Ecological site AX001X04X002
Mesic Udic Flood Plain Forest

Last updated: 5/07/2024
Accessed: 05/18/2024

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): 001X–Northern Pacific Coast Range, Foothills, and Valleys

This long and narrow resource area stretches along the Pacific Border Province of the Pacific Mountain System in Oregon and Washington. The area is bounded by the Olympic Mountains on the north and the Klamath Mountains on the south. Most of the area consists of hills and low mountains with gentle to steep slopes. The parent materials are composed primarily of young Tertiary sedimentary rocks with some minor volcanic rocks. Glacial till and outwash deposits are found in the northern half of the area within Washington. In the far southern portion of the area, near the Klamath Mountains, the sedimentary rocks are older and some have been metamorphosed. The average annual precipitation ranges from 60 to 200 inches, increasing with elevation.
The dominant soil orders in this MLRA are Andisols, Inceptisols, and Ultisols. Soil depth ranges from shallow to very deep. While most soils in the area are well drained and occur on foothills, mountain slopes and ridges, floodplain and depressional soils can range from well drained to very poorly drained. Soil textures are typically medial, loamy, or clayey. The dominant soils in the area have a mesic or frigid soil temperature regime and a udic soil moisture regime; however, soils with an aquic soil moisture regime or cryic soil temperature regime do occur.

LRU notes

The Southern Pacific Coast Range land resource unit (LRU 4) of MLRA 1 is located in central to southern Oregon State. The LRU extends from the Siletz River to the Rogue River and is bounded on the west by MLRA 4a Sitka Spruce Belt and MLRA 2 Willamette and Puget Sound Valleys to the east. Several major rivers carved valleys through the landscape depositing more recent alluvium. These include the Alsea, Coos, Coquille, Green, Yachats, Siletz, Siuslaw, Umpqua, and Rogue Rivers.

Ecological site concept

This ecological site is found on the western Coast Range in the Pacific Northwest from central to southern Oregon. It is found at low elevations in broad and wide riparian corridors on stream terraces and flood plain steps on alluvial soils. These areas are subject to stream overflow. Riparian ecological sites typically differ in topography, vegetation, geomorphology, and microclimate from the surrounding uplands of the forest ecosystem (Dwire, 2003). The most common overstory species are black cottonwood (Populus balsamifera spp. trichocarpa), red alder (Alnus rubra), Douglas-fir (Pseudotsuga menziesii), western hemlock (Tsuga heterophylla) bigleaf maple (Acer macrophyllum), and California laurel (Umbellularia californica). Red alder may dominate the canopy in some sites, especially where there are forest openings or pockets of disturbance. Regeneration is restricted by canopy cover and often limited to gaps where sunlight is most available. Common understory species include salmonberry (Rubus spectabilis), willow species (Salix spp.), western swordfern (Polystichum munitum), and Oregon oxalis (Oxalis oregana).
The most common natural disturbance is flooding, with the volume and longevity of the flooding determining the effect on the dynamics of the forest. Although wildfire is uncommon in this ecological site (greater than 450-year return interval) when it does occur, it may be stand replacing (Balian, 2005). Fallen trees with exposed root systems and large woody debris is common. The longer interval between major disturbance, the more diverse the overstory

becomes as conifers such as Douglas-fir and western hemlock establish. These sites are also commonly cleared for pasture, which may affect the site hydrology and the flooding regime.

Associated sites

AX001X04X001	**Mesic Udic Riparian Forest** Mesic Udic Riparian Forest is found in narrower riparian corridors compared to Mesic Udic Flood Plain Forest. Mesic Udic Riparian Forest is often located along the tributaries that lead into Mesic Udic Flood Plain Forest.

Table 1. Dominant plant species

Tree	(1) *Populus balsamifera ssp. trichocarpa* (2) *Alnus rubra*
Shrub	(1) *Rubus spectabilis*
Herbaceous	(1) *Polystichum munitum*

Legacy ID

F001XD002OR

Physiographic features

his ecological site is found at low elevations in broad and wide riparian corridors on stream terraces and flood plain steps on alluvial soils.

Table 2. Representative physiographic features

Landforms	(1) River valley > Flood plain (2) River valley > Terrace
Flooding frequency	None to frequent
Ponding frequency	None
Elevation	3–244 m
Slope	0–3%
Aspect	W, NW, N, NE, E, SE, S, SW

Climatic features

The climate has hot, moist summers and warm, wet winters. Mean annual precipitation ranges from 60 to 130 inches. Mean annual temperatures range from 44 to 54 degrees F (PRISM Climate Group, 2019). The mild temperatures, abundant precipitation, and a long growing season result in highly productive forestlands.

Table 3. Representative climatic features

Frost-free period (characteristic range)	160-240 days
Freeze-free period (characteristic range)	
Precipitation total (characteristic range)	1,524-3,302 mm

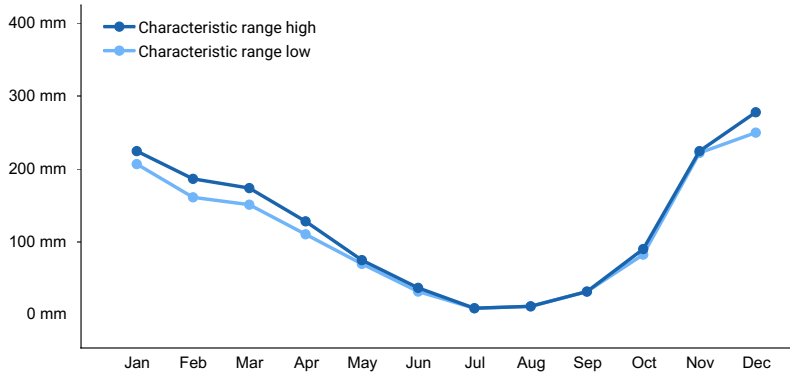


Figure 1. Monthly precipitation range

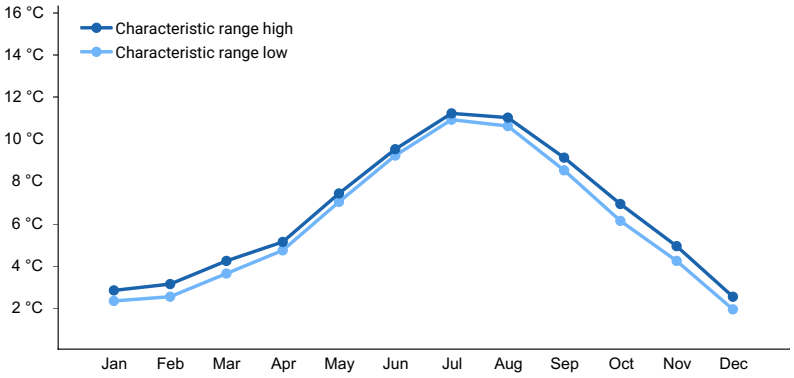


Figure 2. Monthly minimum temperature range

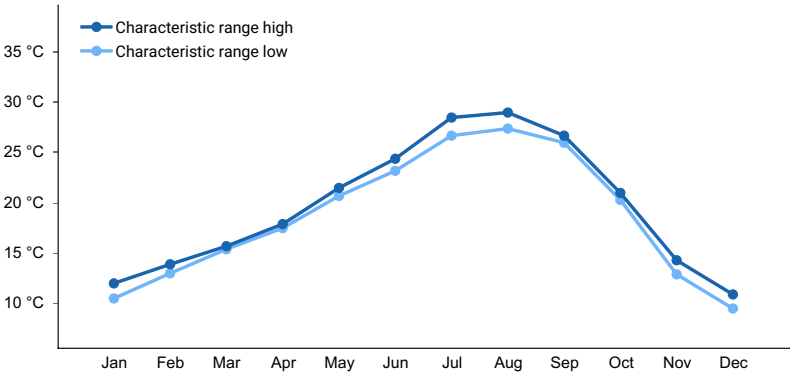


Figure 3. Monthly maximum temperature range

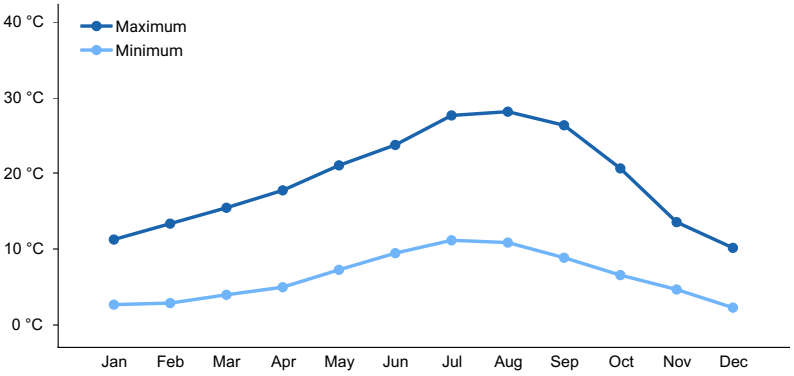


Figure 4. Monthly average minimum and maximum temperature

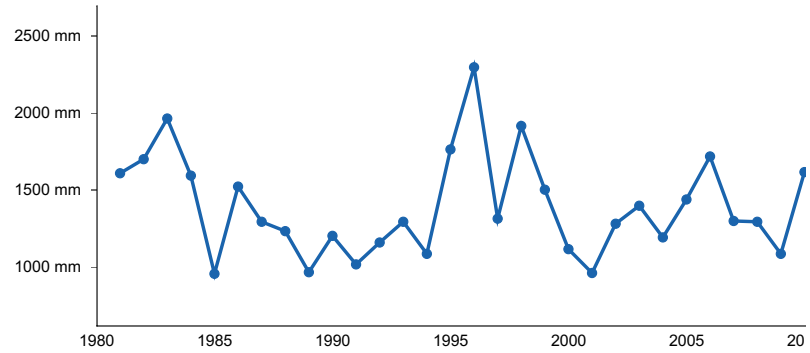


Figure 5. Annual precipitation pattern

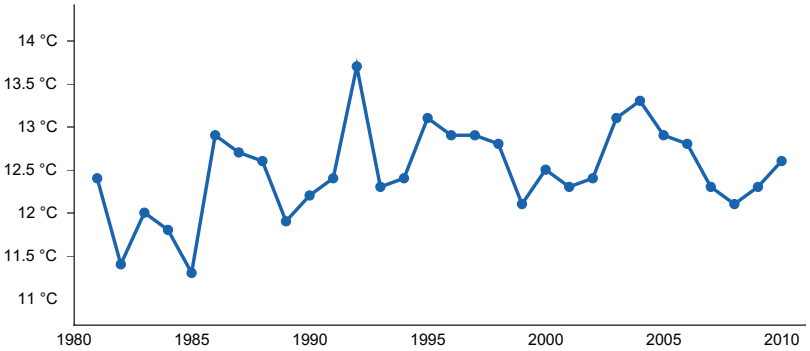


Figure 6. Annual average temperature pattern

Climate stations used

- (1) ELKTON 3 SW [USC00352633], Elkton, OR
- (2) POWERS [USC00356820], Powers, OR

Influencing water features

This ecological site is subject to stream overflow and may experience flooding. Riparian ecological sites typically differ in topography, vegetation, geomorphology, and microclimate from the surrounding uplands of the forest ecosystem

Soil features

Soils that support this ecological site occur in the mesic soil temperature regime and the udic soil moisture regime. They are formed in alluvium on flood plain step and steam terrace positions. These soils are typically subject to flood events from November to April. The smaller, more frequent flood events typically only cause minor scouring in comparison with greater-magnitude 100- to 500-year floods. Soils of this ecological site are weakly developed Inceptisols due to their young age and association with active floodplains.

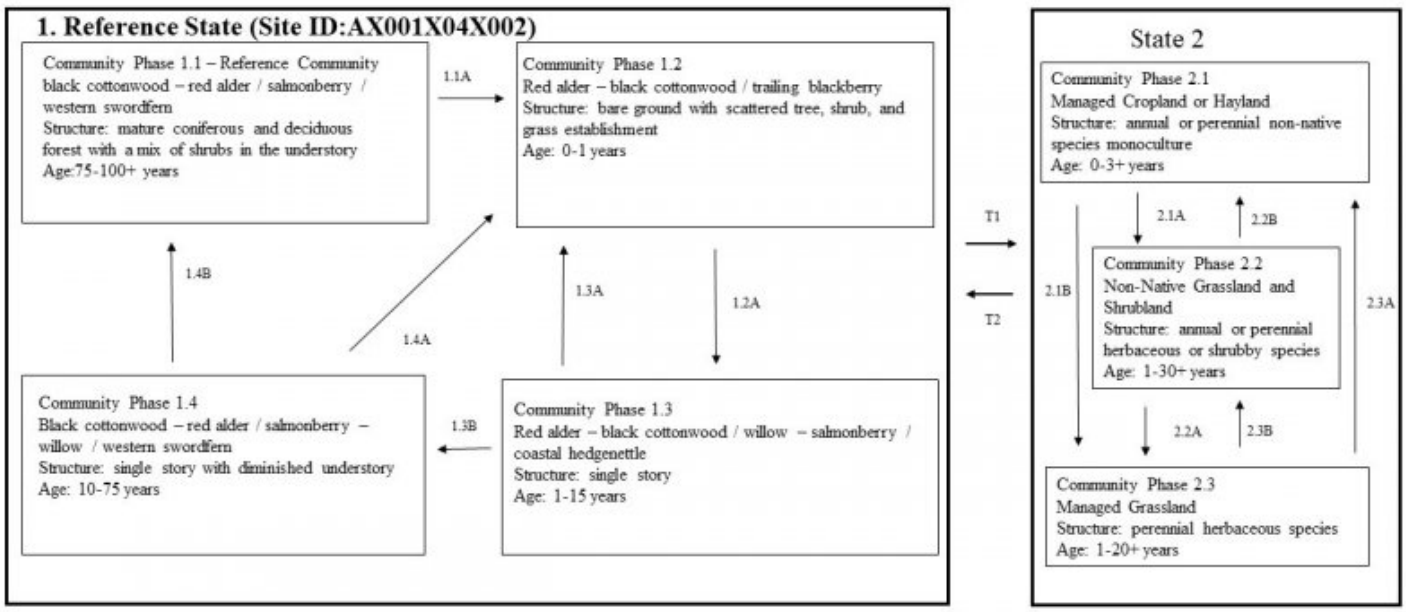
Table 4. Representative soil features

Parent material	(1) Alluvium
Surface texture	(1) Sandy loam (2) Loam
Drainage class	Well drained to somewhat excessively drained
Soil depth	152 cm
Surface fragment cover <=3"	0–7%
Surface fragment cover >3"	0%

Clay content (0-20.3cm)	9–16%
Subsurface fragment volume <=3" (2.5-152.4cm)	0–26%
Subsurface fragment volume >3" (2.5-152.4cm)	0–8%

Ecological dynamics

State and transition model



Populus balsamifera ssp. trichocarpa – Alnus rubra / Rubus spectabilis / Polystichum munitum
black cottonwood – red alder / salmonberry / western swordfern

Community Phase Pathway 1.X = Community Phase X#Y = Transition Pathway
1.XY = Pathway (ecological response to natural processes)

State 1
Reference State

Community 1.1
Black cottonwood – red alder / salmonberry / western swordfern

Black cottonwood – red alder / salmonberry / western swordfern Structure: mature coniferous and deciduous forest

with a mix of shrubs in the understory Black cottonwood is the most differentiating overstory species in the reference community and its dominance separates this site from Ecological Site Mesic Udic Riparian Forest (AX00103X002). Red alder and California laurel may dominate the canopy in some sites, especially where there are forest openings or pockets of disturbance. Regeneration is restricted by canopy cover and often limited to gaps where sunlight is most available. Additionally, conifers such as western hemlock (typically in stands older than 100 years) and Douglas-fir may also be present in the stand. Herbivory on western hemlock by elk (Cervus elaphus) and black-tailed deer (Odocoeleus hemionus columbianus) may greatly impact the prominence of these species (Stolnack, 2010). The reference community represents a lack of major flooding for at least 75 years, allowing the pioneering species to form a mature canopy. The lack of flooding also allows the growth of a robust understory of shrubs including willows, salmonberry, red elderberry (*Sambucus racemosa*), thimbleberry (*Rubus parviflorus*), and snowberry (*Symphoricarpos albus*). Forbs such as western swordfern,, twistedstalk (*Streptopus lanceolatus*), and Oregon oxalis are also often prolific. Common disturbances include small gap dynamics (1/2 acre openings or smaller) following the decline of the red alder canopy and minor scouring from flooding. Soil deposition following minor scouring from smaller scale and periodic flooding temporarily affects the understory community, but it does not alter the composition of the overstory. In addition, beaver (Castor canadensis) activity can by a significant driver in small scale disturbances, hydrologic morphology, and contribute to large woody debris in riparian edges and corridors.

Dominant plant species

- black cottonwood (*Populus balsamifera ssp. trichocarpa*), tree
- red alder (*Alnus rubra*), tree
- Douglas-fir (*Pseudotsuga menziesii*), tree
- western hemlock (*Tsuga heterophylla*), tree
- bigleaf maple (*Acer macrophyllum*), tree
- California laurel (*Umbellularia californica*), tree
- salmonberry (*Rubus spectabilis*), shrub
- thimbleberry (*Rubus parviflorus*), shrub
- red elderberry (*Sambucus racemosa*), shrub
- common snowberry (*Symphoricarpos albus*), shrub
- willow (*Salix*), shrub
- western swordfern (*Polystichum munitum*), other herbaceous
- twistedstalk (*Streptopus lanceolatus*), other herbaceous
- redwood-sorrel (*Oxalis oregana*), other herbaceous

Community 1.2
Red alder – black cottonwood / trailing blackberry

Red alder – black cottonwood / trailing blackberry Structure: Bare ground with scattered tree, shrub, and grass establishment Community phase 1.2 represents a riparian forest that is undergoing regeneration or stand initiation immediately following flooding disturbance. The soil surface is gravelly and highly variable depending on the intensity, frequency, and aggradation of the flooding event (Fonda, 1974). There may be scattered remnant mature trees in some areas and an abundance of woody debris. Successful regeneration is dependent on the local seed source, adequate seed bed, and sufficient light and water (Nierenberg, 2000). Red alder has several competition advantages and can establish quickly, relative to conifers. Red alder can sprout and establish in full sunlight and fixes nitrogen in poorly developed alluvial soils providing an early competitive advantage (Villarin, 2009). In addition, the deciduous species seeds are light and can be transported long distances by wind and water, allowing for rapid recolonization. Trailing blackberry (*Rubus ursinus*) is often established within this community phase.

Dominant plant species

- red alder (*Alnus rubra*), tree
- black cottonwood (*Populus balsamifera ssp. trichocarpa*), tree
- California blackberry (*Rubus ursinus*), shrub

Community 1.3
Black cottonwood - red alder / willow – salmonberry / coastal hedgenettle

Black cottonwood - red alder / willow – salmonberry / coastal hedgenettle Structure: single story Community phase

1.3 is an early seral forest in regeneration, possibly with scattered remnant mature trees. There is increased competition among individual trees for available water, light, and nutrients. Black cottonwood and red alder dominate the overstory in this phase. Trailing blackberry is a large component on the understory, however salmonberry and willow species begin to dominate the shrub layer. Coastal hedgenettle (Stacys chamissonis) and twistedstalk are often present in the forb layer.

Dominant plant species

- black cottonwood (*Populus balsamifera ssp. trichocarpa*), tree
- red alder (*Alnus rubra*), tree
- California blackberry (*Rubus ursinus*), shrub
- willow (*Salix*), shrub
- salmonberry (*Rubus spectabilis*), shrub
- coastal hedgenettle (*Stachys chamissonis*), other herbaceous
- twistedstalk (*Streptopus lanceolatus*), other herbaceous

Community 1.4
Black cottonwood – red alder / salmonberry –willow / western swordfern

Black cottonwood – red alder / salmonberry –willow / western swordfern Structure: single story with diminished understory Community phase 1.4 is a forest in the competitive exclusion stage, possibly with scattered remnant mature trees. Red alder tends to dominate the overstory, however red alder will begin to die between 40-70 years following disturbance and allow more light to penetrate the newly nitrogen rich soil (Naiman, 2009). As a result, conifer regeneration becomes more prevalent in this community phase. Douglas-fir and western hemlock will begin to establish seedlings sporadically, especially in areas with higher shade, and at times within 4 years of hardwood establishment (Stolnack, 2010). Downed logs are an important component for conifer establishment which is more prevalent in more established stands (Villarian, 2009). During this phase, canopy closure will mature to 100 percent, leading to diminished understory. If there is a presence of black cottonwood and red alder regeneration within this community phase, it may be inferred that frequent minor flooding has been influencing site dynamics (Nierenberg, 2000). Shade tolerant forbs such as western swordfern and Oregon oxalis establish during this phase. Over time, the forest begins to self-thin as a result of competition and a decrease in species that are not tolerant of shade.

Dominant plant species

- black cottonwood (*Populus balsamifera ssp. trichocarpa*), tree
- red alder (*Alnus rubra*), tree
- Douglas-fir (*Pseudotsuga menziesii*), tree
- western hemlock (*Tsuga heterophylla*), tree
- California laurel (*Umbellularia californica*), tree
- salmonberry (*Rubus spectabilis*), shrub
- willow (*Salix*), shrub
- California blackberry (*Rubus ursinus*), shrub
- western swordfern (*Polystichum munitum*), other herbaceous
- redwood-sorrel (*Oxalis oregana*), other herbaceous

Pathway 1.1A
Community 1.1 to 1.2

This pathway represents a stand replacing wildfire. catastrophic windstorm, or a major 100 or 500-year flood event which scours the stream channel, removes understory and overstory vegetation, and may alter the stream flow. This type of disturbance may completely reconfigure sediment loads and dramatically reduce or eliminate the forest overstory.

Pathway 1.2A
Community 1.2 to 1.3

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

Pathway 1.3A
Community 1.3 to 1.2

This pathway represents a stand replacing wildfire. catastrophic windstorm, or a major 100 or 500-year flood event which scours the stream channel, removes understory and overstory vegetation, and may alter the stream flow. This type of disturbance may completely reconfigure sediment loads and dramatically reduce or eliminate the forest overstory.

Pathway 1.3B
Community 1.3 to 1.4

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

Pathway 1.4B
Community 1.4 to 1.1

Black cottonwood – red alder / salmonberry –willow / western swordfern

Black cottonwood – red alder / salmonberry / western swordfern

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

Pathway 1.4A
Community 1.4 to 1.2

This pathway represents a stand replacing wildfire. catastrophic windstorm, or a major 100 or 500-year flood event which scours the stream channel, removes understory and overstory vegetation, and may alter the stream flow. This type of disturbance may completely reconfigure sediment loads and dramatically reduce or eliminate the forest overstory.

State 2
Converted State

Community 2.1
Managed Cropland or Hayland

Managed Cropland or Hayland Structure: Annual or perennial non-native species Community Phase 2.1 may consist of a range of crops, including annually planted species, short-lived perennials, and more permanent

shrubby crops. Hayland and grass-legume silage crops are also included in this community phase.

Community 2.2
Non-Native Grassland and Shrubland

Non-Native Grassland and Shrubland Structure: Annual or perennial herbaceous or shrubby species Community phase 2.2 is characterized by a low level of agronomic or management inputs such as added fertility, intensive grazing management, regular mowing or weed control. This plant community is often dominated by introduced weedy species. Sites with extremely low fertility or heavy grazing pressure will have a higher proportion of annual, stoloniferous or rhizomatous species. Wetland areas are often dominated by non-native rhizomatous grasses. This plant community can include remnants of commonly seeded introduced pasture species.

Community 2.3
Managed Grassland

Managed Grassland Structure: perennial herbaceous species Community phase 2.3 receives regular agronomic inputs, including adding soil nutrients and other soil amendments such as lime, implementing grazing management plans, regular mowing, controlling weeds, and reseeding as needed. This plant community typically includes introduced perennial pasture and hay species that commonly are seeded. In areas of historic native grassland, mixtures of perennial and annual native species may be seeded and managed by appropriate agronomic and livestock management activities. Minor amounts of introduced species that commonly are in non-native grassland and shrubland communities (community phase 2.2) are in this phase.

Pathway 2.1A
Community 2.1 to 2.2

In the absence of the following agronomic and livestock management activities, seeds from surrounding weedy plant communities will be transported to the site through factors such as wind, flood water, animals or vehicle traffic where adapted species will become established. Management activities could include tillage, addition of significant fertility or other soil amendments such as lime, mowing, burning, harvest or chemical control of vegetation, planting the site to desirable herbaceous species and implementation of grazing management plans.

Pathway 2.1B
Community 2.1 to 2.3

Agronomic and livestock management activities such as tillage, addition of significant fertility or other soil amendments such as lime, mowing, burning, harvest or chemical control of vegetation, planting the site to desirable herbaceous species and implementation of grazing management plans.

Pathway 2.2B
Community 2.2 to 2.1

Agronomic activities such as tillage, addition of significant fertility or other soil amendments such as lime, mowing, burning, harvest or chemical control of vegetation, and planting the site to desirable crop species.

Pathway 2.2A
Community 2.2 to 2.3

Agronomic and livestock management activities such as tillage, addition of significant fertility or other soil amendments such as lime, mowing, burning, harvest or chemical control of vegetation, planting the site to desirable herbaceous species and implementation of grazing management plans.

Pathway 2.3A
Community 2.3 to 2.1

Agronomic activities such as tillage, addition of significant fertility or other soil amendments such as lime, mowing, burning, harvest or chemical control of vegetation, and planting the site to desirable crop species.

Pathway 2.3B
Community 2.3 to 2.2

In the absence of the following agronomic and livestock management activities, seeds from surrounding weedy plant communities will be transported to the site through factors such as wind, flood water, animals or vehicle traffic where adapted species will become established. Management activities could include tillage, addition of significant fertility or other soil amendments such as lime, mowing, burning, harvest or chemical control of vegetation, planting the site to desirable herbaceous species and implementation of grazing management plans.

Transition T1
State 1 to 2

This pathway represents a change in land use. Land management changes include modifications to the hydrologic function to develop pasture and agriculture. Non-native seed disbursement is introduced (intentionally or unintentionally) which alters the reference community.

Transition T2
State 2 to 1

This pathway represents a transition to restore the natural hydrologic function and native plant habitat. Native seed sources are necessary to restore the community as well as extensive brush and invasive species management and mitigation.

Additional community tables

Inventory data references

Other Established Classifications for Ecological Site

National Vegetation Classification Group: G254 North Pacific Lowland Riparian Forest and Woodland Group and the A3743 Oregon Ash – Black cottonwood – Alder Riparian Forest Alliance

Other references

Christy, J., Kagan, J., Wiedemann, A. 1998. Plant Associations of the Oregon Dunes National Recreation Area. United States Department of Agriculture Forest Service, Pacific Northwest Region. Technical Paper R6-NR-ECOL-TP-09-98

Fonda, R.W. 1974. Forest succession in relation to river terrace development in Olympic National Park, Washington. Ecology, 55(5): 927-942.

Franklin, J.F., and Dyrness C.T. 1973. Natural Vegetation of Oregon and Washington. Oregon State University press, Corvallis, USA.

Dwire, K. and Kauffman, J. 2003. Fire and Riparian Ecosystems in Landscapes in the Western United States. Forest Ecology and Management, Vol. 178 pp 61-74.

Goheen, E.M. and Willhite, E.A. 2006. Field Guide to Common Diseases and Inspect Pests of Oregon and Washington Conifers. Portland, Oregon: USDA Forest Service, Pacific Northwest Region R6-NR-FID-PR-01-06.

Naiman, R., Bechtold, S., Beechie, T., Latterell, J., Van Pelt, R. 2009. A Process-Based View of Floodplain Forest Patterns in Coastal River Valleys of the Pacific Northwest. Ecosystems, Vol 13 pp 1-31.

Hemstrom, M., Logan, S. 1986. Plant Association and Management Guide: Siuslaw National Forest. United States Department of Agriculture Forest Service, Pacific Northwest Region. Technical Paper R6-Ecol 220-1986a

Packee, E.C. 1990. Tsuga heterophylla. Silvics of North American [Online]. U.S. Department of Agriculture, Forest Service, Northeastern Area.

Pojar J., and MacKinnon. 1994. Plants of the Pacific Northwest Coast. Lone Pine, Vancouver, British Columbia. 528 pages.

PRISM Climate Group, Oregon State University, http://prism.orgeonstate.edu, visited Feb., 2015.

Roccio, J., Crawford, R. 2015. Ecological Systems of Washington State. A Guide to Identification. Washington Department of Natural Resources Natural Heritage Report 2015-04.

Soil Survey Staff. 2014. Keys to Soil Taxonomy, 12th ed. USDA-Natural Resources Conservation Service,

Washington, DC.
Soil Survey Staff. 1999. Soil Taxonomy: A Basic System of Soil classification for Making and Interpreting Soil Surveys. 2nd ed. USDA-Natural Resources Conservation Service. U.S. Department of Agriculture Handbook 436.
Steinberg, Peter D. 2001. Populus balsamifera subsp. trichocarpa. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory
Stolnack, S., Naiman, R. 2010. Patterns of Conifer Establishment and Vigor on Montane River Floodplains in Olympic National Park, Washington, USA. Canadian Journal of Forest Resources, Vol. 40, pp 410-422.
United States National Vegetation Classification. 2016. United States National Vegetation Classification Database, V2.0. Federal Geographic Data Committee, Vegetation Subcommittee, Washington DC. (accessed 28, November, 2016.
Van Pelt, R., O'Keefe, T., Latterell, J., Naiman, R., 2006. Riparian forest stand development along the Queets River in Olympic National Park, Washington. Ecological Monographs, 76(2) pp. 277-298
Villarin, L., Chapin, D., Jones, J., 2009. Riparian forest structure and succession in second-growth stands of the central Cascade Mountains, Washington, USA. Forest Ecology and Management, Vol 257 pp. 1375-1385
Washington Department of Natural Resources, Natural Heritage Program. 2015. Ecological Systems of Washington State. A Guide to Identification.

Contributors

Erin Kreutz
Erik Dahlke
David Rand
Marty Chaney

Approval

Kirt Walstad, 5/07/2024

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	12/16/2021
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:**
