USDA Natural Resources Conservation Service

Ecological site F003XN942WA
Southern Washington Cascades Moist Frigid Coniferous Forest

Last updated: 9/09/2023
Accessed: 04/27/2024

General information

Provisional. A provisional ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model and enough information to identify the ecological site.

MLRA notes

Major Land Resource Area (MLRA): 003X–Olympic and Cascade Mountains

Steep mountains and narrow to broad, gently sloping valleys characterize this MLRA. A triple junction of two oceanic plates and one continental plate is directly offshore from Puget Sound. Subduction of the oceanic plates under the westerly and northwesterly moving continental plate contributes to volcanic activity in the Cascade Mountains. Movement among these plates has resulted in major earthquakes and the formation of large stratovolcanoes. The Cascade Mountains consist primarily of volcanic crystalline rock and some associated metasedimentary rock. The mean annual precipitation is dominantly 60 to 100 inches, but it is 30 to 60 inches on the east side of the Cascade Mountains.
The soil orders in this MLRA are dominantly Andisols, Spodosols, and Inceptisols and minor areas of Entisols and Histosols. The soils are dominantly in the frigid or cryic temperature regime and the udic moisture regime. The soils generally are shallow to very deep, well drained, ashy to medial, and loamy or sandy. They are on mountain slopes and ridges.

Ecological site concept

This ecological site is in Mount Rainier National Park at low to middle elevations (1,600 to 3,600 feet). Climate is a key component in the succession of the forest dynamics. This site is in depressions and stream channels of terraces, debris aprons, and valley walls.
The soils that support this ecological site are in the frigid soil temperature regime and the aquic soil moisture regime. They are somewhat poorly drained and very deep. They have a seasonal high water table at a depth of 10 to 20 inches at some time during the growing season. Soil moisture is not a limiting factor to forest growth because of the abundance of precipitation and the inherent water-holding properties of soils influenced by volcanic ash. A thin organic horizon consisting of decomposing twigs, needles, and litter is on the soil surface. This horizon helps to protect the soil from wind and water erosion.
Western hemlock (*Tsuga heterophylla*) and western redcedar (*Thuja plicata*) are the most common overstory species. Douglas-fir (*Pseudotsuga menziesii*) and Sitka spruce (*Picea sitchensis*) are codominant tree species. In the absence of a major disturbance, the heavy shade provided by a hemlock and redcedar forest favors the gradual replacement of Douglas-fir with more shade-tolerant trees. Red alder (*Alnus rubra*) may be a minor component of the overstory in recently disturbed areas and forest openings.

Associated sites

F003XN946WA	**Southern Washington Cascades Moist Low Cryic Coniferous Forest** Ecological site F003NX946WA is located at higher elevations compared to F003XN942WA. The presence of Pacific silver fir is a good indicator for F003XN946WA.

Similar sites

F003XN943WA	**Southern Washington Cascades Frigid Coniferous Forest** Site F003XN943WA has well drained soils and includes drier adapted species such as western hemlock and Cascade Oregon grape.
F003XN941WA	**Southern Washington Cascades Wet Frigid Coniferous Forest** Site F003XN941WA is in areas that have a higher water table and higher susceptibility to ponding. The vegetation in F003XN941WA includes more wet-adapted species such as western redcedar and American skunkcabbage.

Table 1. Dominant plant species

Tree	(1) *Tsuga heterophylla* (2) *Thuja plicata*
Shrub	(1) *Oplopanax horridus* (2) *Rubus spectabilis*
Herbaceous	Not specified

Physiographic features

This ecological site is in depressions and stream channels of terraces, debris aprons, and valley walls at low to middle elevations (1,600 to 3,600 feet) in Mount Rainier National Park. Slope is dominantly 0 to 35 percent.

Table 2. Representative physiographic features

Landforms	(1) Terrace (2) Depression (3)
Flooding frequency	None
Ponding frequency	None
Elevation	1,600–3,600 ft
Slope	0–35%
Water table depth	10–60 in
Aspect	W, NW, N, NE, E, SE, S, SW

Climatic features

Most of the annual precipitation is received in October through March. The mean annual precipitation is 60 to 80 inches, and the mean annual air temperature is 23 to 45 degrees F. Generally, the summers are warm and dry and the winters are cool and wet.

Table 3. Representative climatic features

Frost-free period (characteristic range)	90-130 days
Freeze-free period (characteristic range)	
Precipitation total (characteristic range)	60-80 in

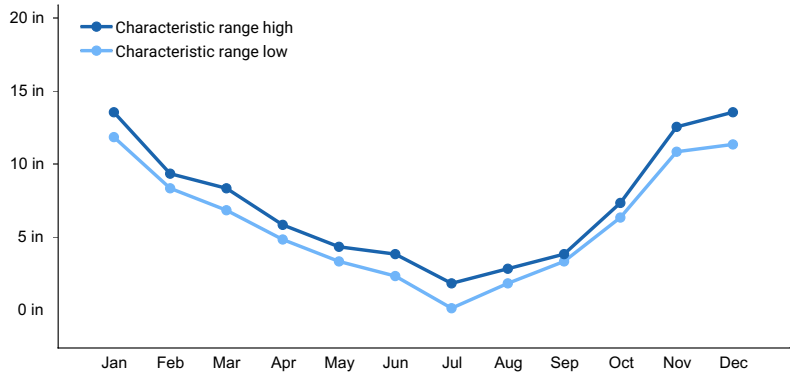


Figure 1. Monthly precipitation range

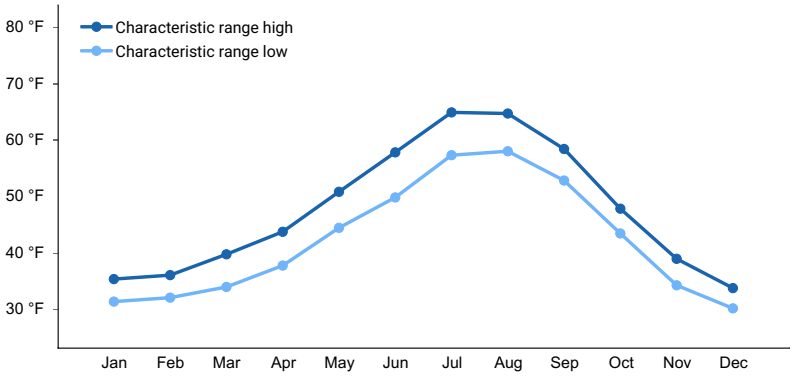


Figure 2. Monthly minimum temperature range

Influencing water features

This ecological site is in depressions and stream channels of terraces, debris aprons, and valley walls at low to middle elevations in Mount Rainier National Park. The soils have a high water table in March through June.

Soil features

Applicable soils: Tokaloo

Applicable soil map units: 6110, 6120, 6125, 7110, 7120, 7125

The Tokaloo soils are in stream channels of terraces, on debris aprons of mountain slopes, and in swales of glacial-valley walls. The soils formed in volcanic ash over andesite colluvium. They have a seasonal high water table at a depth of 10 to 20 inches at some time during the growing season. The soils are not subject to flooding or ponding. They have less than 35 percent rock fragments in the control section. The soils are coarse textured and are primarily ashy sandy loam and ashy loamy sand. Pumice paragravel is in some areas. The Tokaloo soils have an ochric epipedon and andic properties. Podsolization is not evident.
Soil moisture is not a limiting factor to forest growth on these soils because of the abundance of precipitation and the inherent water-holding properties of soils influenced by volcanic ash. A thin organic horizon consisting of decomposing twigs, needles, and litter is on the soil surface. This horizon helps to protect the soil from wind and water erosion.

Table 4. Representative soil features

Parent material	(1) Volcanic ash–andesite (2) Colluvium
Surface texture	(1) Paragravelly, ashy sandy loam (2) Ashy sandy loam (3) Ashy loamy sand
Drainage class	Somewhat poorly drained

Soil depth	60 in
Surface fragment cover <=3"	0–30%
Surface fragment cover >3"	0–5%
Available water capacity (Depth not specified)	3.9–10.2 in
Soil reaction (1:1 water) (Depth not specified)	3.5–6
Subsurface fragment volume <=3" (Depth not specified)	0–35%
Subsurface fragment volume >3" (Depth not specified)	0–5%

Ecological dynamics

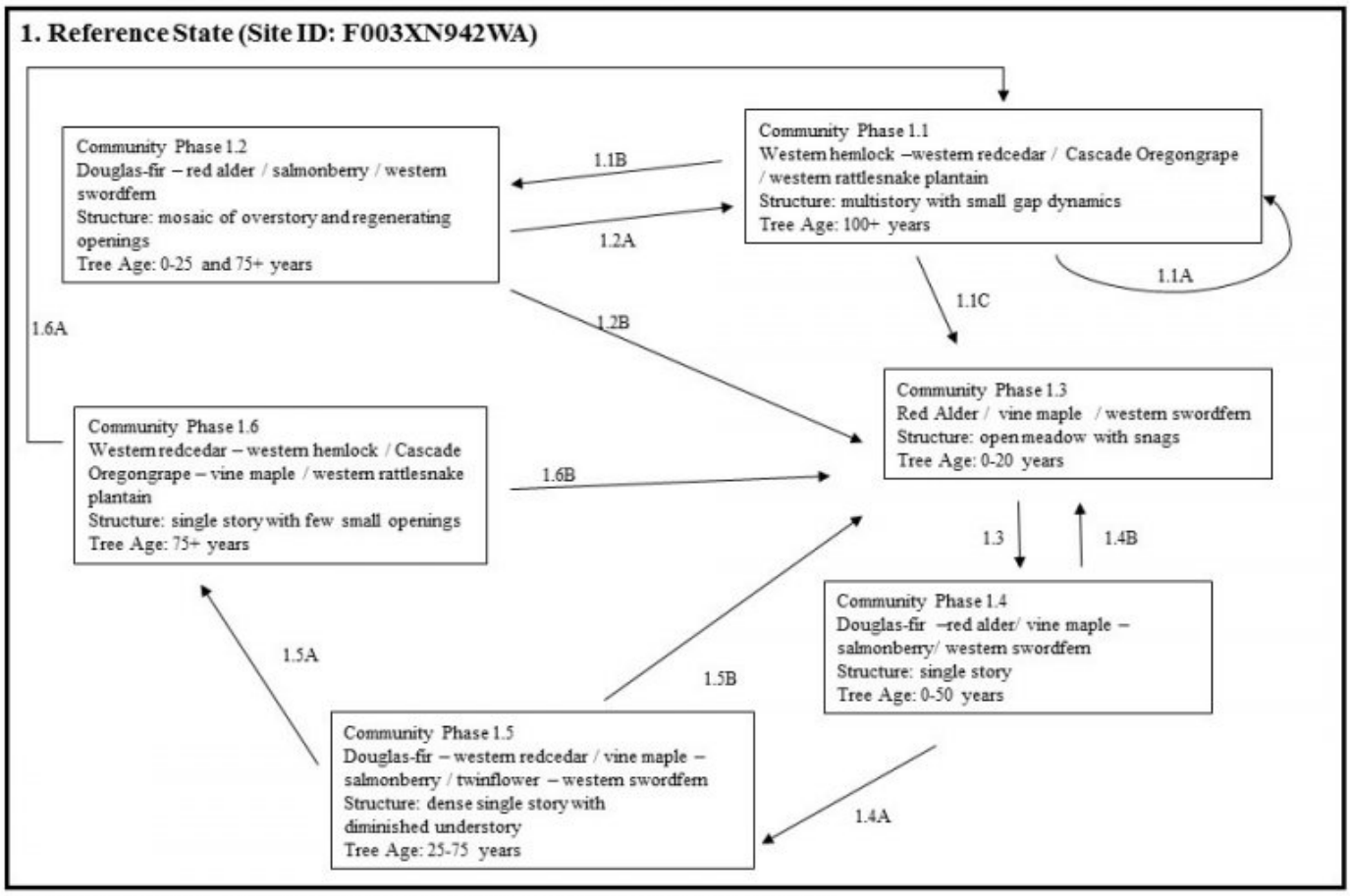
This ecological site is on the warm, moist, lower slopes of Mount Rainier at an elevation of as much as about 3,600 feet, depending on aspect. This site is in areas that have a seasonal high water table at a depth of 10 to 20 inches from the soil surface. Western hemlock (*Tsuga heterophylla*) and western redcedar (*Thuja plicata*) are the most common overstory species. Some Douglas-fir (*Pseudotsuga menziesii*) and Sitka spruce (*Picea sitchensis*) are present.

In the absence of a major disturbance, the shade provided by the hemlock and western redcedar forest favors the gradual replacement of Douglas-fir with more shade-tolerant trees. Red alder (*Alnus rubra*) may be a minor component in the overstory. Cascade Oregon grape (*Mahonia nervosa*), vine maple (*Acer circinatum*), salmonberry (*Rubus spectabilis*), devilsclub (*Oplopanax horridus*), and thimbleberry (*Rubus parviflorus*) make up the dense subcanopy. The understory consists of western rattlesnake plantain (*Goodyera oblongifolia*), western swordfern (*Polystichum munitum*), deer fern (*Blechnum spicant*), western oakfern (*Gymnocarpium dryopteris*), Oregon oxalis (*Oxalis oregana*), twinflower (*Linnaea borealis*), and American skunkcabbage (*Lysichiton americanus*) in scattered areas.

The most common natural disturbance is windthrow, which commonly is a result of the seasonal high water table. The shallow rooting zone in saturated areas causes roots to grow laterally, resulting in frequent tip-ups. This creates openings in the canopy and allows more sunlight to reach the forest floor, leading to a shrubby understory. Because of the frequent tip-ups, the site has a hummocky surface with an abundance of downed woody debris.

Western hemlock is highly susceptible to rot diseases such as armillaria (Armillaria ostoyae), annosus (Heterobasidion annosum), laminated root rot (Phellinus weirii), and Indian paint fungus (Echinodontium tinctorium). The resulting openings in the canopy allow sunlight to reach the forest floor, benefiting the understory. Disturbance by fire is infrequent because of the high humidity and precipitation. Fires occur every 200 to 400 years, and they may be stand-replacing (Tesky, 1992).

State and transition model



Tsuga heterophylla –Thuja plicata / Mahonia nervosa / Goodyera oblongifolia

western hemlock – western redcedar / Cascade Oregongrape / western rattlesnake plantain

→ Community Phase Pathway 1.X = Community Phase
1.XY = Pathway (ecological response to natural disturbances)

State 1

Community 1.1
Western hemlock-western redcedar/Cascade Oregon grape/western rattlesnake plantain

Structure: Multistory with small gap dynamics This community phase represents a lack of major disturbance for at least 100 years. Western hemlock and western redcedar are the dominant overstory species. Both species are shade tolerant and release quickly following extended periods of suppression (Packee, 1990). Douglas-fir and Sitka spruce are present, but regeneration is minimal because of the absence of openings in the canopy. The dense canopy consisting of multiple ages of western hemlock and western redcedar may block most of the sunlight from the forest floor, leading to sparse understory in some areas. Most of the understory vegetation is in areas where there are gaps in the mid-canopy and overstory, which allow sunlight to reach the ground. The understory is more continuous in areas that do not have a mid-canopy. The most common natural disturbance on this site is small gap dynamics resulting from the mortality of one or two trees. Community phase pathway 1.1A This pathway represents minor disturbances, such as small pockets of root disease, individual tree mortality, or windthrow, that maintain the overall structure of the reference community. The mortality of one or two trees creates gaps in the understory, which allow sunlight to reach the forest floor. This promotes growth of forbs and shrubs and regeneration of overstory species, perpetuating a multi-storied, uneven-aged forest.

Forest overstory. The forest canopy consists of western hemlock, western redcedar, Douglas-fir, and Sitka spruce. The forest has multiple layers. The upper canopy is 140 to 250 feet in height, and it averages 155 feet. The diameter of the trees varies depending on the species.

Forest understory. The composition of the understory varies depending on the overstory cover and competition for moisture and light. Overall cover of shrubs such as devilsclub and salmonberry may be as much as 10 to 15 percent in forest openings. Forbs such as western rattlesnake plantain, vanillaleaf, common ladyfern, and western swordfern are common.

Dominant plant species

- western hemlock (*Tsuga heterophylla*), tree
- western redcedar (*Thuja plicata*), tree
- Douglas-fir (*Pseudotsuga menziesii*), tree
- Sitka spruce (*Picea sitchensis*), tree
- Cascade barberry (*Mahonia nervosa*), shrub
- vine maple (*Acer circinatum*), shrub

- salmonberry (*Rubus spectabilis*), shrub
- devilsclub (*Oplopanax horridus*), shrub
- thimbleberry (*Rubus parviflorus*), shrub
- western rattlesnake plantain (*Goodyera oblongifolia*), other herbaceous
- western oakfern (*Gymnocarpium dryopteris*), other herbaceous
- western swordfern (*Polystichum munitum*), other herbaceous
- deer fern (*Blechnum spicant*), other herbaceous
- redwood-sorrel (*Oxalis oregana*), other herbaceous
- American skunkcabbage (*Lysichiton americanus*), other herbaceous

Community 1.2
Douglas-fir–red alder/salmonberry/western swordfern Community phase

Structure: Mosaic of mature overstory and regenerating openings Community phase 1.2 has some areas that resemble phase 1.1, but it also has moderate-sized openings (2 to 4 acres). The vegetation in the openings is dominantly shade-intolerant species such as Douglas-fir and red alder and some remnant species. Many of the shrubs, including salmonberry, vine maple, Cascade Oregon grape, and devilsclub, respond well to increased sunlight and may delay or prevent reforestation of the openings.

Dominant plant species

- Douglas-fir (*Pseudotsuga menziesii*), tree
- red alder (*Alnus rubra*), tree
- salmonberry (*Rubus spectabilis*), shrub
- vine maple (*Acer circinatum*), shrub
- Cascade barberry (*Mahonia nervosa*), shrub
- devilsclub (*Oplopanax horridus*), shrub

Community 1.3
Red alder/vine maple/western swordfern

Structure: Open meadow with snags Community phase 1.3 is an early seral plant community that has been impacted by a stand-replacing disturbance such as a wildfire, large-scale windstorm, mass movement, or major insect infestation. Only fire-resistant trees survive in the understory. The species composition depends on the natural seed sources present and the intensity of the disturbance. Standing, decaying snags are prevalent. Red alder quickly establishes after a disturbance in areas where soil moisture and sunlight are available. Tree seedlings and saplings begin to establish within 3 to 10 years, depending on the severity of the disturbance. Douglas-fir can survive moderate-intensity fires because of the thick, corky bark. Depending on the severity of the fire and damage to the cambium, mature Douglas-fir may remain as a dominant overstory species. Western redcedar and western hemlock may be in a full stand replacement phase post fire (Tesky, 1992). After a moderate or severe fire, shrubs commonly outcompete tree seedlings. Vine maple, red huckleberry, salal, baldhip rose, and Cascade Oregon grape, which may have been moderately abundant previously, recover rapidly and spread when top-killed. This slows successful regeneration of the overstory. The surrounding, undisturbed forest and surviving trees provide seed sources that result in a mixed stand consisting of Douglas-fir, western hemlock, red alder, bigleaf maple,

western redcedar, and grand fir.

Dominant plant species

- red alder (*Alnus rubra*), tree
- Douglas-fir (*Pseudotsuga menziesii*), tree
- vine maple (*Acer circinatum*), shrub
- red huckleberry (*Vaccinium parvifolium*), shrub
- salmonberry (*Rubus spectabilis*), shrub
- salal (*Gaultheria shallon*), shrub
- Cascade barberry (*Mahonia nervosa*), shrub

Community 1.4
Douglas-fir–red alder/vine maple–salmonberry/western swordfern

Structure: Single story Community phase 1.4 is an early seral forest in regeneration. Scattered remnant mature trees may be present. Red alder begins to be replaced by more shade-tolerant species. Douglas-fir and western redcedar regenerate rapidly and increase in dominance, creating thick patches of saplings. Vine maple and salmonberry remain prevalent in the forest openings, and western swordfern begins to re-establish.

Dominant plant species

- Douglas-fir (*Pseudotsuga menziesii*), tree
- red alder (*Alnus rubra*), tree
- western redcedar (*Thuja plicata*), tree
- vine maple (*Acer circinatum*), shrub
- salmonberry (*Rubus spectabilis*), shrub
- western swordfern (*Polystichum munitum*), other herbaceous

Community 1.5
Douglas-fir–western redcedar/vine maple–salmonberry/twinflower–western swordfern

Structure: Dense single story with diminished understory Community phase 1.5 represents the competitive exclusion stage of forest development. Scattered remnant mature trees may be present. Individual trees compete for available water and nutrients. The canopy closure is nearly 100 percent, and the understory is diminished. Some understory species better adapted to partial shade, such as twinflower and red huckleberry, begin to increase in abundance. Over time, the forest begins to self-thin as a result of competition. The species composition depends on the natural seed sources. The forest may consist of a single species or mixed species, including Douglas-fir, western hemlock, red alder, bigleaf maple, and western redcedar.

Dominant plant species

- Douglas-fir (*Pseudotsuga menziesii*), tree
- western redcedar (*Thuja plicata*), tree
- red alder (*Alnus rubra*), tree
- bigleaf maple (*Acer macrophyllum*), tree
- vine maple (*Acer circinatum*), shrub
- salmonberry (*Rubus spectabilis*), shrub
- red huckleberry (*Vaccinium parvifolium*), shrub
- twinflower (*Linnaea borealis*), other herbaceous
- western swordfern (*Polystichum munitum*), other herbaceous

Community 1.6
Western redcedar-western hemlock/Cascade Oregon grape-vine maple/western rattlesnake plantain

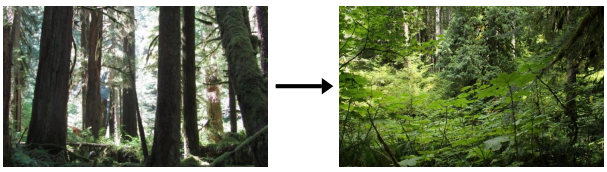
Structure: Single story with a few small openings Community phase 1.6 is a maturing forest that is differentiating vertically. Individual trees are dying from competition, disease, insects, or windthrow, which allows some sunlight to reach the forest floor. The understory increases in abundance, and pockets of overstory tree regeneration are

present.

Dominant plant species

- western redcedar (*Thuja plicata*), tree
- western hemlock (*Tsuga heterophylla*), tree
- Douglas-fir (*Pseudotsuga menziesii*), tree
- Cascade barberry (*Mahonia nervosa*), shrub
- vine maple (*Acer circinatum*), shrub
- salmonberry (*Rubus spectabilis*), shrub
- red huckleberry (*Vaccinium parvifolium*), shrub

Pathway 1.1B
Community 1.1 to 1.2



Western hemlock-western redcedar/Cascade Oregon grape/western rattlesnake plantain

Douglas-fir–red alder/salmonberry/western swordfern Community phase

This pathway represents a disturbance such as a windstorm, an insect infestation, or pockets of root rot. Historically, this pathway was caused by pockets of disease, such as annosum root rot (Heterobasidion annosum) or laminated root rot (Phellinus weirii); minor insect infestations; or low- to moderate-intensity fires. Areas of regeneration are 2 to 4 acres in size.

Pathway 1.1C
Community 1.1 to 1.3

This pathway represents a major stand-replacing disturbance such as a high-intensity fire, large-scale windstorm, major insect infestation, or mass movement. The frequency of high-intensity fires is 200 to 400 years. Volcanic activity has the potential to disrupt the ecology beyond the boundaries of this site and the purpose of this site description.

Pathway 1.2A
Community 1.2 to 1.1

Douglas-fir–red alder/salmonberry/western swordfern Community phase

Western hemlock-western redcedar/Cascade Oregon grape/western rattlesnake plantain

This pathway represents growth over time with no significant disturbance. The areas of regeneration move through the typical phases of stands, including competitive exclusion, maturation, and understory reinitiation, until they resemble the old-growth structure of the reference community.

Pathway 1.2B
Community 1.2 to 1.3

This pathway represents a major stand-replacing disturbance such as a high-intensity fire, large-scale windstorm, major insect infestation, or mass movement.

Pathway 1.3
Community 1.3 to 1.4

This pathway represents growth over time with no further major disturbance.

Pathway 1.4B
Community 1.4 to 1.3

This pathway represents a major stand-replacing disturbance such as a high-intensity fire, large-scale windstorm, major insect infestation, or mass movement that leads to the stand initiation phase of forest development.

Pathway 1.4A
Community 1.4 to 1.5

This pathway represents growth over time with no further major disturbance.

Pathway 1.5B
Community 1.5 to 1.3

This pathway represents a major stand-replacing disturbance such as a high-intensity fire, large-scale windstorm, major insect infestation, or mass movement.

Pathway 1.5A
Community 1.5 to 1.6

This pathway represents growth over time with no further major disturbance.

Pathway 1.6A
Community 1.6 to 1.1

This pathway represents growth over time with no further major disturbance. Continued growth and ongoing mortality lead to more vertical diversification. The community begins to resemble the structure of the reference community, including small pockets of regeneration and a more diversified understory.

Pathway 1.6B
Community 1.6 to 1.3

This pathway represents a major stand-replacing disturbance such as a high-intensity fire, large-scale windstorm, major insect infestation, or mass movement.

Additional community tables

Table 5. Community 1.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
western hemlock	TSHE	*Tsuga heterophylla*	Native	–	–	–	–
western redcedar	THPL	*Thuja plicata*	Native	–	–	–	–
Douglas-fir	PSME	*Pseudotsuga menziesii*	Native	–	–	–	–
Sitka spruce	PISI	*Picea sitchensis*	Native	–	–	–	–

Table 6. Community 1.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Forb/Herb					
sweet after death	ACTR	*Achlys triphylla*	Native	6–18	0–65
twinflower	LIBO3	*Linnaea borealis*	Native	1–3	0–5
western rattlesnake plantain	GOOB2	*Goodyera oblongifolia*	Native	1–2	0–1
Fern/fern ally					
western swordfern	POMU	*Polystichum munitum*	Native	12–36	0–15
common ladyfern	ATFI	*Athyrium filix-femina*	Native	8–18	0–1
western oakfern	GYDR	*Gymnocarpium dryopteris*	Native	4–8	0–1
Shrub/Subshrub					
salmonberry	RUSP	*Rubus spectabilis*	Native	24–96	0–15
red huckleberry	VAPA	*Vaccinium parvifolium*	Native	12–36	0–10
devilsclub	OPHO	*Oplopanax horridus*	Native	36–96	0–10
vine maple	ACCI	*Acer circinatum*	Native	6–240	0–5
Cascade barberry	MANE2	*Mahonia nervosa*	Native	6–12	0–1

Other information

Pathogens
This ecological site is prone to rotting diseases. Annosus, armillaria, and laminated root rot can infest western hemlock and Douglas-fir forests. Indian paint fungus (Echinodontium tinctorium) can cause heart rot in true firs and hemlocks. Root and heart rot can cause mortality of individual trees to several acres of trees and result in widespread windthrow.
Annosus root disease (Heterobasidion annosum) affects nearly all conifer species in the Pacific Northwest. It is a slow-growing pathogen, but it can cause severe root and butt decay in affected stands. It commonly occurs in conjunction with armillaria and laminated root rot and precedes infestations of bark beetle.
Annosus commonly is challenging to differentiate from armillaria. Obvious signs include circular pockets of windthrown trees and dieback of the canopy. Annosus results in growth of a distinctive fruiting body, called a conk, in hollow stumps. Other identifying features include a reddish stain, decay, and “spongy” texture of the heartwood and roots (Goheen, 2006). Regeneration of conifers may be unsuccessful for several decades, until the soil is void of fungal inoculum. Application of borax on freshly cut tree stumps (within 24 hours) may reduce the spread of annosus in managed stands.
Armillaria root disease (Armillaria ostoyae) affects all conifer species and shrubs in the Pacific Northwest. It can affect several acres and cause widespread tree mortality. Western hemlock and western redcedar are susceptible to armillaria, but they commonly are more tolerant of the disease in mixed conifer stands. Young regenerating stands (less than 30 years) are most susceptible; therefore, maturation and succession of the forest may be delayed.
Identification of armillaria is similar to that of other root diseases; however, armillaria produces a distinct white mycelial fan between the wood and bark. Rhizomorphs (brown shoestrings of fungal mycelia) are common under the bark and roots of trees (Goheen, 2006). High resin flow and excessive sapping is also common. Management commonly is limited to use of less susceptible species in plantings.
Hemlock and Douglas-fir forests of the Washington and Oregon Cascades are highly susceptible to laminated root rot (Phellinus weirii), which causes moderate disturbances that result in openings in the forest. The fungus can cause severe root rot and butt decay, leading to stunted growth and mortality. Laminated root rot may affect western hemlock, but it rarely causes mortality of the species.
Laminated root results in pockets of dead and fallen trees, which are broken at or near ground level. Decay is identified by a brown to reddish brown speckled staining in the sapwood and wood that separates along the growth rings. Regeneration of highly susceptible species in areas affected by the fungus typically is unsuccessful (Goheen, 2006).

Table 7. Representative site productivity

Common Name	Symbol	Site Index Low	Site Index High	CMAI Low	CMAI High	Age Of CMAI	Site Index Curve Code	Site Index Curve Basis	Citation
Sitka spruce	*PISI*	–	106	–	230	90	–	–	

Inventory data references

Other Established Classifications

National vegetation classification: Vancouverian Lowland and Montane Rainforest-North Pacific Maritime Douglas-fir-Western Hemlock Forest group

U.S. Department of Agriculture, Forest Service, plant association: TSHE/POMU-TITR

U.S. Department of the Interior, National Park Service, plant association: TSUHET-PSEMEN-(PHUPLI)/OPLHOR/POLMUN

Type locality

Location 1: Pierce County, WA	
Township/Range/Section	T18N R07E S34
Latitude	46° 59′ 49″
Longitude	121° 53′ 24″

Other references

Barnes, George H. 1962. Yield of even-aged stands of western hemlock. U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station Technical Bulletin 1273.

Crawford, R.C., C.B. Chappell, C.C. Thompson, and F.J. Rocchio. 2009. Vegetation classification of Mount Rainier, North Cascades, and Olympic National Parks. Natural Resource Technical Report NPS/NCCN/NRTR-2009/211. National Park Service, Fort Collins, Colorado.

Czuba, J., C. Magirl, C. Czuba, C. Curran, K. Johnson, T. Olsen, H. Kimball, and C. Gish. 2012. Geomorphic analysis of the river response to sedimentation downstream of Mount Rainier, Washington. U.S. Geological Survey Open-file Report 2012-1242. Reston, Virginia.

Dwire, K., and J. Kauffman. 2003. Fire and riparian ecosystems in landscapes in the western United States. Forest Ecology and Management. Volume 178, pages 61-74.

Goheen, E.M., and E.A. Willhite. 2006. Field guide to common diseases and insect pests of Oregon and Washington conifers. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region R6-NR-FID-PR-01-06.

Hanley, D.P., and D.M. Baumgartner. 2002. Forest ecology in Washington. Washington State University Cooperative Extension Technical Report EB 1943.

Hanson, E.J., D.L. Azuma, and B.A. Hiserote. 2002. Site index equations and mean annual increment equations for Pacific Northwest Research Station forest inventory and analysis inventories, 1985-2001. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station Research Note PNW-RN-533.

Harrington, C. 1990. *Alnus rubra*. In Silvics of North America: Volume 2. Hardwoods. U.S. Department of Agriculture, Forest Service, Agriculture Handbook 654. Pages 116-123. https://www.srs.fs.usda.gov/pubs/misc/ag_654_vol2.pdf

Henderson, J.A., R.D. Lesher, D.H. Peter, and D.C. Shaw. 1992. Field guide to the forested plant associations of the Mt. Baker-Snoqualmie National Forest. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region Technical Paper R6-ECOL-TP-028-91.

King, James E. 1966. Site index curves for Douglas-fir in the Pacific Northwest. Weyerhaeuser Company, Forestry Research Center Forestry Paper 8.

Kittel, G., D. Meidinger, and D. Faber-Langendoen. 2015. G240 *Pseudotsuga menziesii-Tsuga heterophylla*/Gaultheria shallon forest group. United States National Vegetation Classification. Federal Geographic Data Committee, Vegetation Subcommittee, Washington, D.C.

Means, J.E. 1990. Tsuga mertensiana. In Silvics of North America: Volume 1. Conifers. U.S. Department of

Agriculture, Forest Service, Agriculture Handbook 654. Pages 623-634.
https://www.srs.fs.usda.gov/pubs/misc/ag_654_vol1.pdf
Minore, D. 1990. *Thuja plicata*. In Silvics of North America: Volume 1. Conifers. U.S. Department of Agriculture, Forest Service, Agriculture Handbook 654. Pages 590-600. https://www.srs.fs.usda.gov/pubs/misc/ag_654_vol1.pdf
Packee, E.C. 1990. *Tsuga heterophylla*. In Silvics of North America: Volume 1. Conifers. U.S. Department of Agriculture, Forest Service, Agriculture Handbook 654. Pages 613-622.
https://www.srs.fs.usda.gov/pubs/misc/ag_654_vol1.pdf
Pojar, J., and A. MacKinnon. 1994. Plants of the Pacific Northwest Coast. Lone Pine, Vancouver, British Columbia.
PRISM Climate Group. Oregon State University. Accessed February 2015. http://prism.oregonstate.edu
Rochefort, R.M., and D.L. Peterson. 1996. Temporal and spatial distribution of trees in subalpine meadows of Mount Rainier National Park. Arctic and Alpine Research. Volume 28, number 1, pages 52-59.
Seastedt, T.R., and G.A. Adams. 2001. Effects of mobile tree islands on alpine tundra soils. Ecology. Volume 82, pages 8-17. Scientia Silvica. 1997. Regeneration patterns in the mountain hemlock zone. Extension Series, Number 6.
Smith, K., G. Kuhn, and L. Townsend. 2008. Culmination of mean annual increment for indicator tree species in the State of Washington. U.S. Department of Agriculture, Natural Resources Conservation Service, Technical Note Forestry-9.
Tesky, J.L. 1992. Tsuga mertensiana. In Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory.
https://www.fs.fed.us/database/feis/plants/tree/tsumer/all.html
Topik, C., N.M. Halverson, and D.G. Brockway. 1986. Plant associations and management guide for the western hemlock zone, Gifford Pinchot National Forest. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region Technical Paper R6-ECOL-230A-1986.
United States Department of Agriculture, Forest Service. 1990. Silvics of North America. Agriculture Handbook 654.
https://www.fs.usda.gov/naspf/
United States Department of Agriculture, Natural Resources Conservation Service, and United States Department of the Interior, National Park Service. 2014. Ecological site descriptions for North Cascades National Park Complex, Washington.

Contributors

Erin Kreutz
Erik Dahlke
Philip Roberts

Approval

Kirt Walstad, 9/09/2023

Rangeland health reference sheet

Interpreting Indicators of Rangeland Health is a qualitative assessment protocol used to determine ecosystem condition based on benchmark characteristics described in the Reference Sheet. A suite of 17 (or more) indicators are typically considered in an assessment. The ecological site(s) representative of an assessment location must be known prior to applying the protocol and must be verified based on soils and climate. Current plant community cannot be used to identify the ecological site.

Author(s)/participant(s)	
Contact for lead author	
Date	04/27/2024
Approved by	Kirt Walstad
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:**

2. **Presence of water flow patterns:**

3. **Number and height of erosional pedestals or terracettes:**

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):**

5. **Number of gullies and erosion associated with gullies:**

6. **Extent of wind scoured, blowouts and/or depositional areas:**

7. **Amount of litter movement (describe size and distance expected to travel):**

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):**

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):**

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:**

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):**

12. **Functional/Structural Groups (list in order of descending dominance by above-ground annual-production or live foliar cover using symbols: >>, >, = to indicate much greater than, greater than, and equal to):**

    Dominant:

    Sub-dominant:

    Other:

    Additional:

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):**

14. **Average percent litter cover (%) and depth (in):**

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):**

16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site:**

17. **Perennial plant reproductive capability:**