Valley width	Very low	Low	Moderate	Steep	Very steep	N
Very broad	3	1	0	0	0	4
Broad	2	6	0	2	1	11
Moderate	0	6	7	5	11	29
Narrow	0	4	2	5	18	29
Very narrow	0	0	3	5	15	23
Series total	5	17	12	17	45	96

The valley data for individual plant associations generally follow that for the ABLA2 series. The trend is that no single ABLA2 association is common on very low gradient, very broad valley bottoms. The ABLA2/COCA association shows a relatively strong tendency toward broad, low gradient valleys, whereas the ABLA2/TRCA3 association is more common in low-gradient as well as steeper valley bottoms.

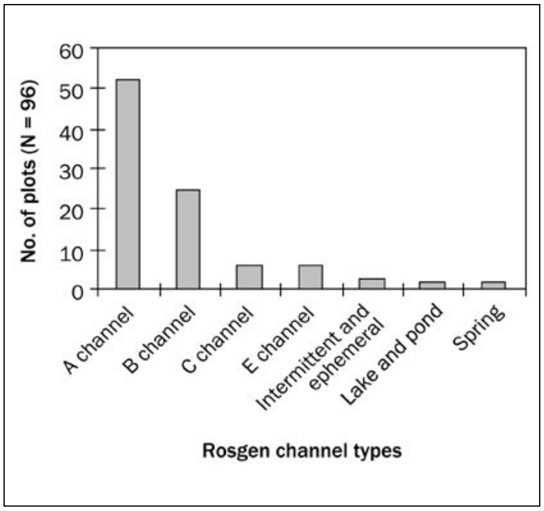
	Valley width					
Plant association	Very broad	Broad	Moderate	Narrow	Very narrow	N
ABLA2/ALSI	0	0	1	2	0	3
ABLA2/ARLA-POPU	0	0	2	0	0	2
ABLA2/ATFI	0	1	3	2	0	6
ABLA2/COCA	0	2	4	0	0	6
ABLA2/GYDR	1	1	4	7	3	16
ABLA2/LEGL-VASC	1	3	1	5	3	13
ABLA2/OPHO	0	0	2	0	0	2
ABLA2/PAMY	0	0	5	1	0	6
ABLA2/RHAL/LUHI	0	1	0	0	1	2
ABLA2/RHAL/SETR	0	1	0	2	6	9
ABLA2/RULA	1	0	0	1	0	2
ABLA2/STAMC	0	0	0	2	4	6
ABLA2/TRCA3	0	1	2	4	4	11
ABLA2/TRLA4	1	0	4	3	2	10
ABLA2/VAME	0	1	1	0	0	2
Series total	4	11	29	29	23	96

	Valley gradient					
Plant association	Very low	Low	Moderate	Steep	Very steep	N
ABLA2/ALSI	0	0	1	1	1	3
ABLA2/ARLA-POPU	0	0	0	1	1	2
ABLA2/ATFI	0	0	1	2	3	6
ABLA2/COCA	0	4	0	1	1	6
ABLA2/GYDR	1	4	2	4	5	16
ABLA2/LEGL-VASC	3	2	0	1	7	13
ABLA2/OPHO	0	0	0	2	0	2
ABLA2/PAMY	0	0	3	1	2	6
ABLA2/RHAL/LUHI	0	1	0	0	1	2
ABLA2/RHAL/SETR	0	1	1	0	7	9
ABLA2/RULA	1	0	0	0	1	2
ABLA2/STAMC	0	0	0	1	5	6
ABLA2/TRCA3	0	4	2	2	3	11
ABLA2/TRLA4	0	1	2	1	6	10
ABLA2/VAME	0	0	0	0	2	2
Series total	5	17	12	17	45	96

Channel Types—

The majority of ABLA2 series plots are located adjacent to Rosgen A and B channel types. A smaller number of plots (20 percent) are located along Rosgen C and E channels. Most of the low gradient, meandering C and E channel types are located in high-elevation basins or wide, low-gradient, riparian wetlands dominated by fens, bogs, and carrs.

The data for individual associations follow observations for the ABLA2 series as most associations are located along A and B channels. Few plots are associated with other channel types. However, the ABLA2/TRLA4 association is probably much more common around springs than indicated by only two plots.

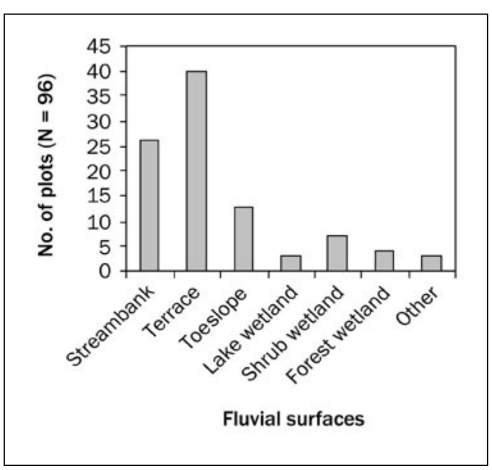


Plant association	Fluvial surfaces							N
	Stream-bank	Terrace	Toe-slope	Lake wetland	Shrub wetland	Forest wetland	Other	
ABLA2/ALSI	2	1	0	0	0	0	0	3
ABLA2/ARLA-POPU	0	2	0	0	0	0	0	2
ABLA2/ATFI	2	2	2	0	0	0	0	6
ABLA2/COCA	0	3	1	0	1	1	0	6
ABLA2/GYDR	6	8	1	0	1	0	0	16
ABLA2/LEGL-VASC	2	2	2	2	3	2	0	13
ABLA2/OPHO	1	1	0	0	0	0	0	2
ABLA2/PAMY	0	5	1	0	0	0	0	6
ABLA2/RHAL/LUHI	0	1	1	0	0	0	0	2
ABLA2/RHAL/SETR	4	3	2	0	0	0	0	9
ABLA2/RULA	0	2	0	0	0	0	0	2
ABLA2/STAMC	4	2	0	0	0	0	0	6
ABLA2/TRCA3	3	6	0	1	0	0	1	11
ABLA2/TRLA4	2	2	2	0	2	1	1	10
ABLA2/VAME	0	0	1	0	0	0	1	2
Series total	26	40	13	3	7	4	3	96

Plant association	Rosgen channel types							N
	A	B	C	E	Intermittent/ ephemeral	Lake/ pond	Spring	
ABLA2/ALSI	2	1	0	0	0	0	0	3
ABLA2/ARLA-POPU	1	1	0	0	0	0	0	2
ABLA2/ATFI	3	3	0	0	0	0	0	6
ABLA2/COCA	0	4	2	0	0	0	0	6
ABLA2/GYDR	10	4	1	1	0	0	0	16
ABLA2/LEGL-VASC	7	1	1	2	1	1	0	13
ABLA2/OPHO	1	1	0	0	0	0	0	2
ABLA2/PAMY	2	3	1	0	0	0	0	6
ABLA2/RHAL/LUHI	1	0	0	1	0	0	0	2
ABLA2/RHAL/SETR	6	2	0	0	1	0	0	9
ABLA2/RULA	1	0	1	0	0	0	0	2
ABLA2/STAMC	6	0	0	0	0	0	0	6
ABLA2/TRCA3	5	3	0	1	1	1	0	11
ABLA2/TRLA4	5	2	0	1	0	0	2	10
ABLA2/VAME	2	0	0	0	0	0	0	2
Series total	52	25	6	6	3	2	2	96

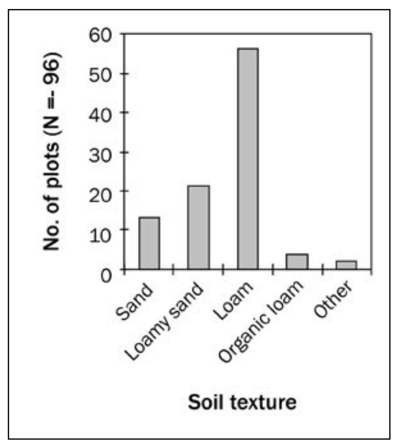
Fluvial Surfaces—

The majority of plots in the ABLA2 series are located in riparian zones on streambanks, terraces, and toeslopes, with relatively few in or on the margin of wetland sites.



Little additional information is gained by looking at the distribution of fluvial surfaces by association. A small number of plots located on wetter sites, such as the ABLA2/TRLA4 or ABLA2/TRCA3 associations, are located along the margins of high-elevation wetlands and basins (some with lakes) and along seeps and springs. In general, subalpine fir is only moderately tolerant of high water tables; riparian sites are the norm, and true wetland associations such as those mentioned above are less common.

Soils—



Mineral soils are the dominant soil types (94 percent) for plots in the ABLA2 series. Loam soils are the most common soil texture. Other mineral soil texture types were not as common. Only a few plots on wetter sites are classified as organic soils (including wood, peat, and muck listed as "other" in the soil texture table).

Few differences are apparent when looking at individual plant associations. As with the entire ABLA2 series, sand, loamy sand, and loam textures predominate. Whatever the association, very few plots occur on organic soils.

Average water tables at the time of sampling ranged from 3 to 75 inches below the soil surface and averaged 22 inches for the ABLA2 series as a whole. The higher water tables correlated well with species that are obligate to wetland soils such as globeflower, false bugbane, claspleaf twistedstalk, and lady fern. The 29-inch average for ABLA2/ALSI is somewhat misleading as these sites are flooded at spring runoff, which occurred before the sample season. Few plots had surface flooding at the time of sampling, so no table is shown. Flooding is most common on the ABLA2/TRLA4 association at snowmelt.

Plant association	Soil texture					N
	Sand	Loamy sand	Loam	Organic loam	Other	
ABLA2/ALSI	0	1	2	0	0	3
ABLA2/ARLA-POPU	0	0	2	0	0	2
ABLA2/ATFI	0	0	5	0	1	6
ABLA2/COCA	0	0	6	0	0	6
ABLA2/GYDR	3	5	8	0	0	16
ABLA2/LEGL-VASC	0	3	9	0	1	13
ABLA2/LIBOL	0	0	0	0	0	0
ABLA2/OPHO	1	0	1	0	0	2
ABLA2/PAMY	2	1	3	0	0	6
ABLA2/RHAL/LUHI	0	0	2	0	0	2
ABLA2/RHAL/SETR	1	1	5	2	0	9
ABLA2/RULA	0	0	2	0	0	2
ABLA2/STAMC	3	1	1	1	0	6
ABLA2/TRCA3	3	8	0	0	0	11
ABLA2/TRLA4	0	0	9	1	0	10
ABLA2/VAME	0	1	1	0	0	2
Series total	13	21	56	4	2	96

Plant association	Water table (inches)			N
	Minimum	Maximum	Average	
ABLA2/TRLA4	-26	-3	-12	6
ABLA2/TRCA3	-24	-8	-14	3
ABLA2/STAMC	-31	-7	-18	6
ABLA2/ATFI	-28	-16	-22	4
ABLA2/GYDR	-75	-8	-23	11
ABLA2/RHAL/SETR	-39	-12	-25	4
ABLA2/ALSI	-35	-22	-29	2
ABLA2/COCA	-31	-24	-29	3
Series	-75	-3	-22	39

Soil temperature data are available for 78 plots. With a few exceptions, the higher elevation, wetter associations have lower soil temperatures. The high average temperature for the ABLA2/OPHO association is an aberration from the one-plot sample. These sites should be much colder.

Plant association	Soil temperature (°F)			N
	Minimum	Maximum	Average	
ABLA2/OPHO	61	61	61	1
ABLA2/VAME	47	56	52	2
ABLA2/RULA	45	56	51	2
ABLA2/LEGL-VASC	42	62	50	9
ABLA2/COCA	41	53	49	5
ABLA2/RHAL/SETR	44	58	49	5
ABLA2/PAMY	46	50	48	3
ABLA2/ALSI	45	58	47	3
ABLA2/STAMC	43	55	47	6
ABLA2/TRLA4	45	58	47	8
ABLA2/ATFI	34	54	46	4
ABLA2/GYDR	33	53	46	15
ABLA2/TRCA3	35	57	46	11
ABLA2/ARLA-POPU	39	53	41	2
ABLA2/RHAL/LUHI	32	47	39	2
Series	32	62	48	78

ECOSYSTEM MANAGEMENT

Natural Regeneration of Subalpine Fir—

Subalpine fir reproduces from seed as well as layering (Alexander 1987, Arno and Hammerly 1984). Seed production can begin at 20 years of age when trees are 4 or 5 feet tall, but under closed-forest conditions, seed production is not significant until trees are older and taller. Maximum seed production is by vigorous, dominant trees between 150 and 200 years old. Good seed crops are erratic, occurring every 3 to 5 years. The large wing seeds are dispersed by the wind in the fall as the cones disintegrate. Most seed falls within one or two tree heights of the tree. Red squirrels harvest large quantities of cones, storing them in caches. Seeds germinating from these middens may form dense thickets. Seed germination occurs in the spring a few days after snowmelt. Seedlings establish best on mineral soils but will establish on litter and decaying wood. Subalpine fir is very shade tolerant and will establish under closed canopies. Therefore, subalpine fir seedlings often outnumber Engelmann spruce under mature canopies, even where Engelmann spruce dominates the overstory. At high elevations, seedling survival is often better on duff as the duff protects the seedlings from summer rainstorms and frost heaving. Seedling densities are often greater on mineral soils at lower elevations (Fiedler et al. 1985). At higher elevations, especially near or above timberline, subalpine fir reproduces by layering as heavy snow, wind, and cold temperatures result in growth along the ground. This often results in cloned clusters of subalpine fir. Layering is negligible at lower elevations under closed-forest canopies. (See the other tree series for descriptions of natural and artificial establishment of other tree species that may be found in ABLA2 series stands.)

Artificial Establishment of Subalpine Fir—

Subalpine fir is an undervalued timber species in eastern Washington, but where it occurs naturally, it can be planted on disturbed sites. A local plant association classification should be used to determine appropriate sites. Because subalpine fir exhibits a large degree of genetic variability, seed or nursery stock should come from a local source. Transplanting nursery-grown, bare root and container stock is usually more dependable than direct seeding. Seedlings grow very slowly so 2- to 3-year-old seedlings work best. Plantings usually do best on bare mineral soil. It is probably better to rely on the release of natural seedlings and saplings when using selection-cutting methods in riparian zones.

Many of the shrubs used to characterize the ABLA2 series are well adapted to planting on disturbed sites. Sitka alder can be established with container stock but usually reproduces faster and better from its abundant seed. Devil's club can be established from seed or cuttings or by layering although establishment is slow. Prickly currant, Hudsonbay currant, baldhip rose, dwarf bramble, bunchberry dogwood, and western thimbleberry can be easily grown from seed. Five-leaved bramble, twinflower, bunchberry dogwood, mountain arnica, dwarf bramble, and many other trailing plants can be easily propagated from root runners. Huckleberry cuttings root poorly but can be established from seed (growth is slow). Cascade azalea, like all ericaceous plants, can be propagated from seed or cuttings. However, the seed is small and the seedlings need two or three transplantings before being set out. Oak fern and lady fern are easily propagated from rhizomes. (For more information on the short- and long-term revegetation potential of selected riparian wetland plant species, see app. B-5.)

Stand Management—

Although tree productivity is fairly high in these sites, tree harvesting and associated management activities need to be carefully planned in riparian zones and especially within wetlands. Cold temperature regimes, including frost, are factors that limit tree growth. Loam soils are prevalent and are very susceptible to compaction during most of the growing season. Many of the larger trees have extensive heart rot and are "cull" trees. Subalpine fir and Engelmann spruce are both very susceptible to windthrow. Timber harvesting in these sites or adjacent sites that are upslope may increase the risk of windthrow and rising water tables. A clearcut adjacent to a small riparian zone could result in near total blowdown in the riparian zone.

Some sites (such as the ABLA2/TRLA4, ABLA2/TRCA3, ABLA2/ATFI, and ABLA2/OPHO associations) are somewhat swampy and, although tree growth is rapid, are difficult to manage for timber production (Lillybridge et al. 1995). Regeneration also may be difficult on these sites. Dense Sitka alder and Scouler's willow thickets can develop after tree removal on many ABLA2 sites. Management options in riparian zones appear to be limited to single-tree or small-group selection to open the canopy and increase understory production. Shelterwood and individual tree selection cuts will favor subalpine fir and Engelmann spruce, whereas group selection and clearcuts will favor seral species such as Douglas-fir and lodgepole pine. Scheduling any management activity during late summer/fall or during winter on snowpack will minimize soil disturbance.

Coarse, compaction-resistant soils are unusual except perhaps in some of the wetter associations. Loam soils, found on most of these sites, may predominate on account of silt and ash deposition on relatively fluvially inactive terraces. They are subject to compaction, especially when wet or moist. Heavy equipment should not be used on these sites in spring or summer when water tables are high. Wetter sites should be avoided at all seasons of the year (Hansen et al. 1995). Roads and trails should be located on adjacent uplands. Protection of water resources should be a major concern in the ABLA2 series.

Tree Growth and Yield—

Cold temperatures and heavy snowpacks are the main limitations to tree growth in the ABLA2 series (Lillybridge et al. 1995). Tree productivity is variable depending on elevation, temperature, and available moisture. In general, growth and yield is moderate or higher within this series. Many sites have favorable environments for producing large Engelmann spruce on account of the longevity of this species. The more productive associations are those located at moderate elevations where growing conditions are more favorable. These sites appear to have higher basal area and site index values. The associations found at high elevations generally have lower productivity, owing to the harsh environment and short growing season characteristic of these sites. Despite high elevations, the ABLA2/TRLA4 often have excellent individual tree growth, but stand production is low to moderate owing to stocking limitations caused by high water tables. Basal area averages 203 square feet per acre, which is moderate (apps. C-1a and C-1b). Subalpine fir and Engelmann spruce are the dominant species, accounting for more than 85 percent of the total basal area. In comparison, the LALY, PICO, TSME, BEPA, ACMA, ALRU, POTR2, and QUGA series have lower average basal areas. Similarly, average site index for individual species (feet) is moderate compared with other series (app. C-2). Tree productivity data are limited and should therefore be considered with caution.

Site index			
Species	Base age	No. of trees	SI
ABLA2	50	115	55
LAOC	50	38	64
PIAL	100	2	44
PICO	100	43	66
PIEN	50	194	63
PSME	50	22	60

Basal area (sq. ft./ac)	
Species	BA
ABAM	Tr
ABGR	2
ABLA2	51
ALIN	Tr
LAOC	6
PIAL	Tr
PICO	14
PIEN	109
PIMO	Tr
PIPO	Tr
POTR	Tr
POTR2	2
PSME	15
TSHE	Tr
Total	203

Down Wood—

The overall amount of down woody material is moderate compared with other tree series (app. C-3). Logs cover 10 percent of the ground surface. Smaller material is largely composed of lodgepole pine and subalpine fir. Larger logs usually are longer lived Engelmann spruce. However, ABLA2 sites are generally not capable of producing trees and logs as big as those seen in the ABAM, TSHE, or THPL series. This is primarily due to the prevalence of lodgepole pine and subalpine fir in younger stands.

Definitions of log decomposition classes are on page 15.

	Down log attributes				
Log decomposition	Tons/ acre	Cu. ft./ acre	Linear ft./ acre	Sq. ft./ acre	% ground cover
Class 1	2.57	216	321	252	0.58
Class 2	5.23	552	1,109	777	1.78
Class 3	6.94	889	2,095	1,308	3.00
Class 4	3.18	1,020	1,433	1,182	2.71
Class 5	2.67	857	912	897	2.06
Total	20.59	3,534	5,870	4,416	10.13

Snags—

The ABLA2 series has the most snags (54.3 snags per acre) of the tree series (app. C-4). Sixty-seven percent of the snags are less than 10 inches in diameter. Only 10 percent of the snags are larger than 15.5 inches in diameter. This is due primarily to the prevalence of smaller size trees, especially lodgepole pine, found in the younger stands.

Definitions of snag condition classes are on page 15.

	Snags/acre by d.b.h. class (inches)				
Snag condition	5–9.9	10–15.5	15.6–21.5	21.6+	Total
Class 1	23.5	4.1	1.2	1.0	29.8
Class 2	7.0	3.1	.8	.4	11.3
Class 3	3.1	.8	.1	.1	4.1
Class 4	1.2	2.7	.8	.3	5.0
Class 5	2.1	1.3	.5	.2	4.1
Total	36.9	12.0	3.4	2.0	54.3

Fire—

Subalpine fir is one of the least fire-resistant western conifers (Starker 1934). It is very susceptible to fire because of its thin flammable bark, shallow roots, low-growing branches, dense stands, highly flammable foliage, and moderate to heavy lichen growth. Engelmann spruce also is susceptible to fire although less so than subalpine fir.

The ABLA2 series varies from cold and wet at higher elevations and in riparian zones, to cool and dry at lower elevations. Lower elevation associations often have more frequent, less intense fires. Fires at this frequency have a tendency to kill subalpine fir and keep forests dominated by seral conifers such as Douglas-fir, lodgepole pine, or western larch (Arno and Hammerly 1984). Forests at higher elevations generally experience high-intensity stand-replacing fires at intervals of 100 years or more. These longer lived stands often have the opportunity to be dominated by subalpine fir and Engelmann spruce. The ABLA2 stands in high subalpine habitats often escape fires because of discontinuous fuels; broken, rocky terrain; and moist, cold environments in adjacent uplands (Pfister et al. 1977).

A total of 471 site index trees were sampled for age in the ABLA2 series. These trees averaged 127 years in age at breast height. One tree was over 400 years old, 9 were 300 to 399 years old, 48 were 200 to 299 years old, 206 were 100 to 199 years old, and 207 were less than 100 years old. Only 13 percent of the site index trees were more than 200 years old. Most of these older trees were Engelmann spruce, which are generally considered fire intolerant. Other old trees included western larch and Douglas-fir, which have high fire tolerance. Of 116 subalpine fir trees sampled, only 8 were older than 200 years. These data suggest that fires usually are large, stand-replacing fires. Average fire-return intervals in the ABLA2 series may be less than 150 years, perhaps closer to 100 years. However, the fire interval appears to be much longer (greater than 200 years) on wetter sites such as the ABLA2/ATFI and ABLA2/TRLA4 associations.

The fire regime of surrounding forests on uplands also may affect how often ABLA2 sites burn. Upland forests of lodgepole pine that are prone to high-intensity stand-replacement fire regimes often surround riparian and wetland zones in the ABLA2 series. The riparian zones most likely burn when the adjacent uplands experience stand-replacing fires.

Animals—

Livestock. The palatability of subalpine fir to domestic livestock is low (Dittberner and Olson 1983). In general, most ABLA2 stands have little utility for domestic livestock. Forage potential may be fair in early successional stages or on some of the wetter, open associations, but is generally poor in late-successional stages. Without suitable forage, these sites primarily represent sources of water and shade. In any case, sites are susceptible to trampling on account of high water tables and moist or wet soils.

If grazed, improving the grazing system and close monitoring of wildlife use often allows the remnant shrub and herb population to sprout and reestablish the stand. The ability to easily reestablish shrubs is lost, however, when the shrubs have been eliminated on account of overgrazing, when the soil has been compacted, or the water tables lowered because of stream downcutting. (For more information on forage palatability, see app. B-1. For potential biomass production, see app. B-5.)

Wildlife. The multiple shrub and tree layers associated with most stands provide considerable habitat diversity for wildlife. In general, these sites offer sources of cover, forage, and water. Most wildlife species use these sites in the summer as winters are cold and harsh. Many sites have large subalpine fir and Engelmann spruce trees with extensive heart rot decay that results in large trees, snags, and logs with hollow interiors.

Caribou are found in the Selkirk Mountains where they are very dependent on mature subalpine fir, Engelmann spruce, and western hemlock forests for the abundant arboreal lichens that are their staple winter food source. Some sites have an abundance of berry-producing shrubs, such as huckleberries, that provide food for a variety of birds and mammals. Large ungulates such as mule deer and elk will forage in subalpine fir stands during summer and fall. Deer, elk, moose, bighorn sheep, and snowshoe hares sometimes eat young subalpine fir, but it is not an important food item. Subalpine fir is an important food source for mountain goats and moose in winter and spring (Peek 1974, Saunders 1955). Black bears and American martens may use hollow logs for dens and rest sites. Black bears and grizzly bears also will forage on the abundant berries found in many subalpine fir stands. Grizzly bears sometimes strip off the bark of subalpine fir to eat the cambium (Blanchard 1980). Brooms formed by rusts are common, and martens use these brooms as platforms for resting. Red squirrels eat seeds from cached conifer cones (Lanner 1983). Chipmunks and mice also eat conifer seed.

Woodpeckers will forage large snags and logs, especially Engelmann spruce, for bark beetles and ants. Some common seed-eating birds include crossbills, nuthatches, pine siskin, chickadees, and Clark's nutcrackers. Blue grouse and Franklin's grouse make extensive use of fir buds, especially in winter. Other avian species include varied thrush, golden-crowned kinglet, Steller's jay, warblers, and flycatchers. Harlequin ducks and American dippers may be observed on nearby streams. (For more information on thermal or feeding cover values, see apps. B-2 and B-3. For information on food values or degree of use, see apps. B-2 and B-4.)

Fish. Riparian zones in the ABLA2 series play important roles in watershed function and hydrology. Many of these sites are located near small first- and second-order streams or basins high in the watershed where winter snowpacks are long and deep. In addition, in continental climate zones, the ABLA2 series follows cold air drainage to lower elevations into larger order drainages with larger fish-bearing streams. These areas serve as hydrologic reservoirs that help maintain streamflows during summer. Owing to windthrow and disease, many sites have an abundance of large woody debris in and along the stream channels. This woody debris, primarily large-diameter logs (especially spruce), provides good stream structure for fish and channel stabilization during peak flows associated with spring runoff or summer storms (for more information, see app. B-5, erosion control potential). The large tree canopies provide shade for the stream, helping to regulate stream water temperatures and promoting good fisheries habitat in downstream locations.

Managers may choose to maintain or manage for stands of larger conifers as future sources of woody debris. They may also manage for stable wetland series such as SALIX or ALSI along streambanks and floodplains. These buffer strips help stabilize streambanks, nearby terraces, and swales; provide a barrier to sedimentation from nearby slopes; and provide a source of large down wood for the stream and nearby fluvial surfaces.

Recreation—

Some sites are not suited for recreation uses owing to inaccessible locations or high water tables. Most recreation use on ABLA2 sites is limited to fishermen, backpackers, and day hikers passing through riparian zones along the streambank or established trails. However, the shrub layers in a few associations (such as ABLA2/RHAL/SETR) may be dense and tangled in open stands, thus resistant to access. Late-seral and old-growth stands may have high recreational value owing to their attractiveness and big trees (especially stands dominated by large Engelmann spruce). Other than fishing opportunities in nearby streams, stands in wetter associations such as ABLA2/ATFI, ABLA2/TRLA4, and ABLA2/TRCA3 are not well suited for recreation purposes owing to moist soils, high water tables, and seeps and springs.

The prevalent loam soils may be highly susceptible to compaction. Wetter sites may require wood boardwalks so that forest visitors do not trample sensitive vegetation and soils. Construction and maintenance of campgrounds and trails is not recommended on wetter associations, but others (such as ABLA2/LEGL-VASC and ABLA2/COCA) often occur on well-drained terraces well away from flood zones, providing favorable camps and trail sites. However, these sites, as well as old-growth stands, also are prone to windthrow of subalpine fir and Engelmann spruce owing to stem and root rot as well as shallow rooting systems.

Insects and Disease—

Root diseases are common in the ABLA2 series and include annosus root disease, armillaria root rot, Tomentosus root disease, brown cubical rot, rust red stringy rot, laminated root rot, and Schweinitzii butt rot (Hessburg et al. 1994). Schweinitzii butt rot is particularly common in older Engelmann spruce trees (Lillybridge et al. 1995). Some common stem rots include brown crumbly rot, brown stringy rot, red heart rot, white pocket rot, armillaria root rot, red belt fungus, and white spongy root rot. Natural or human-caused wounding of trees generally will increase damage from decay fungi in subalpine fir, whereas Engelmann spruce is more resistant. Fungal pathogens also increase, especially in subalpine fir as a result of infecting stumps from past timber harvesting.

Subalpine fir can be damaged or killed by various insects (Alexander et al. 1984, Carlson et al. 1983). Insects also attack many trees infected by fungal agents. Potential bark beetles include spruce beetle, western balsam bark beetle, fir engraver, and mountain pine beetle. The mountain pine beetle primarily infests lodgepole pine; large stands of fire-regenerated lodgepole pine are most susceptible. Other insect pests include Douglas-fir tussock moth, western black-headed budworm, balsam woolly adelgid, and fir engraver.

Estimating Vegetation Potential on Disturbed Sites—

This process is generally not needed on these conifer-dominated sites, as they are seldom heavily disturbed. Clearcutting in riparian areas is unusual on FS land, and many stands lie in wilderness. In addition, other vegetation in the SALIX, MEADOW, and ALSI series often separate the ABLA2 series from active flood zones. Currently, all FS riparian zones are buffered and not managed for timber management. If clearcut or burned in the past, subalpine fir and other conifers (especially lodgepole pine) have usually rapidly reestablished on these sites. Nearby stands or similar valley segments in nearby watersheds can help determine the potential natural vegetation in young stands or in the event of recent wildfire.

Sensitive Species—

Tweedy's willow was located on two plots in the ABLA2/LEGL-VASC and ABLA2/RHAL/SETR associations. It appears from these data that sensitive species are uncommon in the ABLA2 series (app. D).

ADJACENT SERIES

The ABLA2 series is bound below by the TSHE series in maritime climate zones. The TSHE, PIEN, or PSME series occur on lower elevation sites within inland maritime climates. The PSME series also occurs on lower elevation sites within strong continental climates. The parkland and alpine zones lie above the ABLA2 series throughout its distribution. Whitebark pine parkland (Lillybridge et al. 1995, Williams et al. 1995) usually occurs at higher elevations in both continental and inland maritime climates.

RELATIONSHIPS TO OTHER CLASSIFICATIONS

Kovalchik (1992c) described many of the plant associations in the ABLA2 series in the draft classification for northeastern Washington. Riparian plant associations described in the ABLA2 series represent relatively wet stand conditions for subalpine fir plant associations previously described for uplands on the Wenatchee NF by Lillybridge et al. (1995) and the Colville NF by Williams et al. (1995). They focused on upland environments but included several plant associations exclusive to riparian and wetland zones. Some of the associations in this classification that were derived from Lillybridge et al. (1995) and Williams et al. (1995) include ABLA2/ARLA-POPU, ABLA2/COCA, ABLA2/LIBOL, ABLA2/PAMY, ABLA2/RHAL/LUHI, ABLA2/RULA, ABLA2/TRCA3, and ABLA2/VAME. The ABLA2/ALSI, ABLA2/ATFI, ABLA2/GYDR, ABLA2/LEGL-VASC, ABLA2/OPHO, ABLA2/RHAL/SETR, ABLA2/STAMC, and ABLA2/TRLA4 associations were not previously described in published classifications for the study area except for some in the Kovalchik (1992c) draft.

Plant associations belonging to the ABLA2 series have been described in the Washington Cascade Range (Lillybridge et al. 1995, Williams and Lillybridge 1983); Colville, Spokane, and Yakima Indian reservations (Clausnitzer and Zamora 1987, John et al. 1988, Zamora 1983,); eastern Washington, northern Idaho, and Montana (Cooper et al. 1991, Daubenmire and Daubenmire 1968, Hansen et al. 1988, Hansen et al. 1995, Pfister et al. 1977, Williams et al. 1995); and central and northeastern Oregon (Crowe and Clausnitzer 1997, Hall 1973, Johnson and Clausnitzer 1992, Johnson and Simon 1987). Crowe and Clausnitzer (1997) and Hansen et al. (1998, 1995) are strictly riparian/wetland classifications. A similar "Engelmann spruce-subalpine fir zone" has been described for British Columbia (Braumandl and Curran 1992, Lloyd et al. 1990, and Meidinger and Pojar 1991). The ABLA2 series has very limited distribution west of the Cascade crest (Henderson et al. 1989, 1992).

U.S. DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE WETLANDS CLASSIFICATION

System:	palustrine
Class:	forested wetland
Subclass:	needle-leaved evergreen
Water regime:	(nontidal) intermittently saturated to seasonally saturated

KEY TO THE SUBALPINE FIR (*ABIES LASIOCARPA*) PLANT ASSOCIATIONS

1. Saw-leaved sedge (*Carex scopulorum* var. *prionophylla*) ≥10 percent canopy coverage .... **Engelmann spruce/saw-leaved sedge (PIEN/CASCP2) association**
2. Common horsetail (*Equisetum arvense*), wood horsetail (*Equisetum sylvaticum*), and/or soft-leaved sedge (*Carex disperma*) ≥10 percent canopy coverage .... **Engelmann spruce/horsetail (PIEN/EQUIS) association**
3. Devil's club (*Oplopanax horridum*) ≥5 percent canopy coverage .... **Subalpine fir/devil's club (ABLA2/OPHO) association**
4. Lady fern (*Athyrium filix-femina*) ≥5 percent canopy coverage .... **Subalpine fir/lady fern (ABLA2/ATFI) association**
5. Oak fern (*Gymnocarpium dryopteris*) ≥5 percent canopy coverage .... **Subalpine fir/oak fern (ABLA2/GYDR) association**
6. Sitka alder (*Alnus sinuata*) ≥25 percent canopy coverage .... **Subalpine fir/Sitka alder (ABLA2/ALSI) association**
7. False bugbane (*Trautvetteria caroliniensis*) ≥5 percent canopy coverage .... **Subalpine fir/false bugbane (ABLA2/TRCA3) association**
8. Globeflower (*Trollius laxus*) ≥2 percent canopy coverage .... **Subalpine fir/globeflower (ABLA2/TRLA4) association**
9. Labrador tea (*Ledum glandulosum*) ≥5 percent canopy coverage .... **Subalpine fir/Labrador tea-grouse huckleberry (ABLA2/LEGL-VASC) association**
10. Cascade azalea (*Rhododendron albiflorum*) ≥5 percent canopy coverage:
    - 10a. Smooth woodrush (*Luzula hitchcockii*) ≥1 percent canopy coverage .... **Subalpine fir/Cascade azalea/smooth woodrush (ABLA2/RHAL/LUHI) association**
    - 10b. Smooth woodrush (*Luzula hitchcockii*) <1 percent canopy coverage (sites generally wetter) .... **Subalpine fir/Cascade azalea/arrow-leaf groundsel (ABLA2/RHAL/SETR) association**
11. Claspleaf twisted-stalk (*Streptopus amplexifolius*) ≥1 percent canopy coverage .... **Subalpine fir/claspleaf twisted-stalk (ABLA2/STAMC) association**
12. Dwarf bramble (*Rubus lasiococcus*) ≥2 percent canopy coverage .... **Subalpine fir/dwarf bramble (ABLA2/RULA) association**
13. Bunchberry dogwood (*Cornus canadensis*) ≥2 percent canopy coverage .... **Subalpine fir/bunchberry dogwood (ABLA2/COCA) association**
14. Myrtle pachistima (*Pachistima myrsinites*) ≥5 percent canopy coverage .... **Subalpine fir/myrtle pachistima (ABLA2/PAMY) association**
15. Dwarf huckleberry (*Vaccinium caespitosum*) or bearberry (*Arctostaphylos uva-ursi*) ≥5 percent canopy coverage; cold-air drainage sites .... **Subalpine fir/dwarf huckleberry (ABLA2/VACA) association** (not described here—see Williams et al. 1995)
16. Twinflower (*Linnaea borealis* var. *longiflora*) ≥5 percent canopy coverage .... **Subalpine fir/twinflower (ABLA2/LIBOL) association**
17. Mountain arnica (*Arnica latifolia*), skunkleaf polemonium (*Polemonium pulcherrimum*) or Sitka valerian (*Valeriana sitchensis*) ≥2 percent canopy coverage .... **Subalpine fir/mountain arnica-skunkleaf polemonium (ABLA2/ARLA-POPU) association**
18. Big huckleberry (*Vaccinium membranaceum*) ≥5 percent canopy coverage .... **Subalpine fir/big huckleberry (ABLA2/VAME) association**
19. Grouse huckleberry (*Vaccinium scoparium*) ≥5 percent canopy coverage .... **Subalpine fir/grouse huckleberry (ABLA2/VASC) association** (not described here—see Williams et al. 1995)

Table 5—Constancy and mean cover of important plant species in the ABLA2 plant associations—Part 1

Species	Code	ABLA2/ALSI 3 plots		ABLA2/ARLA-POPU 3 plots		ABLA2/ATFI 10 plots		ABLA2/COCA 21 plots		ABLA2/GYDR 19 plots		ABLA2/LEGL-VASC 16 plots		ABLA2/LIBOL 4 plots		ABLA2/OPHO 3 plots	
		CON[a]	COV[b]	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV
Tree overstory:																	
subalpine fir	ABLA2	100	6	100	28	90	23	86	11	100	16	88	14	100	5	100	27
western larch	LAOC	—	—	—	—	10	3	52	13	32	3	—	—	75	15	—	—
Engelmann spruce	PIEN	100	42	100	33	100	32	95	37	100	34	88	29	100	11	100	30
lodgepole pine	PICO	—	—	33	10	10	Tr[c]	38	6	21	1	63	18	100	26	—	—
Douglas-fir	PSME	—	—	—	—	20	5	81	15	42	12	—	—	75	15	33	5
Tree understory:																	
subalpine fir	ABLA2	67	2	100	19	90	3	81	7	100	7	100	8	100	6	100	7
Engelmann spruce	PIEN	67	3	100	8	100	2	95	5	95	4	88	6	100	6	100	1
Douglas-fir	PSME	—	—	—	—	—	—	52	5	26	2	—	—	75	4	—	—
Shrubs:																	
Douglas maple	ACGLD	—	—	—	—	20	15	24	6	26	9	—	—	—	—	33	2
mountain alder	ALIN	—	—	—	—	40	5	14	2	53	3	13	4	—	—	—	—
Sitka alder	ALSI	100	58	33	5	30	Tr	24	2	42	3	13	3	—	—	67	30
Saskatoon serviceberry	AMAL	—	—	—	—	—	—	67	2	47	1	6	Tr	25	1	—	—
red-osier dogwood	COST	—	—	—	—	20	2	29	7	58	3	—	—	—	—	—	—
bearberry honeysuckle	LOIN	67	2	67	5	40	1	62	2	37	2	63	2	50	1	33	2
Utah honeysuckle	LOUT	—	—	—	—	40	2	62	3	47	2	6	Tr	50	3	—	—
rusty menziesia	MEFE	—	—	—	—	30	22	5	Tr	11	11	—	—	—	—	33	70
devil's club	OPHO	—	—	—	—	—	—	—	—	11	3	—	—	—	—	100	13
Cascade azalea	RHAL	—	—	—	—	20	7	5	1	16	11	38	6	—	—	33	10
Hudsonbay currant	RIHU	33	20	—	—	20	1	—	—	16	1	—	—	—	—	33	5
prickly currant	RILA	67	5	33	10	100	6	76	3	95	2	38	2	25	1	100	7
baldhip rose	ROGY	—	—	—	—	10	Tr	57	3	16	2	—	—	—	—	—	—
western thimbleberry	RUPA	33	Tr	33	Tr	70	2	57	3	79	4	—	—	—	—	33	50
Scouler's willow	SASC	33	3	—	—	—	—	—	—	11	3	6	2	—	—	33	8
Cascade mountain-ash	SOSC2	33	Tr	33	2	30	1	19	2	26	Tr	13	Tr	—	—	—	—
shiny-leaf spiraea	SPBEL	—	—	—	—	10	Tr	33	3	37	1	13	1	—	—	—	—
common snowberry	SYAL	33	Tr	—	—	40	1	48	3	37	2	—	—	—	—	—	—
big huckleberry	VAME	—	—	33	13	40	14	38	3	37	4	25	6	25	4	33	5
Low shrubs and subshrubs:																	
western prince's-pine	CHUM	—	—	—	—	10	4	71	2	26	2	6	Tr	75	2	33	Tr
bunchberry dogwood	COCA	—	—	—	—	30	Tr	100	11	68	6	19	3	25	1	—	—
Labrador tea	LEGL	—	—	33	6	—	—	10	1	5	12	100	24	—	—	—	—
twinflower	LIBOL	—	—	—	—	—	—	95	11	79	7	44	6	100	6	—	—
myrtle pachistima	PAMY	—	—	67	18	20	Tr	76	4	21	1	19	10	100	3	67	2
red mountain-heath	PHEM	—	—	33	3	—	—	—	—	—	—	38	7	—	—	—	—
dwarf bramble	RULA	—	—	—	—	—	—	—	—	11	4	—	—	—	—	—	—
five-leaved bramble	RUPE	—	—	—	—	60	6	14	4	53	8	—	—	—	—	—	—
dwarf huckleberry	VACA	—	—	33	2	—	—	24	5	—	—	6	Tr	—	—	—	—
low huckleberry	VAMY	—	—	67	1	—	—	29	6	21	4	31	9	50	3	—	—
grouse huckleberry	VASC	—	—	33	1	20	1	38	6	5	3	81	43	50	38	—	—
Perennial forbs:																	
deerfoot vanilla-leaf	ACTR	—	—	—	—	10	10	—	—	—	—	—	—	—	—	—	—
baneberry	ACRU	33	Tr	—	—	40	1	38	2	74	1	—	—	—	—	67	1
pathfinder	ADBI	—	—	—	—	10	Tr	10	2	26	1	—	—	—	—	33	Tr
sharptooth angelica	ANAR	67	1	67	4	10	Tr	—	—	26	1	19	1	—	—	33	Tr

Table 5—Constancy and mean cover of important plant species in the ABLA2 plant associations—Part 1 (continued)

		ABLA2/ALSI 3 plots		ABLA2/ARLA-POPU 3 plots		ABLA2/ATFI 10 plots		ABLA2/COCA 21 plots		ABLA2/GYDR 19 plots		ABLA2/LEGL-VASC 16 plots		ABLA2/LIBOL 4 plots		ABLA2/OPHO 3 plots	
Species	**Code**	**CON**	**COV**	**CON**	**COV**	**CON**	**COV**	**CON**	**COV**	**CON**	**COV**	**CON**	**COV**	**CON**	**COV**	**CON**	**COV**
wild sarsaparilla	ARNU3	—	—	—	—	—	—	10	18	—	—	—	—	—	—	—	—
heartleaf arnica	ARCO	33	Tr	33	1	20	4	38	2	26	2	44	2	—	—	—	—
mountain arnica	ARLA	33	Tr	67	4	—	—	5	1	—	—	38	6	—	—	67	Tr
queencup beadlily	CLUN	—	—	—	—	50	3	43	2	42	2	—	—	25	1	33	Tr
Hooker's fairy-bells	DIHO	—	—	—	—	30	1	5	5	5	1	—	—	—	—	33	Tr
dentate shooting-star	DODE	—	—	—	—	10	1	5	Tr	16	1	—	—	—	—	—	—
sweetscented bedstraw	GATR	67	Tr	33	Tr	90	2	57	2	95	1	—	—	—	—	—	—
western rattlesnake plantain	GOOB	—	—	—	—	60	1	52	1	37	1	—	—	25	4	33	Tr
common cow-parsnip	HELA	67	1	33	5	30	1	10	1	21	Tr	—	—	—	—	—	—
partridgefoot	LUPE	—	—	—	—	—	—	—	—	—	—	6	1	—	—	—	—
broadleaf lupine	LULA	—	—	33	1	—	—	—	—	—	—	19	Tr	25	35	—	—
fivestamen miterwort	MIPE	—	—	—	—	30	3	—	—	5	5	—	—	—	—	—	—
mountain sweet-root	OSCH	—	—	33	Tr	30	2	52	2	26	1	13	4	25	1	33	2
purple sweet-root	OSPU	67	Tr	33	Tr	20	1	24	1	21	2	6	Tr	—	—	33	Tr
skunkleaf polemonium	POPU	—	—	67	1	—	—	—	—	5	Tr	19	Tr	—	—	—	—
pink wintergreen	PYAS	—	—	—	—	50	2	14	Tr	42	1	13	1	—	—	33	Tr
sidebells pyrola	PYSE	33	1	100	1	70	2	76	2	58	1	50	1	75	2	33	1
brook saxifrage	SAAR	—	—	—	—	10	4	—	—	5	2	—	—	—	—	—	—
dotted saxifrage	SAPU	67	1	—	—	10	1	—	—	11	Tr	13	Tr	—	—	—	—
arrowleaf groundsel	SETR	67	1	33	1	50	3	10	Tr	37	1	31	1	—	—	33	Tr
starry solomonplume	SMST	—	—	—	—	50	1	62	1	42	1	6	2	—	—	—	—
claspleaf twisted-stalk	STAM	33	1	—	—	70	2	33	1	84	2	44	1	—	—	67	Tr
western meadowrue	THOC	67	Tr	33	25	30	1	38	2	21	Tr	13	9	25	3	33	Tr
coolwort foamflower	TITRU	33	Tr	—	—	90	8	29	2	79	7	—	—	25	1	33	Tr
false bugbane	TRCA3	—	—	—	—	30	2	14	1	37	3	6	5	—	—	—	—
globeflower	TRLA4	67	Tr	33	Tr	10	Tr	—	—	5	Tr	25	1	—	—	—	—
Sitka valerian	VASI	33	1	100	22	20	2	5	1	21	1	75	3	—	—	—	—
American false hellebore	VEVI	—	—	—	—	30	2	—	—	11	3	13	Tr	—	—	—	—
Canadian violet	VICA	—	—	—	—	10	10	5	Tr	5	Tr	—	—	—	—	—	—
pioneer violet	VIGL	67	Tr	33	1	30	1	24	2	42	1	6	Tr	—	—	33	Tr
Grasses or grasslike:																	
pinegrass	CARU	—	—	—	—	—	—	62	6	5	5	13	Tr	50	18	—	—
northwestern sedge	CACO	—	—	—	—	—	—	38	3	5	2	6	2	75	2	—	—
soft-leaved sedge	CADI	—	—	—	—	10	3	5	Tr	42	2	—	—	—	—	—	—
saw-leaved sedge	CASCP2	—	—	—	—	—	—	—	—	5	4	44	3	—	—	—	—
wood reed-grass	CILA2	33	Tr	—	—	40	1	14	Tr	58	1	13	Tr	—	—	—	—
blue wildrye	ELGL	—	—	33	5	10	Tr	10	1	5	Tr	—	—	—	—	—	—
smooth woodrush	LUHI	—	—	33	1	10	2	—	—	—	—	13	Tr	—	—	—	—
smallflowered woodrush	LUPA	—	—	—	—	—	—	—	—	21	Tr	13	Tr	—	—	—	—
Ferns and fern allies:																	
lady fern	ATFI	33	Tr	—	—	100	12	10	Tr	68	1	—	—	—	—	100	4
wood-fern	DREX	—	—	—	—	20	10	—	—	5	Tr	—	—	—	—	—	—
wood-fern species	DRYOP	—	—	—	—	—	—	—	—	—	—	—	—	—	—	33	25
common horsetail	EQAR	33	3	—	—	40	2	19	1	68	2	19	1	—	—	—	—
oak fern	GYDR	—	—	—	—	70	15	10	1	100	19	—	—	—	—	—	—

Table 5—Constancy and mean cover of important plant species in the ABLA2 plant associations—Part 2

Species	Code	ABLA2/PAMY 7 plots		ABLA2/RHAL/LUHI 2 plots		ABLA2/RHAL/SETR 10 plots		ABLA2/ABLA2/RULA 2 plots		ABLA2/STAMC 6 plots		ABLA2/TRCA3 19 plots		ABLA2/TRLA4 12 plots		ABLA2/VAME 2 plots	
		CON[a]	COV[b]	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV
Tree overstory:																	
subalpine fir	ABLA2	100	22	100	23	100	12	100	19	100	18	89	22	83	11	100	14
western larch	LAOC	—	—	—	—	—	—	50	3	—	—	42	19	—	—	—	—
Engelmann spruce	PIEN	100	33	100	18	90	18	100	13	100	36	89	25	100	32	100	23
lodgepole pine	PICO	29	1	—	—	30	13	—	—	50	2	42	19	33	7	—	—
Douglas-fir	PSME	86	22	—	—	10	5	100	18	50	2	37	5	—	—	50	28
Tree understory:																	
subalpine fir	ABLA2	100	7	100	10	100	7	100	4	100	3	74	10	83	7	100	4
Engelmann spruce	PIEN	100	7	100	3	90	2	100	Tr	83	3	74	5	75	3	100	5
Douglas-fir	PSME	14	Tr[c]	—	—	—	—	50	3	—	—	5	Tr	—	—	—	—
Shrubs:																	
Douglas maple	ACGLD	43	1	—	—	—	—	50	Tr	17	Tr	—	—	—	—	—	—
mountain alder	ALIN	43	7	—	—	—	—	—	—	67	13	42	7	—	—	—	—
Sitka alder	ALSI	43	3	—	—	30	3	—	—	33	7	32	7	—	—	50	18
Saskatoon serviceberry	AMAL	57	4	—	—	—	—	50	Tr	—	—	16	1	—	—	—	—
red-osier dogwood	COST	29	3	—	—	—	—	—	—	—	—	5	1	—	—	—	—
bearberry honeysuckle	LOIN	86	1	—	—	40	4	50	Tr	100	1	42	1	25	2	100	1
Utah honeysuckle	LOUT	—	—	—	—	10	Tr	—	—	33	Tr	42	2	—	—	—	—
rusty menziesia	MEFE	—	—	—	—	10	1	—	—	—	—	11	3	—	—	—	—
devil's club	OPHO	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cascade azalea	RHAL	—	—	100	36	100	52	—	—	17	Tr	16	1	17	6	—	—
Hudsonbay currant	RIHU	—	—	—	—	—	—	—	—	33	1	32	1	—	—	—	—
prickly currant	RILA	100	4	—	—	40	2	100	1	100	3	89	5	17	4	100	3
baldhip rose	ROGY	29	4	—	—	—	—	50	Tr	—	—	5	2	—	—	50	30
western thimbleberry	RUPA	57	2	—	—	—	—	50	2	33	2	32	3	—	—	50	4
Scouler's willow	SASC	14	3	—	—	10	10	—	—	33	5	11	2	—	—	—	—
Cascade mountain-ash	SOSC2	43	1	—	—	20	2	—	—	33	Tr	11	2	8	Tr	50	5
shiny-leaf spiraea	SPBEL	43	3	—	—	10	Tr	—	—	33	Tr	5	1	—	—	50	1
common snowberry	SYAL	14	1	—	—	—	—	50	12	—	—	16	1	—	—	100	21
big huckleberry	VAME	43	2	50	12	80	10	50	Tr	17	Tr	37	11	8	5	100	35
Low shrubs and subshrubs:																	
western prince's-pine	CHUM	57	1	—	—	20	1	—	—	17	Tr	32	1	8	1	50	3
bunchberry dogwood	COCA	—	—	—	—	—	—	—	—	17	Tr	21	2	8	1	—	—
Labrador tea	LEGL	14	3	50	2	50	4	—	—	33	Tr	—	—	50	2	—	—
twinflower	LIBOL	—	—	—	—	—	—	50	Tr	50	Tr	47	4	—	—	50	15
myrtle pachistima	PAMY	100	23	—	—	20	Tr	100	Tr	17	Tr	37	1	8	Tr	100	44
red mountain-heath	PHEM	—	—	100	7	50	1	—	—	—	—	—	—	33	4	—	—
dwarf bramble	RULA	—	—	—	—	—	—	100	4	—	—	11	17	—	—	—	—
five-leaved bramble	RUPE	14	1	—	—	10	Tr	—	—	17	Tr	11	10	8	5	—	—
dwarf huckleberry	VACA	—	—	—	—	—	—	—	—	—	—	—	—	25	3	—	—
low huckleberry	VAMY	43	1	50	60	40	12	—	—	67	Tr	26	3	—	—	—	—
grouse huckleberry	VASC	43	1	50	8	50	11	50	Tr	33	4	16	3	100	5	—	—
Perennial forbs:																	
deerfoot vanilla-leaf	ACTR	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
baneberry	ACRU	29	Tr	—	—	10	Tr	50	Tr	50	1	16	5	—	—	—	—
pathfinder	ADBI	14	Tr	—	—	—	—	50	20	—	—	—	—	—	—	—	—
sharptooth angelica	ANAR	14	Tr	—	—	—	—	50	Tr	50	Tr	32	2	—	—	50	3
wild sarsaparilla	ARNU3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 5—Constancy and mean cover of important plant species in the ABLA2 plant associations—Part 2 (continued)

Species	Code	ABLA2/PAMY 7 plots		ABLA2/RHAL/LUHI 2 plots		ABLA2/RHAL/SETR 10 plots		ABLA2/ABLA2/RULA 2 plots		ABLA2/STAMC 6 plots		ABLA2/TRCA3 19 plots		ABLA2/TRLA4 12 plots		ABLA2/VAME 2 plots	
		CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV
mountain arnica	ARLA	—	—	100	3	50	6	—	—	—	—	16	26	67	3	—	—
queencup beadlily	CLUN	29	16	—	—	—	—	50	2	—	—	42	4	—	—	50	55
Hooker's fairy-bells	DIHO	29	Tr	—	—	—	—	50	1	—	—	11	1	8	Tr	—	—
dentate shooting-star	DODE	—	—	—	—	10	Tr	—	—	50	1	5	Tr	25	4	—	—
sweetscented bedstraw	GATR	43	Tr	—	—	—	—	—	—	83	Tr	58	2	—	—	50	1
western rattlesnake plantain	GOOB	57	Tr	—	—	20	Tr	50	Tr	17	Tr	42	1	—	—	50	1
common cow-parsnip	HELA	—	—	—	—	10	Tr	50	Tr	33	Tr	16	1	—	—	50	Tr
partridgefoot	LUPE	—	—	50	50	20	2	—	—	—	—	—	—	—	—	—	—
broadleaf lupine	LULA	—	—	—	—	10	Tr	—	—	—	—	11	26	33	Tr	—	—
fivestamen miterwort	MIPE	—	—	—	—	40	1	50	Tr	33	1	5	2	58	7	—	—
mountain sweet-root	OSCH	14	Tr	—	—	10	Tr	50	3	—	—	32	2	17	3	—	—
purple sweet-root	OSPU	43	Tr	—	—	10	Tr	—	—	—	—	16	5	33	1	100	1
skunkleaf polemonium	POPU	—	—	—	—	—	—	—	—	—	—	5	3	42	1	—	—
pink wintergreen	PYAS	14	Tr	—	—	—	—	—	—	33	Tr	16	6	25	1	50	3
sidebells pyrola	PYSE	100	1	50	1	50	1	100	1	100	1	95	2	50	1	50	2
brook saxifrage	SAAR	—	—	—	—	10	1	—	—	100	1	—	—	—	—	—	—
dotted saxifrage	SAPU	14	Tr	—	—	20	1	50	Tr	—	—	16	5	25	17	—	—
arrowleaf groundsel	SETR	—	—	100	Tr	50	1	50	Tr	83	Tr	47	1	100	3	—	—
starry solomonplume	SMST	29	Tr	—	—	—	—	50	15	—	—	42	1	—	—	50	30
claspleaf twisted-stalk	STAM	29	Tr	—	—	60	1	50	Tr	100	1	42	2	50	1	—	—
western meadowrue	THOC	43	Tr	50	Tr	—	—	100	Tr	50	1	53	3	67	2	100	2
coolwort foamflower	TITRU	43	Tr	—	—	10	Tr	—	—	—	—	53	3	8	20	50	4
false bugbane	TRCA3	—	—	—	—	20	3	50	Tr	—	—	95	19	—	—	—	—
globeflower	TRLA4	—	—	—	—	20	2	—	—	17	Tr	5	Tr	100	7	—	—
Sitka valerian	VASI	14	Tr	100	4	60	6	—	—	17	Tr	16	3	83	14	50	25
American false hellebore	VEVI	—	—	50	1	50	2	—	—	—	—	11	2	58	2	—	—
Canadian violet	VICA	—	—	—	—	—	—	—	—	—	—	5	2	—	—	—	—
pioneer violet	VIGL	29	Tr	—	—	—	—	—	—	33	Tr	37	4	17	1	100	2
Grasses or grasslike:																	
pinegrass	CARU	—	—	—	—	—	—	—	—	17	Tr	11	2	—	—	50	3
northwestern sedge	CACO	—	—	—	—	—	—	—	—	—	—	5	3	—	—	—	—
soft-leaved sedge	CADI	—	—	—	—	—	—	—	—	50	Tr	11	2	8	3	—	—
saw-leaved sedge	CASCP2	14	Tr	—	—	70	1	—	—	50	1	11	Tr	42	2	—	—
wood reed-grass	CILA2	—	—	—	—	—	—	50	Tr	50	Tr	11	1	—	—	—	—
blue wildrye	ELGL	—	—	—	—	—	—	50	2	—	—	—	—	—	—	50	2
smooth woodrush	LUHI	—	—	100	1	30	Tr	—	—	—	—	—	—	50	3	—	—
smallflowered woodrush	LUPA	14	Tr	—	—	—	—	—	—	67	Tr	16	Tr	33	Tr	—	—
Ferns and fern allies:																	
lady fern	ATFI	—	—	—	—	—	—	—	—	17	Tr	21	2	—	—	—	—
wood-fern	DREX	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
wood-fern species	DRYOP	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
common horsetail	EQAR	43	1	—	—	—	—	—	—	50	Tr	32	1	—	—	—	—
oak fern	GYDR	14	Tr	—	—	—	—	—	—	—	—	11	Tr	—	—	50	3

[a] CON = percentage of plots in which the species occurred.
[b] COV = average canopy cover in plots in which the species occurred.
[c] Tr = trace cover, less than 1 percent canopy cover.

ENGELMANN SPRUCE SERIES

Picea engelmannii

PIEN N = 100

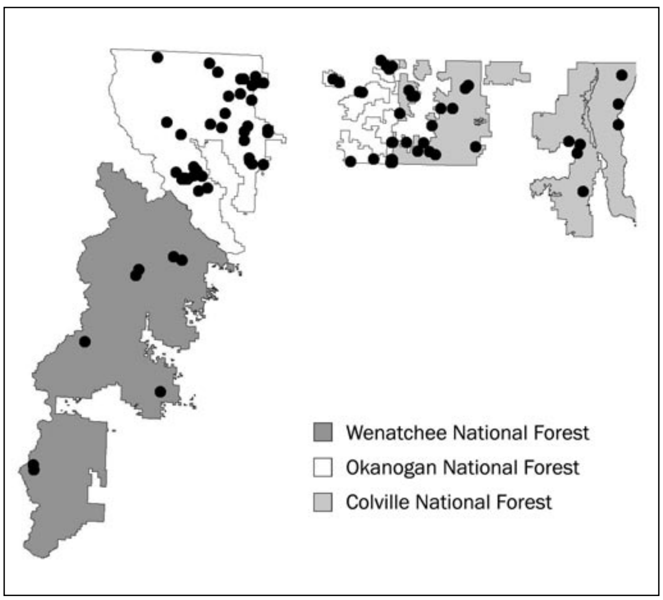


Figure 12—Plot locations for the Engelmann spruce series.

THE RANGE OF Engelmann spruce[1] extends from central British Columbia east to southwestern Alberta, south on the eastern slopes of the Cascade Range, and southeast and south through the Rocky Mountain states to New Mexico and Arizona (Hitchcock and Cronquist 1973). It is a minor component of forests on the west side of the Cascade Range (Alexander and Shepperd 1984).

Engelmann spruce is often thought of as a high-elevation upland species, but in eastern Washington it is found at various elevations on well-drained soils in riparian zones as well as on semipermanently saturated soils in wetlands (Kovalchik 1992c). It is also a very common species at timberline, where it often depends on subalpine larch or whitebark pine "mother tree" microsites for regeneration (Lillybridge et al. 1995). It eventually assumes a surprisingly large, erect form on these sites. Engelmann spruce is commonly codominant with subalpine fir in ABLA2 series upland stands (Lillybridge et al. 1995, Williams et al. 1995) and is also a seral component of the tree canopy in other upland series.

The literature generally considers climax stands of Engelmann spruce as widely scattered and characterized by the absence or scant representation of subalpine fir (Alexander 1987, Pfister et al. 1977, Steele et al. 1983). The PIEN series is generally restricted to wet or cold habitats.

Three conditions lead to a relatively widespread occurrence of the PIEN series in eastern Oregon and eastern Washington (Kovalchik 1987, 1992c). First, Engelmann spruce's shallow, widespread root system allows it to tolerate wetter soil conditions than subalpine fir and other conifers in eastern Washington. The PIEN series dominates many forested wetlands over a wide range of elevations. Secondly, Engelmann spruce also tolerates warmer temperatures than subalpine fir in eastern Washington. This tolerance is aided by the apparent hybridization of Engelmann spruce with white spruce near the Canadian border. Therefore many PIEN sites lie at elevations below the ecological extent of subalpine fir. Finally, extensive areas of continental climate provide an abundance of moist, warm PIEN sites that other series (ABGR, THPL, and TSHE) would occupy within maritime and inland maritime climates.

Engelmann spruce is quite shade tolerant compared with Douglas-fir and ponderosa pine, and it is roughly equivalent to subalpine fir. It is less shade tolerant than mountain hemlock, Pacific silver fir, western redcedar, western hemlock, and (perhaps) grand fir. Like subalpine fir, the PIEN series is most common in areas characterized by continental climates such as those in the northern Cascade Range and the Okanogan Highlands east of the Okanogan Cascade crest, north of the Entiat River, and west of the Kettle Range. In maritime climatic zones the PIEN series is generally replaced by conifers with greater shade tolerance in riparian zones and is largely restricted to wetland sites where other conifers have difficulty growing on waterlogged soils. The PIEN series (other than the PIEN/EQUIS association) was not described in the forested upland classifications for eastern Washington (Lillybridge et al. 1995, Williams et al. 1995).

[1] See appendix A for a cross reference for all species codes and common and scientific names used in this document.

Engelmann spruce plant associations

	Scientific name	Common name	Ecoclass code	Plots
Major associations:				
PIEN/CASCP2	*Picea engelmannii/Carex scopulorum* var. *prionophylla*	Engelmann spruce/saw-leaved sedge	CEM131	31
PIEN/COCA	*Picea engelmannii/Cornus canadensis*	Engelmann spruce/bunchberry dogwood	CEM321	18
PIEN/COST	*Picea engelmannii/Cornus stolonifera*	Engelmann spruce/red-osier dogwood	CES511	16
PIEN/EQUIS	*Picea engelmannii/Equisetum* species	Engelmann spruce/horsetail species	CEM211	19
PIEN/SYAL	*Picea engelmannii/Symphoricarpos albus*	Engelmann spruce/common snowberry	CES521	8
Minor associations:				
PIEN/ARNU3	*Picea engelmannii/Aralia nudicaulis*	Engelmann spruce/wild sarsaparilla	CEM214	4
PIEN/GYDR	*Picea engelmannii/Gymnocarpium dryopteris*	Engelmann spruce/oak fern	CEM21	4

CLASSIFICATION DATABASE

The presence of Engelmann spruce as the most successful conifer is characteristic of the series. The series was sampled on all three NFs and all RDs in eastern Washington (fig. 12). Seventy-seven riparian and wetland sample plots were measured in the PIEN series. Data from an additional 23 plots from other ecology data were included to facilitate classification and to provide additional data for species composition, distribution, and elevation. From this database, five major and two minor plant associations are recognized. Three other potential one-plot associations (PIEN/ALLUVIAL BAR, PIEN/BEGL-SCMI, and PIEN/PAMY) are not used in the database or described in this classification. For the most part, the information in the PIEN series represents mature stands in late-seral to climax conditions. However, some mid-seral plots were located in zones of extensive, mature lodgepole pine stands that originated in the widespread stand-replacing fires of the early 1900s.

VEGETATION CHARACTERISTICS

Late-seral and climax stands are dominated by large, long-lived Engelmann spruce. Engelmann spruce is the most common tree in the understory. Although relatively intolerant of high water tables, subalpine fir overstory and understory is common on dry, raised hummocks in the wetter PIEN/CASCP2 and PIEN/EQUIS associations. Even though subalpine fir may have 10 percent or more canopy coverage in some stands in these two associations, the stands are keyed to the PIEN series on account of the dominance of Engelmann spruce and the greater tolerance of spruce to wet soil conditions. Seral conifer tree species differ greatly by association but include lodgepole pine, Douglas-fir, western larch, and ponderosa pine. Seral deciduous trees include quaking aspen, black cottonwood, and paper birch. Lodgepole pine is a common seral species in some of the moderate- to high-elevation associations such as PIEN/CASCP2 and PIEN/COCA, as well as in fire-regenerated stands. Lodgepole pine is also relatively tolerant of high water tables (Kovalchik 1987) and is occasionally common in wetter associations such as PIEN/CASCP2. Douglas-fir and western larch are more common on drier, well-drained associations such as PIEN/COCA, PIEN/COST, PIEN/GYDR, and PIEN/SYAL.

Shrub species are common to abundant, and their composition differs by association. Primary indicators include red-osier dogwood, common snowberry, and bunchberry dogwood. Other common shrubs include bearberry honeysuckle, western thimbleberry, myrtle pachistima, and twinflower on drier sites; mountain alder, Sitka alder, prickly currant, and willow species on wetter sites.

Indicator herbs include saw-leaved sedge, wild sarsaparilla, oak fern, and various horsetails, especially common horsetail. Common dry site herbs include sweetscented bedstraw, starry solomonplume, and western meadowrue. Arrowleaf groundsel, claspleaf twisted-stalk, and false bugbane are found on wetter sites.

PHYSICAL SETTING

Elevation—

The PIEN series occurs over a wide elevation range compared with most forested series. Most plots lie between 2,200 and 6,300 feet, which reflects the great ecological amplitude of the PIEN series. The upper elevation range is about 1,000 feet higher on the Okanogan NF owing to higher elevation timberlines associated with strong continental climate.

	Elevation (feet)			
Forest	Minimum	Maximum	Average	N
Colville	2,210	6,250	3,999	26
Okanogan	2,170	7,200	3,862	65
Wenatchee	2,380	5,920	3,996	9
Series	2,170	7,200	3,910	100

Additional insight is gained by comparing elevation by plant association. Most plots represent a zone that is low to moderate in elevation and warmer than that of subalpine fir. The one major exception is the PIEN/CASCP2 association, which occurs at moderate to high elevations. Stands in the other six associations are generally found below 4,500 feet. The PIEN/COST and PIEN/SYAL associations represent warmer, lower elevation sites.

Plant association	Elevation (feet) Minimum	Maximum	Average	N
PIEN/CASCP2	4,060	7,200	5,217	31
PIEN/EQUIS	2,600	4,880	3,859	19
PIEN/GYDR	2,980	4,200	3,390	4
PIEN/ARNU3	2,190	4,400	3,348	4
PIEN/COCA	2,210	4,850	3,307	18
PIEN/SYAL	2,190	4,280	3,055	8
PIEN/COST	2,250	3,700	2,815	16
Series	2,170	7,200	3,910	100

Valley Geomorphology—

Plots in the Engelmann spruce series are located in a variety of valley width and valley gradient classes. Over 80 percent of sampled plots are located in moderate to very broad (99 to greater than 990 feet) valleys. These wider valleys are largely characterized by very low to moderate (less than 1 to 5 percent) valley gradient and include both riparian and wetland zones. A smaller number of sites are found in narrower (less than 99 feet), steeper (greater than 5 percent) riparian valleys.

Valley width	Valley gradient: Very low	Low	Moderate	Steep	Very steep	N
Very broad	17	8	0	0	0	25
Broad	7	10	2	0	0	19
Moderate	2	6	7	1	1	17
Narrow	0	2	3	1	3	9
Very narrow	0	0	1	2	4	7
Series total	26	26	13	4	8	77

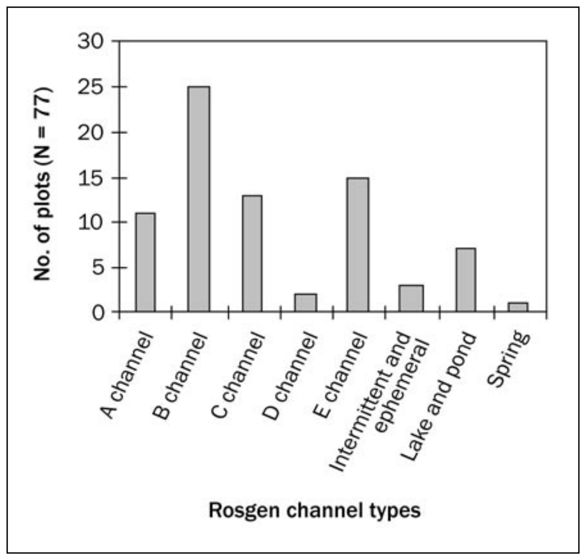
Little additional insight is gained by looking at individual plant associations. The PIEN/CASCP2 and PIEN/EQUIS associations prefer gentle gradient valleys of moderate or greater width, reflecting the need for high water tables in these wet associations. The PIEN/ARNU3 association appears to prefer steeper, narrower valleys. The relations of other associations to valley geomorphology were not quite as clear, perhaps owing to small sample sizes.

Plant association	Valley width: Very broad	Broad	Moderate	Narrow	Very narrow	N
PIEN/ARNU3	0	0	0	1	2	3
PIEN/CASCP2	14	5	4	1	5	29
PIEN/COCA	1	4	2	2	0	9
PIEN/COST	3	4	4	3	0	14
PIEN/EQUIS	6	3	3	1	0	13
PIEN/GYDR	0	0	3	0	0	3
PIEN/SYAL	1	3	1	1	0	6
Series total	25	19	17	9	7	77

Plant association	Valley gradient: Very low	Low	Moderate	Steep	Very steep	N
PIEN/ARNU3	0	0	1	0	2	3
PIEN/CASCP2	15	7	2	2	3	29
PIEN/COCA	3	4	1	0	1	9
PIEN/COST	0	6	4	2	2	14
PIEN/EQUIS	8	4	1	0	0	13
PIEN/GYDR	0	2	1	0	0	3
PIEN/SYAL	0	3	3	0	0	6
Series total	26	26	13	4	8	77

Channel Types—

Because of the range of valley width and gradient classes, the PIEN series occurs along a variety of channel types. The many wide, low gradient valleys associated with the PIEN series are characterized by Rosgen C or E channels, ponds, or lakes. On low and moderate gradient valley bottoms of moderate width, B channels increase. On narrower, steeper gradient valleys, A channels are prominent. A small number of PIEN series plots are located along D, intermittent, and ephemeral channels or springs.



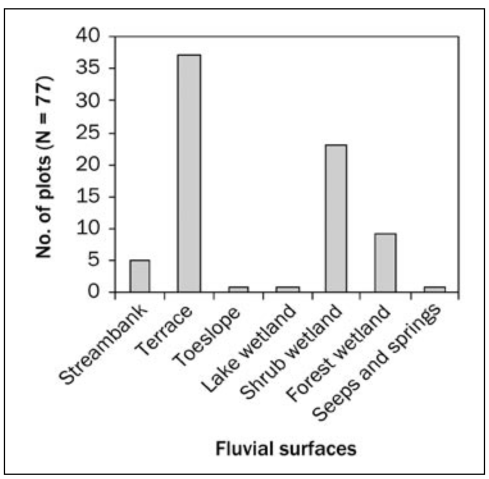
The data for individual associations add additional insight to the observations for the PIEN series. A, B, and intermittent channels are consistent with the relatively narrow, steep valleys associated with the PIEN/ARNU3 association. The PIEN/CASCP2 association is found in a variety of valley configurations supporting various channel types; however, gentler, wider valleys with C and E channels or lakes and ponds predominate. The PIEN/EQUIS wetlands are mostly along relatively wide, gentle valleys with B, C, and E channels. Both PIEN/CASCP2 and PIEN/EQUIS sites are wet for most of the year. The PIEN/GYDR, PIEN/COCA, PIEN/COST, and PIEN/SYAL associations are found mostly along B channels, possibly reflecting their need for better drained soils.

Plant association	Rosgen channel types A	B	C	E	Intermittent/ ephemeral	Lake/ pond	Other*	N
PIEN/ARNU3	1	1	0	0	1	0	0	3
PIEN/CASCP2	5	5	2	11	1	4	1	29
PIEN/COCA	1	4	1	1	0	2	0	9
PIEN/COST	3	4	6	0	0	0	1	14
PIEN/EQUIS	0	5	3	3	1	1	0	13
PIEN/GYDR	0	3	0	0	0	0	0	3
PIEN/SYAL	1	3	1	0	0	0	1	6
Series total	11	25	13	15	3	7	3	77

* "Other" includes both D channel and springs.

Fluvial Surfaces—

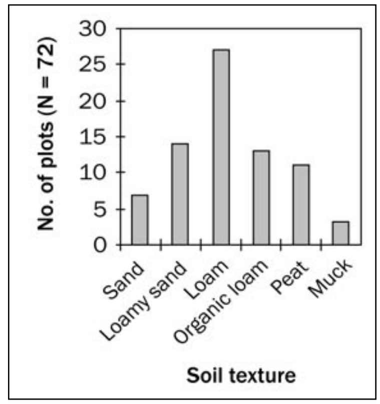
The PIEN series plots are common on both riparian and wetland sites. Sites found in riparian zones usually are located on terraces, with a few sites on well-drained streambanks. Toeslopes are underrepresented in the database. Small areas such as seeps and springs supporting the PIEN series are common but small in size, thus difficult to sample independently from bordering uplands. Alluvial bar, point bar, floodplain, and streambank sites are generally flooded too frequently to support the PIEN series. Rather they are occupied more often by series such as SALIX, COST, or ALIN.



Additional insight is gained by comparing fluvial surfaces to individual plant associations. Virtually all the plots located in wetlands belong to either the PIEN/CASCP2 or PIEN/EQUIS plant associations because of the need for free, unbound water. The other associations are occasionally located on the dry margins of wetlands but are more often found on well-drained terraces.

Plant association	Fluvial surfaces Stream- bank	Terrace	Toe- slope	Lake wetland	Shrub wetland	Forest wetland	Seeps/ springs	N
PIEN/ARNU3	1	1	1	0	0	0	0	3
PIEN/CASCP2	4	4	0	1	14	5	1	29
PIEN/COCA	0	5	0	0	3	1	0	9
PIEN/COST	0	14	0	0	0	0	0	14
PIEN/EQUIS	0	4	0	0	6	3	0	13
PIEN/GYDR	0	3	0	0	0	0	0	3
PIEN/SYAL	0	6	0	0	0	0	0	6
Series total	5	37	1	1	23	9	1	77

Soils—



Mineral soils are most common in riparian zones, whereas organic soils dominate wetlands. Mineral soils account for about 60 percent of the plots, with variations of loam soils being the most common soil texture. Loamy sands and sands account for the remaining mineral textures. Organic soils are found on the wettest sites and include organic loam and peat textures.

Additional insight is gained by looking at soil textures by plant association. All sites with organic texture belong to the wet PIEN/CASCP2 and PIEN/EQUIS plant associations. The other associations usually are associated with well-drained loam soils.

Plant association	Soil texture Sand	Loamy sand	Loam	Organic loam	Peat	Muck	N
PIEN/ARNU3	0	1	2	0	0	0	3
PIEN/CASCP2	0	7	7	6	8	1	29
PIEN/COCA	0	3	5	0	0	0	8
PIEN/COST	4	1	9	0	0	0	14
PIEN/EQUIS	0	1	0	7	3	2	13
PIEN/GYDR	0	1	1	0	0	0	2
PIEN/SYAL	3	0	3	0	0	0	6
Series total	7	14	27	13	11	3	75

Water tables were accessible on 59 plots. The PIEN/CASCP2 and PIEN/EQUIS associations have the highest water tables. The PIEN/ARNU3 is indicated as nearly as wet as PIEN/EQUIS. However, data are limited for PIEN/ARNU3, and its mineral soils indicate a soil/water relationship much drier than PIEN/EQUIS. PIEN/COST appears to be the driest association. However, the water table could not be reached on the drier PIEN/SYAL association. Flooded soil surfaces were uncommon during the sampling season except on the PIEN/CASCP2 and PIEN/EQUIS plant associations, which averaged 2.4 and 8.9 percent submerged, respectively.

With the exception of PIEN/EQUIS, lower elevation associations (PIEN/COST through PIEN/COCA) generally have higher average soil temperatures. The wet PIEN/EQUIS and PIEN/CASCP2 associations have colder soil temperatures.

Plant association	Water table (inches)			N
	Minimum	Maximum	Average	
PIEN/CASCP2	-26	0	-11	27
PIEN/EQUIS	-24	-4	-12	13
PIEN/ARNU3	-18	-12	-15	3
PIEN/GYDR	-35	-18	-28	3
PIEN/COCA	-44	-16	-30	3
PIEN/COST	-51	-20	-37	10
Series	-51	0	-18	59

Plant association	Soil temperature (°F)			N
	Minimum	Maximum	Average	
PIEN/COST	47	62	54	12
PIEN/SYAL	48	57	52	5
PIEN/ARNU3	47	55	51	2
PIEN/GYDR	44	54	49	3
PIEN/COCA	40	55	49	8
PIEN/CASCP2	33	58	48	28
PIEN/EQUIS	44	55	48	12
Series	33	62	50	70

ECOSYSTEM MANAGEMENT

Natural Regeneration of Engelmann Spruce—

Engelmann spruce reproduces well from seed (Alexander and Shepperd 1990). Seed production begins at 15 to 20 years of age when trees are typically 4 or 5 feet tall. Under closed-forest conditions, seed production is generally poor until trees are older and taller. Generally, trees greater than 15 inches in diameter produce the most seed. Although seed crops are erratic, Engelmann spruce is considered a good seed producer; good seed crops are produced every 2 to 5 years. The winged seeds are relatively light and generally are dispersed within 300 feet of the parent tree. Seed viability (averaging 69 percent) is good compared with many conifers. Most seeds overwinter under snow and germinate within 3 weeks of snowmelt (Alexander and Shepperd 1984, 1990). Seed germination is best on mineral soil. Seedlings that establish on organic matter (duff) more than 2 inches deep soon die because the shallow roots cannot penetrate to mineral soil before the organic material dries out (Alexander 1987). At higher elevations, survival may be greater on duff because the duff is more likely to remain moist through the growing season (Fiedler et al. 1985). Seedlings survive best under conditions of shade, cool temperatures, and consistent moisture. Under the best conditions, Engelmann spruce seedlings grow very slowly (Alexander and Shepperd 1990). Seedlings may be very suppressed under dense tree canopies. First-year seedlings are seldom taller than 1 inch, fifth-year seedlings are seldom over 5 inches tall, and 3- to 5-foot saplings may be 100 years old. In light shade, the 5-foot trees may be only 20 years old.

Like subalpine fir, Engelmann spruce may reproduce by layering on harsh, high-elevation sites, where it assumes a dwarf, prostrate form (Alexander and Shepperd 1990). Layering is negligible in closed forest stands.

Artificial Establishment of Engelmann Spruce and Associated Shrubs and Herbs—

Engelmann spruce is a valued timber species. Its light, uniform, and strong wood is used for lumber, plywood, poles, ties, and mine timbers. It is an excellent source of pulp (Parish et al. 1996). Nursery-grown bare-root and container stock is widely planted on disturbed sites in the Pacific Northwest and does best on cool, moist sites. Two- to three-year-old bare-root or container-grown stock is planted following snowmelt (Alexander 1987). Because seedlings are sensitive to direct sunlight, they should be planted in the protective shade of stumps, logs, or vegetation. It is probably better to rely on the release of natural seedlings and saplings when using selection cutting methods in riparian zones.

Many of the shrubs used to characterize the PIEN series are well adapted to planting on disturbed sites. Red-osier dogwood can be established from nursery stock, seed, and cuttings, or by layering. Prickly currant, dwarf red blackberry, red raspberry, and western thimbleberry can be easily grown from seed. Five-leaved bramble, bunchberry dogwood, and other trailing plants can be easily propagated from root runners. Huckleberry cuttings root poorly; they can be established from seed, but growth is slow. Common snowberry can be established from stem or root cuttings, nursery stock, or seed. Oak fern, saw-leaved sedge, and horsetails can be easily propagated from rhizomes. (For more information on the short- and long-term revegetation potential of selected riparian wetland plant species, see app. B-5.)

Stand Management—

Although tree productivity is fairly high on these sites, tree harvesting and associated management activities should be carefully planned and monitored. Cold temperature regimes, including cold-air drainage and frost, are factors that limit tree regeneration. Plant associations such as PIEN/CASCP2 and PIEN/EQUIS are swampy and difficult to manage for timber production. Wet, organic soils limit any kind of mechanical activity on wetter associations. Loam soils are prevalent on riparian sites and are susceptible to compaction during much of the growing season. Engelmann spruce and other trees may have extensive heart rot. Engelmann spruce is very susceptible to windthrow on account of shallow root systems and soft, saturated soils. Timber harvesting on these sites or adjacent upslope sites may increase the risk of windthrow and rising water tables. A clearcut adjacent to or in a riparian zone could result in near-total blowdown in the riparian zone.

The PIEN series supports a variety of seral tree species including western larch and Douglas-fir. Ponderosa pine will normally do well on warmer associations such as PIEN/SYAL. Regeneration of any tree species will be difficult on the wetter sites, where there is usually advanced regeneration of Engelmann spruce or lodgepole pine on raised hummocks. These seedlings should be protected during any harvest operation. Direct exposure to sunlight, combined with cold temperatures and problems with frost, further limit the success of conifer regeneration.

Although regeneration harvests may be a viable option in upland Engelmann spruce stands, management options in riparian zones might best be limited to single-tree or small-group selection. These options can be used to open the canopy to increase shrub and herb production for wildlife resources as well as increase shrub root biomass for streambank stability and other riparian-dependent resources. After release by logging or windfall, suppressed Engelmann spruce will usually respond with immediate release and growth. Management activities would have less impact if scheduled during late summer or early fall, or on snowpack to minimize soil disturbance. Commercial rotations in uplands are seldom longer than 110 years, but a period of 150 to 200 years is more suited to riparian zones, especially for the provision of future supplies of large wood. Managers may choose to avoid arvesting on wetland sites (PIEN/EQUIS and PIEN/CASCP2)..

Coarse-textured, compaction-resistant soils are unusual, except on some of the more fluvially active sites. Loam soils, found on most of the drier associations, may predominate owing to silt and ash deposition on fluvially inactive terraces. Very sensitive organic soils are associated with the wetter associations. Machinery and livestock easily displace or otherwise damage the associated organic soils during periods of high water tables (Hansen et al. 1995). Poorly drained sites, streamside locations, or sites with organic soils warrant special consideration, for example, by locating roads and trails on the adjacent upland.

Tree Growth and Yield—

Environmental conditions usually range from cool and moist to cold and wet in the PIEN series. The more productive associations are those located at mid to lower elevations where growing conditions are more favorable. Sites with moist, well-drained soils produce large Engelmann spruce, western larch, and Douglas-fir. More productive associations in these riparian zones include PIEN/COCA, PIEN/COST, and PIEN/SYAL. Contrary to the other PIEN associations, the wet PIEN/CASCP2 and PIEN/EQUIS associations have lower growth potential owing to soil conditions. Diameter and height of individual tree growth may be good on these wet sites, especially for Engelmann spruce, but saturated soils limit tree stocking. Tree productivity in the PIEN series is moderate to above average, exhibiting relatively high basal area and site index values. The average basal area of 212 square feet per acre was moderate compared with other tree series (apps. C-1a and C-1b). The ABAM, ABGR, PSME, THPL, and TSHE series were all higher. Similarly, average site index for individual species (feet) was moderate compared with other tree series (app. C-2). Tree production data are limited and should be viewed with caution.

Site index			
Species	Base age	No. of trees	SI
ABLA2	50	23	43
LAOC	50	27	68
PICO	100	18	68
PIEN	50	127	63
PIPO	100	5	109
POTR2	80	3	122
PSME	50	50	68

Basal area (sq. ft./ac)	
Species	BA
ABLA2	13
BEPA	1
CHNO	2
LAOC	11
PICO	18
PIEN	125
PIPO	3
POTR	2
POTR2	5
PSME	32
THPL	1
TSHE	>1
Total	212

Down Wood—

The overall amount of down wood was surprisingly low given the size of some of the individual Engelmann spruce trees in these stands (app. C-3). These sites are capable of growing high stand volume and large Engelmann spruce, western larch, and Douglas-fir trees, but logs covered less than 8 percent of the ground surface. Many stands in the drier associations appear to be susceptible to relatively frequent stand-replacement fires, possibly owing to being near drier upland sites, thus limiting the size of down wood. Relatively rapid decomposition rates for Engelmann spruce also may contribute to the lack of logs. Wetter sites (PIEN/EQUIS and PIEN/CASCP2) are generally fire resistant and usually have larger individuals of live Engelmann spruce and larger down logs. However, stand stocking restrictions limit the number of live trees, snags, and logs compared with closed stands.

Definitions of log decomposition classes are on page 15.

	Down log attributes				
Log decomposition	Tons/ acre	Cu. ft./ acre	Linear ft./ acre	Sq. ft./ acre	% ground cover
Class 1	0.74	62	205	113	0.26
Class 2	3.29	353	843	509	1.17
Class 3	6.73	853	1,965	1,279	2.94
Class 4	2.56	812	1,094	960	2.20
Class 5	1.91	612	429	531	1.22
Total	15.23	2,692	4,536	3,392	7.79

Snags—

Conversely, at 41.3 snags per acre, the PIEN series is above average compared with other tree series (app. C-4). Only the ABAM and ABLA2 series exceed it, with 53.5 and 54.3 snags per acre, respectively. Over 85 percent of the snags are in the 5 to 15.5 inch diameter classes, with about 75 percent in condition classes 1 or 2.

Definitions of snag condition classes are on page 15.

Snag condition	Snags/acre by d.b.h. class (inches)				Total
	5–9.9	10–15.5	15.6–21.5	21.6+	
Class 1	18.4	3.6	2.1	0.5	24.6
Class 2	0	5.1	1.3	0	6.4
Class 3	1.3	1.5	.9	0	3.7
Class 4	0	2.8	.2	.3	3.3
Class 5	1.9	.6	.3	.5	3.3
Total	21.6	13.6	4.8	1.3	41.3

Fire—

Engelmann spruce is fire sensitive on account of its thin bark and is usually killed by low-intensity fires (Fischer and Bradley 1987). The multicanopy fuel structure found in mature Engelmann spruce stands might promote highly destructive fires in severe drought years, at least in the drier associations. Fuel loads are high, and the fuel beds tend to be irregular and have large amounts of deep litter under the narrow-crowned trees. The needles form a compact fuel bed in which the fire spreads slowly yet provides flames high enough to reach the medium to high herb and shrub layer and lichen-draped branches, which starts crown fires (Crane 1982, Taylor and Fonda 1990). Postfire establishment is via wind-dispersed seeds from occasional mature trees and those that escaped in small dispersed pockets, which then germinate on fire-prepared seedbeds. Caches of cones by red squirrels also may provide seed for regeneration (Alexander and Shepperd 1984).

The literature indicates riparian and wetland Engelmann spruce forests usually develop in relatively cool, moist locations and experience fire-free intervals averaging 150 years or more (Arno 1980). Some stands, especially those dominated by seral lodgepole pine, are even aged, suggesting they developed after a fire (Loope and Gruell 1973). Although these observations are generally related to uplands, the interpretations can easily be applied to riparian sites. Fire-free intervals in wet PIEN associations appear to be even longer.

A total of 263 site index trees were sampled for age data. These trees averaged 131 years in age at breast height. Only five trees were more than 299 years old, 33 trees were 200 to 299 years old, 135 trees were 100 to 199 years old, and 90 trees were less than 100 years old. Only 32 percent of the site index trees were greater than 149 years in age. These data seem to suggest that stand-replacing fire-return intervals in the PIEN series in eastern Washington range from 80 years in drier stands to well over 200 years in wet stands. The fire-return interval in the PIEN series appears to be shorter than forest series common in more maritime climate zones such as the TSME, ABAM, THPL, or TSHE series. The data also seem to indicate that many of the sampled stands experienced average fire-return intervals that were less than the 150 years mentioned above (Arno 1980). The widespread stand-replacing fires of the late 1800s and early 1900s might be a factor in this apparent disagreement.

The PIEN associations found at lower elevations may be exposed to fire more frequently than series found at higher elevations or where the maritime climate occurs. The drier PIEN/COCA and PIEN/SYAL associations appear to be the youngest stands, based on ages of trees sampled for productivity estimates. The wet, low-elevation PIEN/EQUIS and wet, high-elevation PIEN/CASCP2 associations had the oldest stands. In these associations, many site index trees were more than 170 years old, which indicates that these wet associations probably burn less frequently than the lower elevation, warmer associations.

The fire regime of surrounding upland forests also may affect how often these riparian and wetland sites burn. Where the PIEN series is found at low to moderate elevations, it is often adjoined by drier Douglas-fir upland forests that are prone to more frequent low- to moderate-intensity fire events. These ground fire events may burn into the PIEN bottomlands in drought years. The PIEN associations at higher elevations usually are found only in wetlands, whereas surrounding drier riparian or upland sites host members of the ABLA2 series. Lodgepole pine forests that are prone to moderately frequent stand-replacement fires often dominate these drier upland sites. In these environments, hot stand-replacement fires in the upland lodgepole pine forests may threaten the PIEN associations. The wetter sites, however, probably burn only in extreme drought years.

Animals—

Livestock. Many of the plant associations lack suitable forage and thus primarily represent sources of water and shade. Forage potential on the drier associations may be fair in early-successional stages, but is generally poor in later successional stages. Wetter sites, such as PIEN/CASCP2 and PIEN/EQUIS, may provide an abundant supply of forage but are susceptible to trampling owing to high water tables and wet soils. Overuse is possible as livestock seek shelter from the heat during hot summer months. Usually, livestock avoid these wet sites until they can walk on the soil surface in late August or September (Kovalchik 1987). At this time, most plants are physiologically mature and can withstand light to moderate grazing pressure.

Few sample stands were highly impacted by livestock grazing. However, if overgrazed, elimination of grazing coupled with close monitoring of wildlife often allows the remnant shrub and herb populations to sprout and reestablish the stand. The ability of shrubs to easily reestablish may be lost when they have been eliminated owing to overgrazing and the water table has been lowered on account of stream downcutting or lateral erosion. (For more information on forage palatability, see app. B-1. For potential biomass production, see app. B-5.)

Wildlife. Riparian and wetland zones in the PIEN series provide valuable habitat for a variety of wildlife species (Alexander 1987, Alexander and Shepperd 1984, Mauk and Henderson 1984, McCaughey et al. 1986). This value is common to riparian and wetland sites in general, not just to the PIEN series. In general, these sites offer good sources of hiding and thermal cover, forage, or water. Multiple shrub and tree layers associated with most stands provide considerable habitat diversity for wildlife. The mosaic of PIEN and other riparian and wetland plant associations at lower elevations is often key habitat that is located in a matrix of fairly dry forest. Higher elevation sites often provide a source of diversity in otherwise extensive monotypic stands of lodgepole pine. The majority of wildlife species use these sites during summer and fall as winters are snowy and cold, but lower elevation sites also may be used in winter too. Owing to the moist, productive environments, some of these stands have late-seral or old-growth stand structures that serve as important habitat for old-growth-dependent species. Some sites have large Engelmann spruce with extensive heart rot decay, resulting in large trees, snags, and logs with hollow interiors. The seeds of spruce and other conifers are eaten by a variety of birds, squirrels, and other rodents. In addition, many sites have an abundance of berry-producing shrubs in the understory.

Large ungulates such as mule deer and elk will forage in these sites during summer and fall. Deer also may use these sites as fawning areas in early summer. Engelmann spruce needles and twigs are low in protein and fair in energy value (Dittberner and Olson 1983). The new growth of Engelmann spruce may be eaten by ungulates but is not an important food item except as a last resort. Other species associated with Engelmann spruce stands, such as red-osier dogwood and various huckleberries, provide more valuable forage for ungulates. Brooms formed by rusts in Engelmann spruce are common, and American marten use these brooms as rest sites. Marten also use hollow logs for dens and rest sites. Squirrels and chipmunks cache spruce seeds for winter food and sometimes clip and eat twigs and buds (Safford 1974). The seeds also are taken off the ground by squirrels, chipmunks, and voles. Black bears use hollow logs for dens and rest sites. Black bears and grizzly bears also will forage in these sites. Bear also use Engelmann spruce stands for hiding and thermal cover as well as bedding sites and protection from storms. The wetter associations may provide beneficial herbaceous forage for bears. Many associations support berry-producing shrubs that provide forage for bears. Beavers have been observed to feed on the shrubs of some of the associations, especially those with willows and red-osier dogwood, but other shrubs may be used for emergency food or dam building.

Woodpeckers use snags and logs for foraging for bark beetles and ants. Spruce grouse and blue grouse feed extensively on buds and needles of Engelmann spruce (Martin et al. 1951, Schroeder 1984). Many species of small birds such as chickadees, nuthatches, crossbills, and pine siskin eat the seed from Engelmann spruce cones (Hall 1973). Other birds that nest and feed in Engelmann spruce trees include Williamson's sapsucker, red-breasted nuthatch, brown creeper, and owls. Harlequin ducks and American dippers may be observed on nearby streams. (For more information on thermal or feeding cover values, see apps. B-2 and B-3. For information on food values or degree of use, see apps. B-2 and B-4.)

Fish. Riparian and wetland zones in the PIEN series play important roles in watershed function and hydrologic regimes. Many sites, such as those of PIEN/CASCP2, are located in high-elevation basins where winter snowpacks are heavy. At lower elevations, PIEN/EQUIS stands are equally important in acting as hydrologic reservoirs and helping maintain streamflows and runoff during summer. In addition, owing to windthrow and disease, many PIEN sites have moderate amounts of large woody debris in and alongside the stream channels. This woody debris, especially large-diameter logs, provides good fish habitat and stream channel stabilization, particularly during peak flows associated with spring runoff or following summer storms. The large tree canopies also provide shade for the stream, helping to regulate water temperatures and promote good fisheries habitat downstream. Maintaining healthy, vigorous stands of Engelmann spruce and other series such as SALIX, ALIN, and ALSI along streams and rivers creates buffer strips of erosion-resistant plant communities that help stabilize streambanks and floodplains as well as nearby terraces and swales, provide a barrier to sedimentation from nearby slopes, and provide a source of down wood for the stream and nearby fluvial surfaces. (For more information, see app. B-5, erosion control potential.)

Recreation—

Higher elevation associations are not well suited for recreation owing to inaccessible locations, high water tables, and wet soils. Sites at lower elevations may be impacted by recreation activities where they are accessed from nearby roads most often for fishing and dispersed camping. The predominant loam soils are highly susceptible to compaction, and vegetation is easily trampled. Whether wet or dry, construction and maintenance of roads, campgrounds, and trails is not recommended on PIEN sites. These sites are highly prone to windthrow of Engelmann spruce owing to their shallow rooting system and weakness from fungal disease.

Insects and Disease—

Wood-rotting fungi that result in root rot or butt decay are the most common tree diseases in the PIEN series. The primary diseases include rust red stringy rot, brown cubical rot, armillaria root rot, and Tomentose root disease (Hessburg et al. 1994). Schweinitzii butt rot is particularly common in older Engelmann spruce trees. Many of these fungal pathogens also infect western larch and Douglas-fir. Annosus root disease may be common in the subalpine fir found in the wet PIEN/CASCP2 and PIEN/EQUIS associations. These rots were scattered before the era of intensive resource management but have increased dramatically by attacking through stumps and other wounds associated with logging. Spruce broom rust is also common in spruce-fir forests and causes bole deformation, spike tops, wind breakage, and an entry point for decay fungi (Alexander and Shepperd 1990). Dwarf mistletoe infestations may be common in lodgepole pine, western larch, and Douglas-fir (Hadfield 1995).

Occasional insect outbreaks occur in the PIEN series (Alexander and Shepperd 1990, Flanagan 1995, Hessburg et al. 1994). The spruce beetle is the most serious insect pest of Engelmann spruce. Outbreaks are associated with extensive windthrow, untreated logging slash, or wildfire, as dead and down trees provide a good food supply, causing a rapid expansion of the beetle population. Other bark beetles infecting Engelmann spruce, Douglas-fir, and lodgepole pine include the spruce beetle, Douglas-fir beetle, and mountain pine beetle, respectively. Potential defoliators include the western spruce budworm and the Douglas-fir tussock moth.

Estimating Vegetation Potential on Disturbed Sites—

Estimating vegetation potential on disturbed sites, therefore, is generally not needed on these conifer-dominated sites. Clearcutting in riparian areas is unusual, at least on FS land. Wetter associations in the SALIX, MEADOW, ALIN, and ALSI series often separate PIEN stands from active flood zones. Currently, all FS riparian and wetland zones are buffered and not managed for timber production. Where clearcut in the past, Engelmann spruce and other conifers rapidly regenerated these productive sites. Similar valley landforms can help determine the potential of young stands.

Sensitive Species—

Only three sensitive plants were found under PIEN series stands. Moxieplum, glaucous willow, and tall agoseris were found on PIEN/CASCP2 association plots. Tall agoseris also was found on a PIEN/COCA site (app. D). (See app. A for a cross reference to scientific names.)

ADJACENT SERIES

The PIEN series is generally bound by the ABLA2 series at higher elevations. The PSME series usually replaces the PIEN series on warmer sites at low elevation. Wetter series such as the COST, ALIN, ALSI, SALIX, and MEADOW series often occur on more fluvially active surfaces or in adjacent wetlands, thus separating the PIEN series from the direct influence of streams except during very high flows.

RELATIONSHIPS TO OTHER CLASSIFICATIONS

Traditionally, the PIEN series has been considered an inclusion in the subalpine fir series in Washington. This has proved adequate in describing upland habitats but is not well suited for riparian and wetland zones. Engelmann spruce is quite tolerant of high water tables, extends to lower elevations than subalpine fir, and therefore displays wider ecological amplitude in riparian zones and wetlands compared with subalpine fir.

Kovalchik (1992c) described many of the plant associations in the PIEN series in the draft classification for northeastern Washington. Riparian plant associations described in the PIEN series represent relatively wet stand conditions for some plant associations in the ABLA2 plant associations previously described for uplands on the Wenatchee NF by Lillybridge et al. (1995) and the Colville NF by Williams et al. (1995). The PIEN/EQUIS association was the only association described in these eastern Washington upland classifications. Other climax Engelmann spruce stands are lumped into the ABLA2 series by these authors. Crowe and Clausnitzer (1997) describe PIEN/EQUIS and PIEN/COST associations in northeastern Oregon that are very similar to the ones described here. Hansen et al. (1995) also describe similar PIEN/EQUIS and PIEN/COST associations for western Montana.

Plant associations belonging to the PIEN series have been previously described for nearby areas in the Pacific Northwest. These include central and northeastern Oregon (Crowe and Clausnitzer 1997, Kovalchik 1987) and Montana (Hansen et al. 1988, 1995). Strangely, no Engelmann spruce associations are described for northern Idaho (Cooper et al. 1991). Braumandl and Curran (1992) and Lloyd et al. (1990) describe similar communities in British Columbia.

U.S. DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE WETLANDS CLASSIFICATION

System:	palustrine
Class:	forested wetland
Subclass:	needle-leaved evergreen
Water regime:	(nontidal) intermittently saturated to temporarily flooded

KEY TO THE ENGELMANN SPRUCE (*PICEA ENGELMANNII*) PLANT ASSOCIATIONS

1. Holm's and/or saw-leaved sedge (*Carex scopulorum* var. *bracteosa* and/or *prionophylla*) ≥10 percent canopy coverage .... **Engelmann spruce/saw-leaved sedge (PIEN/CASCP2) association**
2. Common horsetail (*Equisetum arvense*), wood horsetail (*Equisetum sylvaticum*), and/or soft-leaved sedge (*Carex disperma*) ≥10 percent canopy coverage .... **Engelmann spruce/horsetail (PIEN/EQUIS) association**
3. Lady fern (*Athyrium filix-femina*) ≥5 percent canopy coverage ....**Subalpine fir/lady fern (ABLA2/ATFI) association**[2]
4. Oak fern (*Gymnocarpium dryopteris*) ≥5 percent canopy coverage ....**Engelmann spruce/oak fern (PIEN/GYDR) association**
5. Labrador tea (*Ledum glandulosum*) ≥5 percent canopy coverage .... **Subalpine fir/Labrador tea-grouse huckleberry (ABLA2/LEGAL-VASC) association**[2]
6. Globeflower (*Trollius laxus*) ≥2 percent canopy coverage .... **Subalpine fir/globeflower (ABLA2/TRLA4) association**[2]
7. Red-osier dogwood (*Cornus stolonifera*) ≥10 percent canopy coverage ....**Engelmann spruce/red-osier dogwood (PIEN/COST) association**
8. Wild sarsaparilla (*Aralia nudicaulis*) ≥2 percent canopy coverage .... **Engelmann spruce/wild sarsaparilla (PIEN/ARNU3) association**
9. Bunchberry dogwood (*Cornus canadensis*) ≥2 percent canopy coverage .... **Engelmann spruce/bunchberry dogwood (PIEN/COCA) association**
10. Common snowberry (*Symphoricarpos albus*) ≥5 percent canopy coverage .... **Engelmann spruce/common snowberry (PIEN/SYAL) association**

[2] These ABLA2 associations occasionally key to the PIEN series because subalpine fir is less than 10 percent canopy coverage in some plots otherwise dominated by Engelmann spruce. Detailed analysis of data indicates Engelmann spruce communities with lady fern or globeflower characterizing the understory will eventually be dominated by subalpine fir.

Table 6—Constancy and mean cover of important plant species in the PIEN plant associations

Species	Code	PIEN/ARNU3 4 plots		PIEN/CASCP2 31 plots		PIEN/COCA 18 plots		PIEN/COST 16 plots		PIEN/EQUIS 19 plots		PIEN/GYDR 4 plots		PIEN/SYAL 8 plots	
		CON[a]	COV[b]	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV
Tree overstory:															
subalpine fir	ABLA2	25	Tr[c]	77	9	11	6	25	6	63	13	—	—	38	Tr
western larch	LAOC	100	13	—	—	56	19	13	4	5	5	100	10	13	10
Engelmann spruce	PIEN	100	30	100	30	89	26	88	42	100	43	100	54	88	35
lodgepole pine	PICO	—	—	39	15	61	24	—	—	21	3	—	—	13	4
ponderosa pine	PIPO	—	—	—	—	11	6	13	4	—	—	—	—	38	18
quaking aspen	POTR	—	—	—	—	17	15	6	1	16	10	25	2	25	14
black cottonwood	POTR2	—	—	—	—	—	—	31	10	5	1	—	—	25	15
Douglas-fir	PSME	75	12	6	2	50	28	88	22	16	10	75	6	75	29
Tree understory:															
subalpine fir	ABLA2	—	—	87	7	6	Tr	13	3	74	5	—	—	50	2
Engelmann spruce	PIEN	75	1	97	5	89	5	69	6	89	5	75	6	75	6
lodgepole pine	PICO	—	—	26	4	17	6	—	—	5	8	—	—	—	—
Douglas-fir	PSME	75	2	3	1	67	5	50	4	—	—	25	2	75	1
Shrubs:															
Douglas maple	ACGLD	100	17	—	—	39	10	63	3	5	3	25	Tr	88	4
mountain alder	ALIN	25	Tr	23	11	28	2	63	6	63	13	75	9	25	5
Sitka alder	ALSI	—	—	6	2	—	—	19	3	16	14	—	—	25	3
Saskatoon serviceberry	AMAL	100	1	3	2	78	2	44	4	26	2	100	1	88	2
red-osier dogwood	COST	75	2	6	5	44	2	100	47	53	5	75	13	50	3
bearberry honeysuckle	LOIN	25	Tr	42	3	28	1	50	1	42	1	—	—	38	1
Utah honeysuckle	LOUT	50	1	13	2	50	2	6	2	5	Tr	50	1	13	Tr
prickly currant	RILA	75	4	32	2	61	2	63	3	68	3	100	2	88	1
baldhip rose	ROGY	75	2	3	3	44	3	19	5	16	2	100	3	38	3
red raspberry	RUID	25	Tr	3	1	17	Tr	19	1	11	1	50	1	25	1
western thimbleberry	RUPA	100	5	—	—	50	5	75	2	32	2	75	4	100	4
dwarf red blackberry	RUPU2	50	1	—	—	11	3	6	5	21	3	25	7	—	—
Drummond's willow	SADR	—	—	16	5	—	—	—	—	5	10	—	—	—	—
Farr's willow	SAFA	—	—	26	8	—	—	—	—	5	3	—	—	—	—
Scouler's willow	SASC	—	—	10	Tr	6	1	13	8	5	2	—	—	13	2
russet buffaloberry	SHCA	50	2	6	1	28	3	13	2	11	1	25	Tr	13	1
shiny-leaf spiraea	SPBEL	75	2	—	—	33	6	19	5	—	—	—	—	63	6
common snowberry	SYAL	100	7	3	4	89	7	94	10	32	6	75	20	100	12
Low shrubs and subshrubs:															
Oregon hollygrape	BEAQ	75	2	—	—	72	4	50	1	11	Tr	25	Tr	50	1
western prince's-pine	CHUMO	100	2	6	Tr	50	3	13	Tr	16	1	25	Tr	50	1
bunchberry dogwood	COCA	100	7	42	4	100	10	13	5	74	5	100	5	13	Tr
Labrador tea	LEGL	—	—	58	15	—	—	—	—	21	6	—	—	—	—
twinflower	LIBOL	100	10	52	4	94	18	13	6	68	4	100	7	25	8
myrtle pachistima	PAMY	—	—	—	—	33	2	56	7	5	Tr	—	—	63	16
five-leaved bramble	RUPE	—	—	19	7	—	—	6	Tr	21	3	25	Tr	—	—
dwarf huckleberry	VACA	25	1	35	3	28	7	—	—	—	—	—	—	—	—
low huckleberry	VAMY	—	—	35	3	11	7	—	—	26	2	—	—	—	—
grouse huckleberry	VASC	—	—	55	12	6	10	—	—	—	—	25	1	—	—
Perennial forbs:															
baneberry	ACRU	75	Tr	3	3	28	1	25	1	32	3	75	1	25	Tr
wild sarsaparilla	ARNU3	100	7	—	—	—	—	—	—	5	7	25	Tr	—	—
heartleaf arnica	ARCO	50	1	19	1	50	3	19	1	16	1	25	Tr	63	1
showy aster	ASCO	50	3	3	Tr	33	2	19	1	—	—	25	Tr	25	1

Table 6—Constancy and mean cover of important plant species in the PIEN plant associations (continued)

Species	Code	PIEN/ARNU3 4 plots		PIEN/CASCP2 31 plots		PIEN/COCA 18 plots		PIEN/COST 16 plots		PIEN/EQUIS 19 plots		PIEN/GYDR 4 plots		PIEN/SYAL 8 plots	
		CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV	CON	COV
enchanter's nightshade	CIAL	25	Tr	—	—	—	—	13	1	16	2	50	2	—	—
queencup beadlily	CLUN	50	8	6	2	56	5	13	1	21	1	25	1	13	Tr
roughfruit fairy-bells	DITR	50	Tr	—	—	39	1	25	Tr	5	2	50	2	25	10
woods strawberry	FRVEB	50	Tr	—	—	22	Tr	13	1	5	2	75	1	25	Tr
sweetscented bedstraw	GATR	75	1	13	1	78	2	50	1	58	2	75	2	50	1
western rattlesnake plantain	GOOB	50	1	3	Tr	67	1	25	Tr	11	1	25	Tr	75	1
fivestamen miterwort	MIPE	—	—	26	2	6	5	—	—	16	7	—	—	—	—
miterwort species	MITEL	50	Tr	42	2	17	1	13	2	42	5	100	3	13	1
mountain sweet-root	OSCH	25	2	10	1	61	2	31	1	26	2	75	4	38	2
purple sweet-root	OSPU	75	1	10	1	—	—	38	1	11	1	25	Tr	38	1
pink wintergreen	PYAS	25	Tr	13	2	11	1	19	1	58	2	—	—	25	4
sidebells pyrola	PYSE	25	7	32	1	61	1	44	1	58	2	100	1	50	1
arrowleaf groundsel	SETR	—	—	58	2	11	Tr	—	—	58	1	—	—	—	—
western solomonplume	SMRA	25	1	—	—	39	1	38	2	11	1	—	—	50	1
starry solomonplume	SMST	100	2	13	2	67	2	56	2	79	2	100	2	88	1
claspleaf twisted-stalk	STAM	75	1	58	1	28	Tr	38	1	79	1	100	2	13	1
western meadowrue	THOC	75	1	23	1	61	2	63	2	32	2	25	Tr	75	2
coolwort foamflower	TITRU	25	Tr	13	1	6	Tr	13	1	53	3	50	4	13	Tr
false bugbane	TRCA3	—	—	10	2	11	1	13	4	42	8	75	19	—	—
Canadian violet	VICA	50	Tr	—	—	17	3	19	1	5	3	25	3	13	1
pioneer violet	VIGL	—	—	3	2	28	5	38	1	26	3	—	—	63	Tr
Grasses or grasslike:															
Columbia brome	BRVU	75	1	—	—	6	2	19	1	5	Tr	25	1	63	1
bluejoint reedgrass	CACA	25	Tr	65	7	11	3	—	—	53	5	50	2	13	Tr
pinegrass	CARU	25	2	10	1	67	9	—	—	—	—	—	—	38	2
Sitka sedge	CAAQS	—	—	—	—	—	—	—	—	11	5	—	—	—	—
soft-leaved sedge	CADI	25	4	29	3	6	Tr	6	1	47	20	25	2	—	—
black alpine sedge	CANI2	—	—	3	15	—	—	—	—	—	—	—	—	—	—
Holm's sedge	CASCB	—	—	6	45	—	—	—	—	—	—	—	—	—	—
saw-leaved sedge	CASCP2	—	—	94	31	—	—	—	—	11	8	—	—	—	—
bladder sedge	CAUT	—	—	16	5	—	—	—	—	16	2	—	—	—	—
wood reed-grass	CILA2	25	1	13	3	17	1	6	2	26	2	50	2	—	—
blue wildrye	ELGL	25	4	10	14	44	3	19	1	16	1	25	Tr	38	1
Ferns and fern allies:															
wood-fern species	DRYOP	—	—	—	—	—	—	—	—	5	20	—	—	—	—
common horsetail	EQAR	25	2	55	2	33	2	38	1	95	36	100	1	38	1
common scouring-rush	EQHY	25	Tr	—	—	11	8	25	Tr	5	Tr	—	—	38	Tr
wood horsetail	EQSY	—	—	6	17	—	—	—	—	5	5	50	4	—	—
oak fern	GYDR	50	1	—	—	—	—	6	Tr	26	6	100	17	—	—

[a] CON = percentage of plots in which the species occurred.
[b] COV = average canopy cover in plots in which the species occurred.
[c] Tr = trace cover, less than 1 percent canopy cover.

GRAND FIR SERIES

Abies grandis

ABGR N = 36

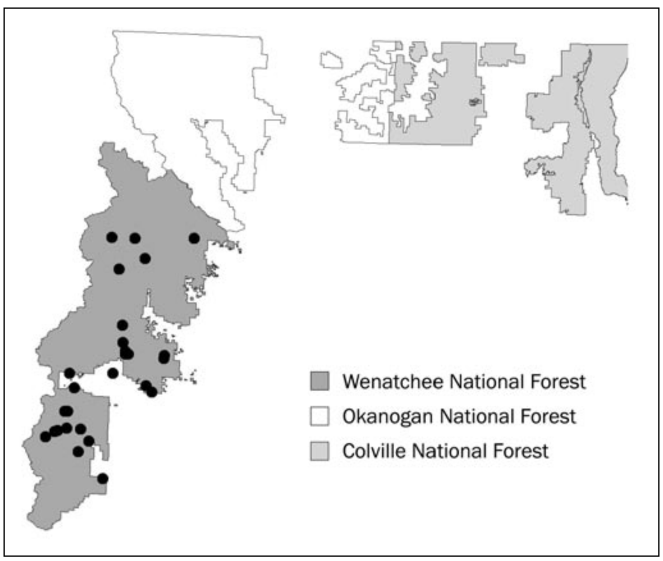


Figure 13—Plot locations for the grand fir series.

GRAND FIR[1] ranges from southern British Columbia south through the Coast and Cascade Ranges to central Oregon, where it hybridizes with white fir (Hitchcock and Cronquist 1973). In the continental interior it extends from the Okanogan and Kootenay Lakes area of British Columbia south and southeast through eastern Washington, northern and central Idaho, and into Montana west of the Continental Divide and the Blue and Ochoco Mountains of northeastern Oregon (Foiles et al. 1990, Steinhoff 1978). Grand fir reaches its northern limit as an important forest species in the Cascade Range on the Wenatchee NF (Lillybridge et al. 1995). Except for a few outlying stands, the northern boundary follows the Entiat River. Grand fir is again common east of the Kettle Mountains on the Colville NF, extending into Montana. This distribution suggests that grand fir has an affinity for maritime climates and does not tolerate dry, cold climates. It does, however, tolerate warmer, drier conditions than western redcedar or western hemlock, which share similar geographic distribution across the Northwest.

The above information on grand fir distribution shows the ABGR series only occurs where the climate is moderated by Pacific maritime influence (Cooper et al. 1991, Pfister et al. 1977). The ABGR series is extremely limited within the continental climate of the central interior of the study area (Lillybridge et al. 1995, Williams et al. 1995). Although common in uplands, the ABGR series does not exist in riparian areas in the Colville NF. It is rare on the Okanogan NF, except west of the Cascade crest. It is common in both uplands and riparian areas on the Wenatchee NF.

CLASSIFICATION DATABASE

The ABGR series includes all forest stands potentially dominated by grand fir at climax. Stands are common on the southern two-thirds of the Wenatchee NF on the Naches, Cle Elum, Leavenworth, and Lake Wenatchee RDs (fig. 13). It also can be found in limited areas of the western portions of the Entiat and Chelan RDs. One stand was observed but not sampled on the Twisp RD of the Okanogan NF. Riparian plots of the ABGR series have not been observed on the Colville NF, although they might be found on the Colville Indian Reservation and other nonfederal lands to the south of the Colville NF. A total of 24 riparian and wetland sampling plots were measured in the ABGR series. Data from an additional 12 plots from other ecology databases were included to increase the data for this series to aid classification and provide additional data for species composition, distribution, and elevation. From this database, three major plant associations are recognized. One potential one-plot community (ABGR/ARCO) was found on a drier site but is not used in the data or described in this classification. For the most part, these samples represent late-seral to climax conditions.

[1] See appendix A for a cross reference for all species codes and common and scientific names used in this document.

Grand fir plant associations

	Scientific name	Common name	Ecoclass code	Plots
Major associations:				
ABGR/ACCI-WEN	*Abies grandis/Acer circinatum*-Wenatchee	Grand fir/vine maple-Wenatchee	CWS551	9
ABGR/ACTR-WEN	*Abies grandis/Achlys triphylla*-Wenatchee	Grand fir/dearleaf vanilla-leaf–Wenatchee	CWF524	18
ABGR/SYAL-FLOODPLAIN	*Abies grandis/Symphoricarpos albus*-floodplain	Grand fir/common snowberry-floodplain	CWS314	9

VEGETATION CHARACTERISTICS

Mature stands characteristically have an overstory co-dominated by Douglas-fir and grand fir. Engelmann spruce is a common seral species in the moist ABGR/ACCI-WEN and ABGR/ACTR-WEN associations. However, stands where Engelmann spruce is reproducing more successfully than grand fir will key to the PIEN series. Bigleaf maple is often present in the drier ABGR/SYAL-FLOODPLAIN association, mostly in stands where ocean-spray is well represented. The tree understory of mature stands is composed primarily of grand fir regeneration, with lesser amounts of Engelmann spruce and subalpine fir in the ABGR/ACCI-WEN and ABGR/ACTR-WEN associations.

The shrub and herb layer are floristically rich and varied. Shrub species with high constancy or cover include vine maple, twinflower, western thimbleberry, myrtle pachistima, and Oregon hollygrape on ABGR/ACCI and ABGR/ACTR associations and Douglas maple, ocean-spray, baldhip rose, Lewis' mock orange, western thimbleberry, common snowberry, and myrtle pachistima on the ABGR/SYAL association. Understory plant cover is commonly depauperate in heavily shaded stands.

Some common herbs found in the moist associations include deerfoot vanilla-leaf, queencup beadlily, pioneer violet, and white trillium. Drier associations support herbs such as sidebells pyrola, purple sweet-root, elk sedge, and western and starry solomonplume.

PHYSICAL SETTING

Elevation—

The ABGR series occurs at low to moderate elevations. The majority of sites are below 3,500 feet. One unusual 4,100-foot plot in the ABGR/ACCI-WEN association was located over 1,000 feet higher than other plots in the ABGR series and could have easily keyed to the ABLA2 series. However, it seemed to better fit the ABGR series, as vine maple is not a common plant in most subalpine fir plant associations (Lillybridge et al. 1995).

Forest	Elevation (feet)			
	Minimum	Maximum	Average	N
Wenatchee only	2,160	4,100	2,495	36

Additional insight is gained by looking at individual associations. The ABGR/ACTR-WEN association is found at the highest elevations in the series, and most plots are above 3,000 feet. The ABGR/ACCI-WEN and ABGR/SYAL-FLOODPLAIN associations usually are found at lower elevations, quite often below 3,000 feet. The ABGR/ACCI-WEN and ABGR/ACTR-WEN associations are found within the relatively moist fringes of maritime climate zones on the Wenatchee NF. The ABGR/SYAL-FLOODPLAIN association is found in the eastern half of the Wenatchee NF on the transition to a continental climate with less precipitation and warmer temperatures.

Plant association	Elevation (feet)			
	Minimum	Maximum	Average	N
ABGR/ACTR-WEN	2,550	3,675	3,269	18
ABGR/SYAL-FP	2,180	3,700	2,633	9
ABGR/ACCI-WEN	2,160	4,100	2,574	9
Series	2,160	4,100	2,945	36

Valley Geomorphology—

The ABGR series is found in the whole range of valley width and gradient classes. Most plots are in moderate or broad valleys (330 to 990 feet). Broad valleys more than 990 feet wide are more common in private lands at elevations below FS ownership. Valley gradient classes are more defined, with the two most common being low (1 to 3 percent) and, at the other extreme, very steep (greater than 8 percent). This likely reflects a relatively quick change in gradient from wider, gentler river valley bottoms (such as those of the Taneum, Teanaway, Naches, and Wenatchee Valleys) to the narrower, steeper profiles of their tributaries.

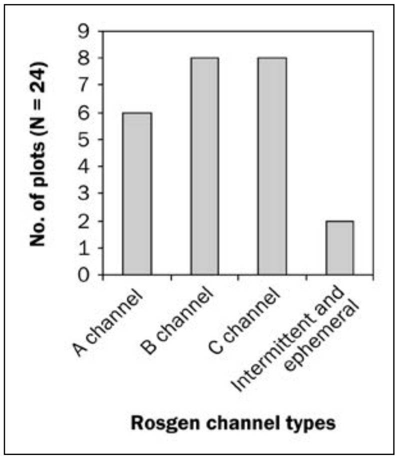
Valley width	Valley gradient					
	Very low	Low	Moderate	Steep	Very steep	N
Very broad	1	1	0	0	0	2
Broad	0	6	0	0	1	7
Moderate	0	4	2	1	3	10
Narrow	0	1	0	1	1	3
Very narrow	0	0	0	0	2	2
Series total	1	12	2	2	7	24

Valley geomorphology is most clear when considering the individual ABGR plant associations. The ABGR/ACCI-WEN and ABGR/ACTR-WEN associations are more common in broad, low gradient valleys. The tree plots located in narrower, steeper valleys are found in side drainages and ephemeral draws. The ABGR/SYAL-FLOODPLAIN association is found in similar valleys but is more prominent in steeper drainages, perhaps because the drainages are warmer and better drained.

Plant association	Valley width					
	Very broad	Broad	Moderate	Narrow	Very narrow	N
ABGR/ACCI-WEN	1	1	1	0	0	3
ABGR/ACTR-WEN	0	6	3	2	1	12
ABGR/SYAL-FP	1	0	6	1	1	9
Series total	2	7	10	3	2	24

Plant association	Valley gradient					N
	Very low	Low	Moderate	Steep	Very steep	
ABGR/ACCI-WEN	1	1	0	0	1	3
ABGR/ACTR-WEN	0	9	0	2	1	12
ABGR/SYAL-FP	0	2	2	0	5	9
Series total	1	12	2	2	7	24

Channel Types—

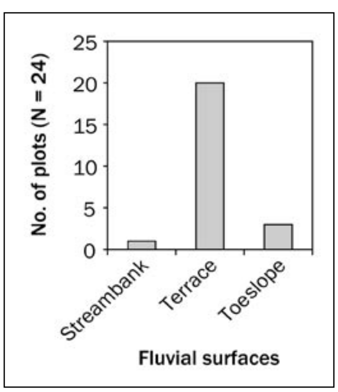


The ABGR series plots are equally common on fluvial surfaces associated with Rosgen A, B, and C channel types. The B and C channels usually are found within wider, lower gradient valley bottoms, whereas A channels are characteristic of narrower, steeper tributaries. Intermittent and ephemeral stream channels were infrequently sampled during the study, so these channel types are likely underrepresented in the data.

Additional insight is gained by looking at individual ABGR plant associations. For instance, ABGR/SYAL-FLOODPLAIN is found along A and B channels, whereas the other two associations are more frequent along B and C channels.

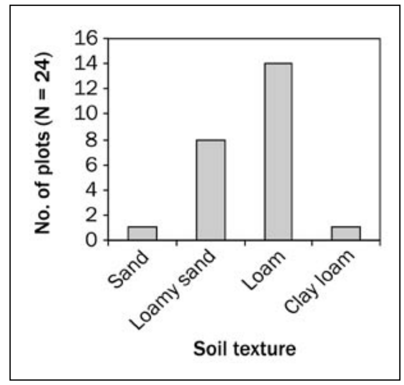
Plant association	Rosgen channel types				N
	A	B	C	Intermittent and ephemeral	
ABGR/ACCI-WEN	1	1	1	0	3
ABGR/ACTR-WEN	1	4	6	1	12
ABGR/SYAL-FP	4	3	1	1	9
Series total	6	8	8	2	24

Fluvial Surfaces—



The ABGR series plots are located in riparian zones, especially on drier, well-drained fluvial terraces. Only one plot is on a well-drained streambank, and only three plots are on toeslope positions. No plots are located on wet fluvial surfaces owing to the low tolerance of grand fir to high water tables. Other series (such as ALIN, COST, PIEN, SALIX, or POTR2) occupy wetter sites such as alluvial bars, floodplains, and overflow channels that often separate ABGR series sites from the active stream channel.

Plant association	Fluvial surfaces			N
	Streambank	Terrace	Toeslope	
ABGR/ACCI-WEN	0	2	1	3
ABGR/ACTR-WEN	1	10	1	12
ABGR/SYAL-FP	0	8	1	9
Series total	1	20	3	24



As with the entire ABGR series, all three ABGR plant associations are more likely to occur on terraces.

Soils—

All the ABGR series plots have mineral soils in their rooting zones, reflecting drier fluvial surfaces and relatively infrequent flood deposition. Loamy sand and loam are the most common soil textures, with only one plot having sand texture and one plot having clay loam. Terraces farther from flooding may have significant deposits of ash.

Plant association	Soil texture				N
	Sand	Loamy sand	Loam	Clay loam	
ABGR/ACCI-WEN	1	2	0	0	3
ABGR/ACTR-WEN	0	1	10	1	12
ABGR/SYAL-FP	0	5	4	0	9
Series total	1	8	14	1	24

As with the ABGR series, the three ABGR associations are most common on loam and loamy sand soils.

Water tables measured during the growing season were well below the soil surface, and the soil auger could reach the water table on only a few plots, which averaged 27 inches below the soil surface. Similarly, no plots were flooded during the growing season. Therefore, no tables are shown.

The ABGR/SYAL association has the warmest soil temperatures due to its low elevation and location in the transition zone from maritime to continental climate. ABGR/ACTR-WEN has the coldest soil temperatures owing to its higher elevation and maritime climate. Data are limited and should be read with caution.

Plant association	Soil temperature (°F)			N
	Minimum	Maximum	Average	
ABGR/SYAL-FP	49	60	55	9
ABGR/ACCI-WEN	48	58	52	3
ABGR/ACTR-WEN	45	54	49	12
Series	45	60	52	24

ECOSYSTEM MANAGEMENT

Natural Regeneration of Grand Fir—

Grand fir reproduces only from seed. Flowering occurs between late March and June; cones ripen in August and September. One month later, seeds from disintegrating cones are dispersed by wind and rodents. Cone and seed production begins at 20 years of age, increasing with age and vigor. There may be as many as 200 seeds per cone (Franklin 1968). Good seed crops are frequent; they are reported every 2 to 3 years on Vancouver Island, where there is good correlation between weather and cone crops (Tanaka 1982). Wind dispersal of seed is usually restricted to within a few hundred feet of the tree owing to the medium weight of the seed (Arno and Hammerly 1984). Seed germination occurs in spring and is most successful when the seed falls on mineral soil, although grand fir germinates almost as well on duff under shade (Foiles et al. 1990, Schmidt 1957). Cool, moist sites are optimal for germination and growth of seedlings, although grand fir seeds are relatively drought resistant compared with other true firs. Seedlings establish readily in small openings in mature forests (Antos and Shearer 1980), and initial root penetration growth is relatively rapid on sites with full sunlight. However, root penetration is relatively slow on shaded sites, and desiccation is the major cause of seedling mortality (Foiles et al. 1990).

Artificial Establishment of Grand Fir and Associated Shrubs and Herbs—

Because grand fir grows well on a variety of sites, including riparian sites, it is a good candidate for management (Hall 1983). Cones must be collected before they ripen, as they disintegrate at maturity. Nursery-grown bare-root and container-stock fir are both planted in the Pacific Northwest and do best on bare, mineral soil; although broadcast burning has been shown to decrease the success of regeneration. When using selection cutting in riparian zones, it is probably better to rely on the release of natural seedlings and saplings.

Many shrubs and herbs that characterize the ABGR series are well adapted to planting on disturbed sites. Vine maple and myrtle pachistima can be established from nursery stock or cuttings, depending on the species. Prickly currant and western thimbleberry can be easily grown from seed. Common snowberry, Saskatoon serviceberry, Douglas maple, baldhip and woods rose, and ocean-spray can be established from stem or root cuttings, nursery stock, or seed. Deerfoot vanilla-leaf, solomonplume, sweetscented bedstraw, pioneer violet, and other trailing herbs can be easily propagated from root runners and rhizomes. (For more information on the short- and long-term revegetation potential of selected riparian wetland plant species, see app. B-5.)

Stand Management—

The ABGR series supports a variety of tree species. The dominant trees are grand fir, Douglas-fir, and Engelmann spruce. Other common trees may include bigleaf maple, lodgepole pine, western white pine, and black cottonwood. Subalpine fir, western redcedar, and western hemlock are occasionally present but are not suited to these environments.

Although the wood of grand fir is light in weight and weak compared with many other conifers, it is commercially valuable as timber. Timber harvesting in these sites may increase the risks of windthrow and of rising water tables. Engelmann spruce is particularly susceptible to windthrow. Many larger grand firs have extensive heart rot. In riparian zones, management options appear to be limited to single-tree or small-group selection to open the canopy and increase understory production. During any management activity, care is needed to prevent scarring of the bole of grand fir and subsequent entry of decay organisms. Although tree productivity is high in these relatively warm, moist environments, any management activities need to be planned carefully.

Coarse-textured, compaction-resistant soils are unusual, except on more fluvially active sites. Most sites have loam soils, which are subject to compaction much of the year, especially when moist. During periods of excessive soil moisture or high water tables, machinery and livestock easily compact or otherwise damage the soil. Moist sites and streamside locations should warrant special concern. Roads and trails generally should be located on drier terraces or adjacent upland. To minimize soil disturbance, management activity should be confined to late summer or fall, or during winter on snowpack.

Tree Growth and Yield—

The ABGR series riparian sites are characterized by ample soil moisture, plus relatively warm and mild growing conditions (Lillybridge et al. 1995). The ABGR series has fair to good productivity compared with other forested series, exhibiting high basal areas and site index values. Basal area averages 240 square feet per acre, a moderately high value for the forested tree series (apps. C-1a and C-1b). Only the ABAM, PSME, THPL, and TSHE series are higher. Similarly, average site index for individual species (height in feet) is high compared with many other series (app. C-2). The two moist associations (ABGR/ACCI-WEN and ABGR/ACTR-WEN) are found in areas with higher levels of precipitation and cooler temperatures, allowing better growth compared with the ABGR/SYAL-FLOODPLAIN association. The ABGR/ACCI-WEN is probably the most productive association, followed by ABGR/ACTR-WEN. The ABGR/SYAL-FLOODPLAIN is less productive owing to its warmer, drier environments. This is supported by comparable productivity values for similar types described in Lillybridge et al. (1995). Tree production data are limited and should be used with caution.

Site index			
Species	Base age	No. of trees	SI
ABGR	50	24	82
ACMA	80	2	55
LAOC	50	5	74
PIEN	50	4	78
PIPO	100	5	107
POTR	80	2	80
PSME	50	20	82

Basal area (sq. ft./ac)	
Species	BA
ABGR	83
ACMA	2
CHNO	1
LAOC	13
PICO	4
PIEN	19
PIPO	5
POTR2	23
PSME	91
Total	240

Down Wood—

The overall amount of down woody material is moderate compared with other forested tree series (app. C-3), with logs covering about 8 percent of the ground surface in the ABGR series. This reflects lower elevations, warmer temperatures, and perhaps relatively frequent, log-destroying ground fire. The two moist associations, ABGR/ACCI-WEN and ABGR/ACTR-WEN, have higher amounts of down wood than the drier ABGR/SYAL-FLOODPLAIN association. Log ground cover is lower in the ABGR series than in the moister ABAM, ABLA2, THPL, and TSHE series.

Definitions of log decomposition classes are on page 15.

	Down log attributes				
Log decomposition	Tons/ acre	Cu. ft./ acre	Linear ft./ acre	Sq. ft./ acre	% ground cover
Class 1	1.01	84	210	109	0.25
Class 2	5.24	552	700	561	1.29
Class 3	2.17	271	682	421	0.97
Class 4	1.06	341	611	456	1.05
Class 5	7.88	2,526	1,098	1,742	4.00
Total	17.36	3,774	3,301	3,289	7.56

Snags—

Similarly, the ABGR series has moderate snag production (35.6 snags per acre) compared with other series (app. C-4). Only the TSHE and POTR2 series have fewer numbers of snags. More than half the snags are 5 to 9.9 inches in diameter and only 10 percent are larger than 21.5 inches in diameter.

Definitions of snag condition classes are on page 15.

	Snags/acre by d.b.h. class (inches)				
Snag condition	5–9.9	10–15.5	15.6–21.5	21.6+	Total
Class 1	17.0	5.7	3.3	2.8	28.8
Class 2	2.4	.4	2.1	0	4.9
Class 3	0	0	0	0	0
Class 4	0	0	.5	.2	.7
Class 5	0	0	.5	.7	1.2
Total	19.4	6.1	6.4	3.7	35.6

Fire—

Young grand fir has thin bark and is killed easily by light ground fires until it is at least 4 inches in diameter. Mature trees have 2-inch bark, which protects them against low to moderately severe fires (Crane and Fischer 1986); however, if the bark is injured, the tree bole becomes readily susceptible to Indian paint fungus. Other characteristics that make grand fir susceptible to fire include dense, low branches, flammable foliage, heavy fruticose lichen growth hanging from branches, and relatively shallow roots (Crowe and Clausnitzer 1997, Davis et al. 1980, Fischer and Bradley 1987). In general, grand fir is more resistant to fire than subalpine fir, Engelmann spruce, and lodgepole pine, but less resistant than Douglas-fir and ponderosa pine.

Return intervals of stand-replacing fires on moist ABGR habitat types in the northern Rocky Mountains (ABGR/ACCI-WEN and ABGR/ACTR-WEN are likely similar) probably ranged from 70 to 250 years (Arno 1980). Light ground fires were probably infrequent. Mature stands were dominated by grand fir with lesser amounts of Douglas-fir. Drier sites in continental climate areas (ABGR/SYAL-FLOODPLAIN) probably experienced frequent ground fire return intervals of 16 to 47 years (Agee 1994). Before fire control, mature stands on drier sites and some moist sites were probably composed of large, widely spaced grand fir, Douglas-fir, and ponderosa pine, with relatively dense understory of low and tall shrubs. Ground fires thinned the smaller trees. The advent of intensive fire control encouraged development of multistoried tree canopies in all associations, and many grand fir stands are now at risk to stand-replacing wildfire.

Many ecology plot stands are relatively young compared with other conifer tree series; most are less than 175 years old. Seventy site index trees were sampled for age data. They averaged 118 years in age at breast height. Forty-three trees were less than 100 years old; 18 were 100 to 199, 2 were 200 to 299, and 5 were 300 to 399 years old. One western larch was 500 years old. Most trees older than 199 years were in the moister ABGR/ACTR association. These data seem to suggest that stand-replacing fire-return intervals on the east side of the Cascade Range generally ranged from 100 to 175 years, which is similar to the 100- to 200-year interval reported above. The stand composition regime of neighboring forests also may affect how often these sites burn. Relatively dry grand fir or Douglas-fir upland forests, for example, often adjoin riparian ABGR series sites, and they are prone to more frequent fire, particularly in late summer and during drought periods.

Grand fir seeds can regenerate burned areas but have a short period of viability. Regeneration can be delayed for years if conditions for regeneration are not met at the time of seed fall or planting. In that event, grand fir sites may turn into shrub fields.

Animals—

Livestock. Domestic animals seldom use grand fir as browse (Johnson and Simon 1987). Browse and forage in the shrub and herb layers are greatly reduced in late-successional stands; however, early-seral stands may produce moderate amounts of palatable browse and forage, and use by domestic livestock can be high. However, most use of these sites by livestock (and elk and deer) depends on the availability of cover, shade, and water.

Grazing allotments in the grand fir zone are common, especially on the Cle Elum and Naches RDs, but livestock grazing is not usually a serious problem. However, since many sites have moist, fine-textured soils, managers need to make sure that such sites are not overused. Overuse can result in muddy, trampled areas in early summer or in compaction. Both lead to a significant decline in vegetative cover. If grazed too heavily, eliminating grazing or changing the grazing system, coupled with close monitoring of wildlife, often will allow the remnant shrub and herb populations to sprout and reestablish the stand. This ability to easily reestablish desired shrubs and herbs may be lost when they have been eliminated by overgrazing or when the water table has been lowered by stream downcutting (rare in eastern Washington NFs) or lateral erosion. (For more information on forage palatability, see app. B-1, and for potential biomass production, see app. B-5.)

Wildlife. The ABGR series is good wildlife habitat owing to its structural diversity, closeness to water, mild conditions, and low elevations (Johnson and Simon 1987). Many sites can be used in summer, winter, or both seasons. Wild ungulates, particularly elk, will use them extensively for forage, water, and thermal and hiding cover. Deer and elk trails and beds were common in the vicinity of many sample sites. Deer and elk may eat grand fir needles in winter (Crowe and Clausnitzer 1997). Elk will forage on deerfoot vanilla-leaf when available. Sites are probably used for calving or fawning as well. Older stands often contain ample amounts of snags and logs, which are important for various wildlife species. Black bears may hibernate in large logs and in the base of snags. Old, rotten snags provide dens, nests, and feeding sites for cavity nesters such as martens, fishers, squirrels, weasels, bushy-tailed wood rats, skunks, flying squirrels, and deer mice. Hollowed trunks and logs are used as dens by many small mammals, and the thick grand fir boughs provide temporary shelter from rain (Arno and Hammerly 1984). Beavers have been observed eating the bark of young grand fir trunks and stems, and they occasionally use branches and stems for dam-building material.

Sapsuckers, chickadees, and nuthatches will forage and nest in snags (Crane 1991, Crowe and Clausnitzer 1997, Foiles et al. 1990). Many woodpeckers prefer grand fir and subalpine fir as nesting trees (Agee 1982, Thomas 1979). Pileated woodpeckers and Vaux's swifts roost in snags. Spotted owls are known to use dwarf mistletoe brooms as nest sites. Prey is abundant owing to the frequent logs and snags found on grand fir sites. Grand fir needles are a major part of the diet of grouse. Many species of birds eat the seeds. (For more information on thermal or feeding cover values, see apps. B-2 and B-3. For information on food values or degree of use, see apps. B-2 and B-4.)

Fish. Owing to windthrow and disease, many ABGR sites have moderate amounts of large woody debris in and along adjacent stream channels. This debris provides good channel stabilization, particularly during peak flows associated with spring runoff, and modifies stream structure to provide good fish habitat. (For more information, see app. B-5, erosion control potential.) In addition, older stands with large tree canopies provide shade for smaller streams, which helps regulate water temperatures, a benefit for fish directly in the shade as well as for fish downstream.

Healthy, vigorous stands of ABGR series conifers in riparian zones act as barriers to sedimentation from nearby slopes, and provide a source of large down wood for the stream and nearby fluvial surfaces. Shrub series (such as ALIN) on fluvially active surfaces provide strips of erosion-resistant plants to help stabilize streambanks.

Recreation—

Older stands of grand fir have high value owing to opportunities for undeveloped recreation activities such as hunting, bird watching, and fishing in nearby streams. These sites are not well suited for recreation such as campsites owing to occasional flooding, high water tables, or soils susceptible to compaction much of the year. In addition, shrub layers in open stands, especially the ABGR/ACCI-WEN association, may be dense and tangled, hindering site access and use. Care needs to be taken when selecting such sites for developed recreation purposes. Stands on drier terraces well away from flood zones may provide favorable camps and road sites. However, owing to the number of trees with root rot and decay, these sites are susceptible to windthrow and are hazardous enough that they are not recommended for campsites.

Insects and Disease—

The ABGR series may be the most disease-ridden tree series in eastern Washington (Lillybridge et al. 1995, McDonald et al. 1987a, 1987b). Fungal pathogens, especially various species of decay fungi, are common. Armillaria, annosus, and laminated root rots are particularly common in the ABGR series on the Wenatchee NF (Flanagan 1995).

Laminated and armillaria root rots commonly infect both Douglas-fir and grand fir. Annosus root disease may infect virtually any conifer species on these sites except western larch but is most common in grand fir trees. Schweinitzii butt rot also may infect most conifer species found on these sites. Indian paint fungus also is common in the ABGR series. Dwarf mistletoe infestations affect Douglas-fir, grand fir, and western larch on ABGR sites (Hessburg et al. 1994).

Various insect pests also are possible, most notably western pine beetle, mountain pine beetle, pine engraver beetle, Douglas-fir beetle, fir engraver, western spruce budworm, fir cone moth, fir cone maggot, seed chalcids, and the Douglas-fir tussock moth (Crowe and Clausnitzer 1997).

Estimating Vegetation Potential on Disturbed Sites—

Generally, riparian ABGR sites are not disturbed, so estimating potential vegetation is usually not needed. Clearcutting in riparian areas is unusual, at least on FS land, and currently all FS riparian zones are buffered and not managed for timber production. Also, many stands are located on dry terraces and are infrequently flooded. The ABGR stands usually are separated from active flood zones by wetter plant associations in the SALIX, MEADOW, and ALSI series. In addition, grand fir and other conifers have rapidly reestablished on past clearcut sites. However, to help determine the potential of young stands, or in the event of recent wildfire, sites in similar, nearby watersheds, should be examined.

Sensitive Species—

No sensitive species were located on the ecology plots (app. D).

ADJACENT SERIES

The ABGR series usually transitions into the PSME series (rarely, the PIPO series) on warmer or drier sites. The upper boundaries of the ABGR series are transitional to the THPL or TSHE series on wetter or cooler sites. It changes into the ABLA2 series on colder sites in continental areas of the forests.

RELATIONSHIPS TO OTHER CLASSIFICATIONS

Kovalchik (1992c) described some of the plant associations in the ABGR series in the draft classification for northeastern Washington. Riparian plant associations described in the ABGR series represent relatively wet stand conditions for grand fir associations previously described for the uplands on the Wenatchee NF by Lillybridge et al. (1995). They focused primarily on upland environments but included several plant associations that occur in or in the vicinity of riparian/wetland zones. The ABGR/ACCI-WEN and ABGR/ACTR-WEN associations in this classification are very similar to those described in Lillybridge's Wenatchee classification. The ABGR/SYAL-FLOODPLAIN association is newly classified and similar to the ABGR/SYAL/CARU and ABGR/HODI/CARU associations described by Lillybridge et al. (1995), but the data are from plots only in riparian zones.

Many authors in the Pacific Northwest have described the ABGR series. A partial list of the areas and authors includes the Cascade Range (Diaz and Mellen 1996, John et al. 1988, Topik 1989, Topik et al. 1988); Colville Indian Reservation (Clausnitzer and Zamora 1987); northeastern Washington, northern Idaho, and Montana (Cooper et al. 1991, Daubenmire and Daubenmire 1968, Hansen et al. 1988, 1995, Pfister et al. 1977, Williams et al. 1995); and central and northeast Oregon (Crowe and Clausnitzer 1997, Hall 1973, Johnson and Clausnitzer 1992, Johnson and Simon 1987, Kovalchik 1987). Crowe and Clausnitzer (1997), Diaz and Mellen (1996), and Hansen et al. (1995) are strictly riparian/wetland classifications. Lloyd et al. (1990) and Meidinger and Pojar (1991) described grand fir types in British Columbia.

U.S. DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE WETLANDS CLASSIFICATION

System:	palustrine
Class:	forested wetland
Subclass:	needle-leaved evergreen
Water regime:	(nontidal) intermittently saturated

KEY TO THE GRAND FIR (*ABIES GRANDIS*) PLANT ASSOCIATIONS

1. Vine maple (*Acer circinatum*) ≥5 percent canopy coverage .... **Grand fir/vine maple (ABGR/ACCI) association**

2. Deerfoot vanilla-leaf (*Achlys triphylla*) ≥2 percent canopy coverage .... **Grand fir/deerfoot vanilla-leaf (ABGR/ACTR) association**

3. Dwarf huckleberry (*Vaccinium caespitosum*) or bearberry (*Arctostaphylos uva-ursi*) ≥5 percent canopy coverage; cold-air drainage sites east of the Okanogan River .... **Grand fir/dwarf huckleberry (ABGR/VACA) association** (refer to Williams et al. 1995)

4. Common snowberry (*Symphoricarpos albus*) or ocean-spray (*Holodiscus discolor*) ≥5 percent canopy coverage .... **Grand fir/common snowberry-floodplain (ABGR/SYAL-FLOODPLAIN) association**

Table 7—Constancy and mean cover of important plant species in the ABGR plant associations

		ABGR/ACCI-WEN 9 plots		ABGR/ACTR-WEN 18 plots		ABGR/SYAL-FLOODPLAIN 9 plots	
Species	**Code**	**CON[a]**	**COV[b]**	**CON**	**COV**	**CON**	**COV**
Tree overstory:							
grand fir	ABGR	89	36	100	42	78	27
subalpine fir	ABLA2	11	15	6	5	—	—
bigleaf maple	ACMA	22	2	—	—	44	9
Alaska yellow-cedar	CHNO	—	—	11	3	—	—
Engelmann spruce	PIEN	22	26	50	8	—	—
lodgepole pine	PICO	—	—	6	35	—	—
western white pine	PIMO	44	2	11	5	—	—
black cottonwood	POTR2	11	10	33	15	11	3
Douglas-fir	PSME	89	31	61	16	89	31
western redcedar	THPL	11	5	—	—	—	—
Tree understory:							
grand fir	ABGR	56	9	100	7	89	4
subalpine fir	ABLA2	11	5	6	Tr[c]	—	—
Engelmann spruce	PIEN	33	3	50	2	11	Tr
western white pine	PIMO	11	8	—	—	—	—
Douglas-fir	PSME	22	1	17	1	56	1
western hemlock	TSHE	—	—	11	2	—	—
Shrubs:							
vine maple	ACCI	100	39	—	—	—	—
Douglas maple	ACGLD	—	—	44	4	89	25
mountain alder	ALIN	—	—	33	9	22	1
Saskatoon serviceberry	AMAL	22	1	44	1	67	1
California hazel	COCO	11	4	—	—	11	20
ocean-spray	HODI	—	—	11	1	67	18
Lewis' mock orange	PHLE2	—	—	—	—	56	22
prickly currant	RILA	11	5	83	3	33	3
baldhip rose	ROGY	78	3	72	2	56	8
woods rose	ROWO	11	5	22	1	11	3
western thimbleberry	RUPA	67	13	72	3	56	2
Scouler's willow	SASC	11	3	—	—	11	7
Sitka mountain-ash	SOSI	11	5	6	Tr	11	Tr
shiny-leaf spiraea	SPBEL	22	8	6	Tr	78	10
common snowberry	SYAL	22	5	83	4	100	26
big huckleberry	VAME	33	12	17	Tr	—	—
Low shrubs/subshrubs:							
Oregon hollygrape	BEAQ	11	Tr	28	1	67	1
Cascade hollygrape	BENE	67	4	61	2	—	—
western prince's-pine	CHUMO	56	2	44	1	22	Tr
twinflower	LIBOL	56	5	39	10	—	—
myrtle pachistima	PAMY	89	6	67	1	89	2
Perennial forbs:							
deerfoot vanilla-leaf	ACTR	22	2	100	27	—	—
baneberry	ACRU	22	2	50	1	—	—
largeleaf sandwort	ARMA3	11	1	33	2	56	2
heartleaf arnica	ARCO	—	—	33	1	22	Tr

Table 7—Constancy and mean cover of important plant species in the ABGR plant associations (continued)

		ABGR/ACCI-WEN 9 plots		ABGR/ACTR-WEN 18 plots		ABGR/SYAL-FLOODPLAIN 9 plots	
Species	**Code**	**CON**	**COV**	**CON**	**COV**	**CON**	**COV**
wild ginger	ASCA3	44	9	—	—	—	—
queencup beadlily	CLUN	78	8	28	1	—	—
Hooker's fairy-bells	DIHO	44	1	17	Tr	44	Tr
broadpetal strawberry	FRVIP	—	—	11	Tr	—	—
sweetscented bedstraw	GATR	22	3	61	1	33	1
western rattlesnake plantain	GOOB	56	1	44	1	33	Tr
white hawkweed	HIAL	11	Tr	17	Tr	56	Tr
peavine species	LATHY	—	—	6	Tr	—	—
purple sweet-root	OSPU	11	Tr	61	1	56	1
pink wintergreen	PYAS	11	40	17	3	11	Tr
sidebells pyrola	PYSE	33	2	72	1	22	3
western solomonplume	SMRA	78	3	67	1	56	Tr
starry solomonplume	SMST	89	6	67	1	22	15
claspleaf twisted-stalk	STAM	—	—	17	Tr	11	Tr
western meadowrue	THOC	22	3	67	6	11	Tr
broadleaf starflower	TRLA2	22	2	50	1	11	Tr
white trillium	TROV	78	2	78	1	—	—
pioneer violet	VIGL	44	2	67	1	22	1
Grass or grasslike:							
elk sedge	CAGE	—	—	28	1	67	5

[a] CON = percentage of plots in which the species occurred.
[b] COV = average canopy cover in plots in which the species occurred.
[c] Tr = trace cover, less than 1 percent canopy cover.

MISCELLANEOUS CONIFER TREE SERIES AND PLANT ASSOCIATIONS N = 19

THIS SECTION IS composed of three coniferous tree series, each with one plant association or community type. The LALY, PICO, and PSME[1] series have 6, 3, and 10 plots, respectively. The PSME series (PSME/SYAL-FLOODPLAIN association) is somewhat uncommon at very low elevations on eastern Washington NFs but very common at lower elevations on lands of other ownership. The LALY series (LALY/CAME-PHEM association) is very common at timberline on the Okanogan NF and northern half of the Wenatchee NF. The PICO series (PICO community type) is a catchall for three very different (vegetation and site) lodgepole pine-dominated plots. Descriptions for these series are short compared with series with more plots and plant associations. Because there is only one association in each series, the following writeups also substitute for plant association writeups.

PHYSICAL SETTING

The three miscellaneous conifer series are first combined into a common set of environmental tables, and then the individual series/plant associations are described. The locations of the sample plots are shown in figures 14, 15, and 16.

[1] See appendix A for a cross reference for all species codes and common and scientific names used in this document.

Elevation—

Series	Elevation (feet) Minimum	Maximum	Average	N
LALY	6,860	7,320	7,058	6
PICO	4,300	4,400	4,367	3
PSME	1,320	2,550	2,118	10

Valley Geomorphology—

Series	Valley width					N
	Very broad	Broad	Moderate	Narrow	Very narrow	
LALY	1	4	1	0	0	6
PICO	0	1	2	0	0	3
PSME	3	1	3	2	0	9

Series	Valley gradient					N
	Very low	Low	Moderate	Steep	Very steep	
LALY	5	1	0	0	0	6
PICO	1	2	0	0	0	3
PSME	1	5	2	1	0	9

Channel Types—

Series	Rosgen channel types					N
	B	C	E	Intermittent and ephemeral	Lake/pond	
LALY	0	0	2	0	4	6
PICO	0	0	3	0	0	3
PSME	6	3	0	1	0	10

Fluvial Surfaces—

Series	Fluvial surfaces				N
	Terrace	Toeslope	Shrub wetland	Forest wetland	
LALY	0	0	4	2	6
PICO	0	0	2	1	3
PSME	6	3	0	0	9

Soils—

Series	Soil texture				N
	Sand	Loamy sand	Loam	Clay loam	
LALY	0	3	3	0	6
PICO	0	0	1	2	3
PSME	1	1	7	0	9

Miscellaneous conifer plant associations

	Scientific name	Common name	Ecoclass code	Plots
Major associations:				
LALY/CAME-PHEM	*Larix layallii/Cassiope mertensiana-Phyllodoce empetriformis*	Subalpine larch/Merten's moss-heather–red mountain-heath	CAC116	6
PSME/SYAL-FLOODPLAIN	*Pseudotsuga menziesii/Symphoricarpos albus*-floodplain	Douglas-fir/common snowberry-floodplain	CDS628	10
Minor associations:				
PICO	*Pinus contorta*	Lodgepole pine community type	CLMO	3

KEY TO THE MISCELLANEOUS CONIFER TREE SERIES

1. Moss-heathers (*Cassiope* spp.), mountain-heaths (*Phyllodoce* spp.), and/or partridgefoot (*Luetkea pectinata*) ≥10 percent canopy coverage .... **Subalpine larch series and subalpine larch/Merten's moss-heather–red mountain-heath (LALY/CAME-PHEM) association**

2. Douglas-fir (*Pseudotsuga menziesii*) present with ≥10 percent canopy coverage and reproducing successfully .... **Douglas-fir series and Douglas-fir/common snowberry-floodplain (PSME/SYAL-FLOODPLAIN) association**

3. Lodgepole pine (*Pinus contorta*) dominates the stand, other conifers are not reproducing successfully .... **Lodgepole pine series and lodgepole pine (PICO) community type**

DOUGLAS-FIR SERIES

Pseudotsuga menziesii

PSME/SYAL-FLOODPLAIN Plant Association DS628

N = 10

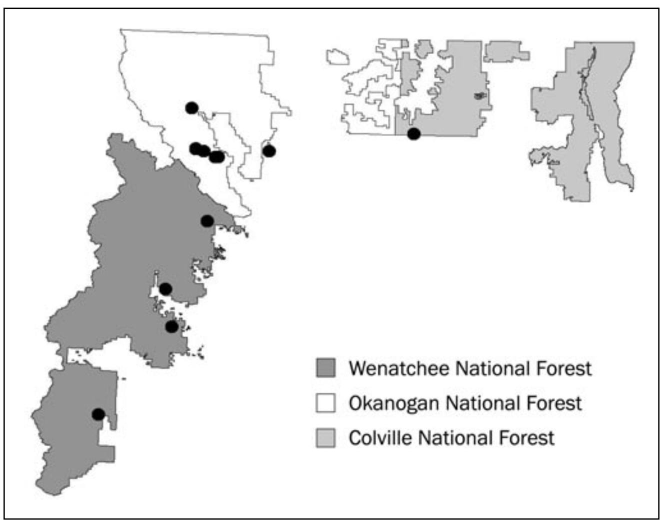


Figure 14—Plot locations for the Douglas-fir series.

VEGETATION CHARACTERISTICS

Mature PSME/SYAL-FLOODPLAIN[1] stands are characterized by an abundance of Douglas-fir and common snowberry. Other trees are seral opportunists and include bigleaf maple, western larch, lodgepole pine, ponderosa pine, quaking aspen, and black cottonwood. Shrubs, especially common snowberry, dominate the ground cover. Other shrubs with high constancy or cover include Douglas maple, Saskatoon serviceberry, Oregon hollygrape, red-osier dogwood, myrtle pachistima, western thimbleberry, and shinyleaf spiraea. These shrubs may form a rich thicket on some of the moister sites in the PSME/SYAL-FLOODPLAIN association. Herbs are generally scarce, especially under dense shrub canopies, and include broadpetal strawberry and starry solomonplume.

PHYSICAL SETTING

The PSME series (PSME/SYAL-FLOODPLAIN association) is somewhat common on the Okanogan and Wenatchee NFs but is rare on the Colville NF, where it was sampled only on the Republic RD. This is the warmest and driest riparian conifer series; although, it is relatively moist compared with PSME associations described in upland classifications (Lillybridge et al. 1995, Williams et al. 1995). Two potential one-plot associations (PSME/ALLUVIAL BAR and PSME/VACA) were sampled but not described in this classification (PSME/VACA is found in the classifications mentioned above).

The PSME/SYAL-FLOODPLAIN sites are generally near the lower elevation distribution of forest zones and occasionally adjacent to shrub-steppe. Ecology plot elevations range from 1,320 to 2,550 feet and average 2,118 feet. Most stands are associated with terraces and gentle toeslopes in broad, low gradient valleys. Valley side slopes usually are quite steep. Only 2 of 10 sample plots are located in narrower, moderate to steep gradient valleys. The streams associated with the PSME series are classified as Rosgen B and C channel types. Most soils are well-developed loam except for one plot with sandy soil deposited during a recent flood. With a few exceptions, these sites are elevated well above the stream and are flooded only by 50- to 100-year flood events. Water tables may be located within a few feet of the soil surface in May and June and lower to more than 5 feet below the soil surface in July and August.

ECOSYSTEM MANAGEMENT

Natural Regeneration of Douglas-Fir

Douglas-fir has winged seeds that are dispersed primarily by wind and gravity (Fowells 1965). Seed is produced annually; good crops are produced about every 6 to 10 years. The seeds are capable of traveling a distance of about 265 feet from the parent tree. Seedlings establish best on mineral seedbeds or on organic seedbeds less than 2 inches thick (Ryker 1975). Seedling survival is higher on undisturbed litter on exposed surfaces in clearcuts (Schmidt 1969); however, it is best under partial shade (Ryker 1975).

Artificial Establishment of Douglas-Fir—

Douglas-fir is a valued timber species. Nursery-grown container and bare-root stock is widely planted on disturbed sites in the Pacific Northwest and does best on warm, mesic sites. Trees can usually be established from seed or advanced, natural regeneration with proper regeneration strategies. Seedlings are somewhat sensitive to direct sunlight and

[1] See appendix A for a cross reference for all species codes and common and scientific names used in this document.

should be planted in the protective shade of stumps, logs, or vegetation. (For more information on the short- and long-term revegetation potential of selected riparian wetland plant species, see app. B-5.)

Stand Management—

Clearcutting was often the method of choice before the 1990s (even in riparian zones), and the success of regeneration using stand regeneration harvest methods has been variable. Overstory removal may result in a long-term conversion of site potential to nonforest communities, especially shrubs, in the PSME/SYAL association (Lillybridge et al. 1995, Pfister et al. 1977). This is especially true on moister sites. Partial overstory removal (selection or group selection) is more appropriate for riparian sites. This is probably not a problem on sites with drier, better drained soils. Most riparian sites on FS lands are presently managed as buffer zones.

Growth and Yield, Down Wood, and Snags—

Wood fiber production is moderately high compared with upland Douglas-fir plant associations (Lillybridge et al. 1995, Williams et al. 1995). Site index averaged 155 (100-year base) for ponderosa pine and 83 (50-year base) for Douglas-fir. Basal area averaged 249 square feet per acre for Douglas-fir and 282 square feet for all species. Down wood averaged 12 tons per acre, 1,824 cubic feet per acre, 2,400 linear feet per acre, 1,878 square feet per acre, and 8 percent ground cover. (For more information, see apps. C-1a through C-4.)

Fire—

Vegetation occurring in this association has a moderate to high resistance to fire. Pole and sawlog ponderosa pine and Douglas-fir will tolerate moderate to hot ground fire. Common snowberry and many of the shrubs will sprout from the stem base or underground rhizomes following cool and moderate ground fire.

Animals—

Livestock. These low-elevation sites have often received a century or more of intensive use (roads, season-long grazing, logging, flooding) because of easy access. Therefore, the majority of stands are highly altered. Past disturbance has lowered the competitive ability of native trees, shrubs, and herbs, thus allowing increasers and invaders to become dominant. Some stands are presently orchards or pastures (for example, Swaukane Creek). (For more information on forage palatability, see app. B-1, and for potential biomass production, see app. B-5.)

Wildlife and fish. The fish habitats on most streams within PSME/SYAL-FLOODPLAIN sites are degraded. Degraded Rosgen B and C channels have wide, shallow, dished profiles, and streambanks (supporting different series) are at least partially denuded of shrubs, especially red-osier dogwood and mountain alder. Depending on the condition of the watershed upstream, the hydrology of these sites may be altered to abnormally high peak flows and low summer flows (for more information, see app. B-5, erosion control potential). Establishing natural plant communities, such as the ALIN/SYAL or COST/SYAL associations, on floodplains and streambanks will influence the development of normal channels with good vegetation control. Ponderosa pine and Douglas-fir should be reestablished on degraded PSME/SYAL-FLOODPLAIN terraces to provide a long-term presence of woody debris for the stream channel. Valleys supporting these associations provide important habitat for a variety of wildlife. Passerines, deer, elk, grouse, woodpeckers, squirrels, chipmunks, and quail use this habitat. (For more information on thermal or feeding cover values, see apps. B-2 and B-3. For information on food values or degree of use, see apps. B-2 and B-4.)

Estimating Vegetation Potential on Disturbed Sites—

Most forested valley bottoms below the elevation distribution of Engelmann spruce belong to the PSME series and PSME/SYAL-FLOODPLAIN association. Forest stands on lower elevation sites on other land ownerships may belong to the PIPO or POTR2 series.

RELATIONSHIPS TO OTHER CLASSIFICATIONS

The PSME series was sampled but not described in the draft classification for northeastern Washington (Kovalchik 1992c). The PSME/SYAL-FLOODPLAIN association is similar to the PSME/SYAL-FLOODPLAIN association described by Crowe and Clausnitzer (1997). The PSME/SYAL-FLOODPLAIN stands with red-osier dogwood are similar to the PSME/COST4 habitat type in Montana (Hansen et al. 1995). This association was sampled but not described on the Ochoco NF in central Oregon (Kovalchik 1987). It is also somewhat similar (in vegetation composition) to the upland PSME/SYAL associations described for eastern Washington (Lillybridge et al. 1995, Williams et al. 1995).

U.S. DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE WETLANDS CLASSIFICATION

System:	palustrine
Class:	forested wetland
Subclass:	needle-leaved evergreen
Water regime:	(nontidal) intermittently flooded

SUBALPINE LARCH SERIES

Larix lyallii

LALY/CAME-PHEM plant association CAC116

N = 6

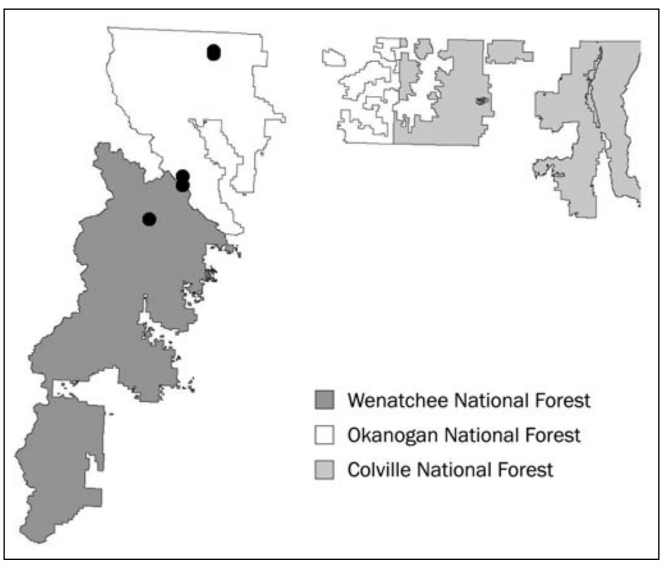


Figure 15—Plot locations for the subalpine larch series.

VEGETATION CHARACTERISTICS

Stands of LALY/CAME-PHEM[1] usually are open and relatively dwarfed compared with adjacent upland stands of subalpine larch (usually the LALY/CAME-LUPE and LALY/VADE-CAME associations, Lillybridge et al. 1995). Individual trees may be centuries old, yet only 3 to 5 inches in diameter. Subalpine larch has at least 10 percent canopy coverage and is usually dominant. Subalpine fir or Engelmann spruce are codominant in some stands. Ericaceous shrubs, especially moss-heathers or mountain-heaths, are characteristic of the ground cover. Other shrubs with high constancy or cover include alpine laurel, Labrador tea, dwarf huckleberry, and grouse huckleberry. The herb layer is often richer relative to adjacent uplands. Partridgefoot was well represented on one-third of the plots and can be used to help key the sites to LALY/CAME-PHEM. Other herbs with high constancy or cover may include woolly pussytoes, hairy arnica, twinflower marsh-marigold, slender hawkweed, fanleaf cinquefoil, black alpine sedge, and smooth woodrush.

PHYSICAL SETTING

The LALY series (LALY/CAME-PHEM association) is very common on the Okanogan and Wenatchee NFs (Lillybridge et al. 1995) but is absent on the Colville NF (Williams et al. 1995). This is one of the harshest, coldest associations in the various conifer series. It generally occurs at very high elevations at the upper margin of forest development. Ecology plot elevations range from 6,860 to 7,320 feet and average 7,058 feet. Sites are generally adjacent to high-elevation fens or carrs (such as the CAME-PHEM, CANI2, CASCB, or SAFA/CASCB associations) on wetter sites or alpine meadows, and adjacent to cliffs or talus slopes on uplands. Stands lie in the transition (xeroriparian) zone that occurs between wetland or riparian zones and uplands. Most sites seem to fall in valleys that are moderate to very broad in width and low to moderate in gradient. Valley side slopes range from gentle to extremely steep. The LALY series usually occurs next to E channels, lakes, or ponds. It also occurs next to A channels. Soil textures within the rooting zone are sandy loam and loam. The soil surface is often very hummocky owing to frost heaving of the moist, loam soils. The LALY/CAME-PHEM sites usually are elevated well above the stream or body of water and are saturated at snowmelt but rarely flooded in the traditional sense.

ECOSYSTEM MANAGEMENT

Natural Regeneration of Subalpine Larch—

Subalpine larch begins to produce cones when it is about 100 years old but generally does not produce significant numbers of seed until it is 200 years old (Arno 1970). Cone production is generally low, presumably owing to late-season frost damage. Large seed crops are infrequent, averaging perhaps 1 out of 10 years. The small, winged seeds are wind disseminated in September. Gravity and snow slides may transport seeds to lower elevations. The seed germinates in July, soon after snowmelt. Seedlings establish best on mineral seedbeds on north slopes. Dry, warm winds contribute to less regeneration on south-facing slopes; however, vigorous stands of subalpine larch are found on gentle, south-facing slopes with deep, moist soils.

[1] See appendix A for a cross reference for all species codes and common and scientific names used in this document.

Stand Management—

Subalpine larch is not a valued timber species. These harsh sites lie at high elevations in climates with deep snowpack and short growing seasons, often in roadless areas, and regeneration cannot be assured. Management should concentrate on limiting any kind of disturbance on these harsh, sensitive sites.

Growth and Yield, Down Wood, and Snags—

Tree production data are limited in the LALY series. Basal area averaged a surprising 111 square feet per acre on six sample plots, probably on account of stand selection bias. Subalpine fir, subalpine larch, and Engelmann spruce each averaged 24, 45, and 42 square feet per acre, respectively. However, wood fiber production was low. Site index averaged only 18, 17, and 34 feet (50-year base) for subalpine fir, subalpine larch, and Engelmann spruce, respectively. The site index numbers are probably too high for the growing conditions as western larch site index curves were used. The western larch curves assume the tree reached breast height at 5 years of age, but it may take subalpine larch 50 or more years to reach breast height on these harsh sites. (For more information, see apps. C-1a through C-4.)

Fire—

Subalpine larch stands lie in zones of very frequent lightning strikes. However, stand-replacement fires are rare because areas of cliff, talus, and rock often interrupt LALY stands. Fires usually are restricted to the immediate vicinity of the lightning-struck tree (Lillybridge et al. 1995). Very little evidence of fire was observed in subalpine larch stands in eastern Washington.

Animals—

Livestock. Large numbers of sheep and cattle were grazed on LALY/CAME-PHEM sites in the late 1800s and early 1900s. Modern-day grazing is limited to an occasional allotment. Still, the damage to vegetation cover of the late 1800s and early 1900s may have initiated erosion that continues to present day (Lillybridge et al. 1995). Examination of areas lying within the LALY series that were used as sheep bedding grounds reveal that erosion is still common, even though the sites have not had sheep on them for many decades. (For more information on forage palatability, see app. B-1. For potential biomass production, see app. B-5.)

Wildlife and fish. Timberline and alpine sites are extremely important for a variety of wildlife. Pikas, ptarmigan, and mountain goats represent a few of the unique animals that inhabit this zone (Lillybridge et al. 1995). (For more information on thermal or feeding cover values, see apps. B-2 and B-3. For information on food values or degree of use, see apps. B-2 and B-4.) These sites usually are located away from streambanks. (For more information, see app. B-5, erosion control potential.)

Recreation—

Subalpine larch forms a distinctive zone of open forests at upper treeline. Heavy, late-melting snowpacks form the headwaters of many streams. Summer recreational use is often high because of the rugged beauty of this country, with subalpine larch being an attractive feature of these landscapes (Lillybridge et al. 1995). Watershed and recreation values are extremely high, but these fragile and valuable habitats need to be carefully managed to protect their soils and vegetation. Excessive horse use is one of the biggest modern-day threats to LALY/CAME-PHEM and other timberline and alpine plant associations. Horses have caused major trail damage and vegetation obliteration on many campsites, and managing this activity is one of the biggest challenges to managing the wilderness.

Insects and Disease—

Subalpine larch is relatively disease free compared with other trees (Lillybridge et al. 1995). No known threats exist for subalpine larch stands.

Estimating Vegetation Potential on Disturbed Sites—

Most LALY stands are in fair or better ecological condition, and it is rare to find stands that cannot be identified to the proper series and plant association.

RELATIONSHIPS TO OTHER CLASSIFICATIONS

Except for the proximity to riparian and wetland ecosystems, the LALY/CAME-PHEM association is similar to the LALY/CAME-LUPE and LALY/VADE-CAME associations described by Lillybridge et al. (1995). Upland plant associations belonging to the LALY series have been described in the Washington Cascade Range (Lillybridge et al. 1995, Williams and Lillybridge 1983), northern Idaho, and Montana (Cooper et al. 1991, Pfister et al. 1977).

U.S. FISH AND WILDLIFE SERVICE WETLANDS CLASSIFICATION

System:	palustrine
Class:	forested wetlands
Subclass:	needle-leaved evergreen
Water regime:	(nontidal) intermittently saturated

LODGEPOLE PINE SERIES

Pinus contorta

PICO N = 3

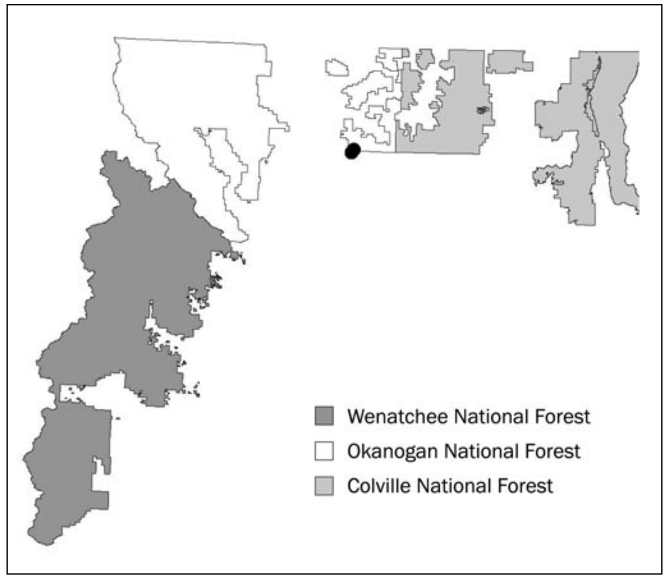


Figure 16—Plot locations for the lodgepole pine series.

ALL THREE PLOTS were sampled in the headwaters of Lost Creek on the Tonasket RD, Okanogan NF. Elevations of these plots range from 4,300 to 4,400 feet. Lodgepole pine[1] dominates the overstory of all three plots. Other conifers are uncommon, and the climax cannot be determined. Two plots are located in wetlands and would have keyed to PICO/CACA and PICO/CAUT associations if there had been more than one plot in each type. Bluejoint reedgrass dominates the undergrowth of the first plot with 80 percent canopy coverage. No other herb is well represented. Sedges dominate the undergrowth of the second plot. Bladder sedge is most abundant with 20 percent canopy coverage. Gray, northern clustered, Buxbaum's, and inflated sedges, as well as weak alkaligrass, are well represented. It is likely that both plots are early-seral stages of PIEN/CACA and PIEN/CAUT associations. The driest plot is located on the transition zone between the above wetlands and the adjacent upland. Shrubby cinquefoil dominates the undergrowth. Dwarf huckleberry, timber oatgrass, Kentucky bluegrass, cutting wheatgrass, spike trisetum, broadpetal strawberry, white clover, and Sitka valerian are well represented. This plot is likely an early-seral, disturbance phase of the ABLA2/VACA plant association found in Lillybridge et al. (1995). (For more information, see apps. B-1 through B-5 and C-1a through C-4.)

[1] See appendix A for a cross reference for all species codes and common and scientific names used in this document.

Table 8—Constancy and mean cover of important plant species in the miscellaneous conifer associations

Species	Code	LALY/CAME-PHEM 6 plots		PICO 3 plots		PSME/SYAL-FLOODPLAIN 11 plots	
		CON[a]	COV[b]	CON	COV	CON	COV
Tree overstory:							
subalpine fir	ABLA2	33	9	—	—	—	—
bigleaf maple	ACMA	—	—	—	—	9	20
subalpine larch	LALY	67	5	—	—	—	—
western larch	LAOC	—	—	—	—	9	15
Engelmann spruce	PIEN	33	13	33	Tr[c]	9	Tr
lodgepole pine	PICO	—	—	100	55	9	10
ponderosa pine	PIPO	—	—	—	—	27	16
quaking aspen	POTR	—	—	—	—	18	7
black cottonwood	POTR2	—	—	—	—	18	7
Douglas-fir	PSME	—	—	—	—	100	56
Tree understory:							
subalpine fir	ABLA2	50	3	33	1	9	Tr
subalpine larch	LALY	100	18	—	—	—	—
Engelmann spruce	PIEN	67	5	67	2	18	1
lodgepole pine	PICO	—	—	100	5	—	—
Douglas-fir	PSME	—	—	—	—	82	3
Shrubs:							
Douglas maple	ACGLD	—	—	—	—	73	16
mountain alder	ALIN	—	—	—	—	27	6
Saskatoon serviceberry	AMAL	—	—	—	—	82	8
red-osier dogwood	COST	—	—	—	—	36	9
Lewis' mock orange	PHLE2	—	—	—	—	27	20
rose species	ROSA	—	—	—	—	9	15
red raspberry	RUID	—	—	—	—	27	10
western thimbleberry	RUPA	—	—	—	—	55	8
shiny-leaf spiraea	SPBEL	—	—	—	—	55	3
common snowberry	SYAL	—	—	—	—	100	50
Low shrubs and subshrubs:							
Oregon hollygrape	BEAQ	—	—	—	—	82	2
Merten's moss-heather	CAME	50	35	—	—	—	—
four-angled moss-heather	CATE2	50	63	—	—	—	—
western wintergreen	GAHU	33	8	—	—	—	—
alpine laurel	KAMI	83	2	—	—	—	—
Labrador tea	LEGL	83	8	—	—	—	—
twinflower	LIBOL	—	—	33	3	9	25
myrtle pachistima	PAMY	—	—	—	—	73	3
red mountain-heath	PHEM	100	13	—	—	—	—
cream mountain-heath	PHGL	17	5	—	—	—	—
shrubby cinquefoil	POFR	—	—	100	14	—	—
dwarf huckleberry	VACA	83	6	67	12	—	—
grouse huckleberry	VASC	50	13	—	—	—	—
Perennial forbs:							
woolly pussytoes	ANLA	67	3	—	—	—	—
rose pussytoes	ANMI	—	—	67	3	—	—
Chamisso arnica	ARCH	—	—	67	3	—	—
hairy arnica	ARMO	50	2	—	—	—	—
western aster	ASOC	—	—	67	3	—	—
twinflower marshmarigold	CABI	50	3	—	—	—	—
Hooker's fairy-bells	DIHO	—	—	—	—	55	4
broadpetal strawberry	FRVIP	—	—	100	5	—	—
largeleaf avens	GEMA	—	—	100	3	—	—
slender hawkweed	HIGR	67	1	—	—	—	—
Canby's licoriceroot	LICA2	17	Tr	67	2	—	—
partridgefoot	LUPE	67	10	—	—	—	—
fanleaf cinquefoil	POFL2	50	1	—	—	—	—
northwest cinquefoil	POGR	—	—	67	3	—	—
hooked buttercup	RAUN2	—	—	100	1	9	Tr
starry solomonplume	SMST	—	—	—	—	64	1
common dandelion	TAOF	—	—	100	1	18	Tr
western meadowrue	THOC	—	—	67	3	36	2
white clover	TRRE	—	—	67	5	—	—
Sitka valerian	VASI	33	5	—	—	—	—
Grass or grasslike:							
cutting wheatgrass	AGCA	—	—	67	4	—	—
bluejoint reedgrass	CACA	—	—	100	30	—	—

Table 8—Constancy and mean cover of important plant species in the miscellaneous conifer associations (continued)

		LALY/CAME-PHEM 6 plots		PICO 3 plots		PSME/SYAL-FLOODPLAIN 11 plots	
Species	**Code**	**CON**	**COV**	**CON**	**COV**	**CON**	**COV**
slimstem reedgrass	CANE3	—	—	67	3	—	—
northern clustered sedge	CAAR2	—	—	33	10	—	—
Buxbaum's sedge	CABU2	—	—	33	5	—	—
gray sedge	CACA4	—	—	33	5	—	—
black alpine sedge	CANI2	83	4	—	—	—	—
bladder sedge	CAUT	—	—	33	20	—	—
inflated sedge	CAVE	—	—	33	5	—	—
timber oatgrass	DAIN	—	—	67	9	—	—
tufted hairgrass	DECE	—	—	67	4	—	—
smooth woodrush	LUHI	83	3	—	—	—	—
timothy	PHPR	—	—	67	2	—	—
Kentucky bluegrass	POPR	—	—	67	4	9	2
weak alkaligrass	PUPAH	—	—	33	10	—	—
Ferns and fern allies:							
common horsetail	EQAR	—	—	67	2	—	—

[a] CON = percentage of plots in which the species occurred.
[b] COV = average canopy cover in plots in which the species occurred.
[c] Tr = trace cover, less than 1 percent canopy cover.

Go to Part 2