Ecological site group R006XG226WA
Stony Foothills South Aspect, Bitterbrush, 2800-4000 feet

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Key Characteristics

None specified

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.

Physiography

Hierarchical Classification
Major Land Resource Area (MLRA): 6 – Cascade Mountains, East Slope

LRU – Common Resource Areas (CRA):
6.1 – North Cascades Subalpine/Alpine
6.2 – Pasayten/Sawtooth Highlands
6.3 – Okanogan Pine/Fir Hills
6.4 – Chelan Tephra Hills
6.5 – Chiwaukum Hills and Lowlands
6.6 – Yakima Plateau and Slopes
6.7 – Grand Fir Mixed Forest
6.8 – Oak-Conifer Eastern Cascades-Columbia Foothills

Site Concept Narrative:
Diagnostics:

Stony foothills south aspect, bitterbrush, 2800-4000 feet is transitional between sagebrush steppe and forest. More than 80% of the landscape of MLRA 6 is forest, so this site stands out because of a lack of trees.

This ecological site is an upland site at low elevations (2,800-4,000 feet) of MLRA 6 in the 15-18” precipitation zone. This site is found on southeast and south to west aspects. Neutral and other aspects are forest. The soils are generally deep and stony. Loam and sandy loam are the main textures.

Stony foothills south aspect, bitterbrush, 2800-4000 feet is shrub steppe. The shrub layer is dominated by bitterbrush, but Wyoming sagebrush is also present. Bluebunch wheatgrass dominates the reference state while native forbs fill the interspaces. Idaho fescue is noticeably absent on the south slopes.

Principle Vegetative Drivers:

The vegetative expression of this ecological site is driven by the combination of four factors:
(1) Low elevation (2,800 and 4,000 feet) with a hotter, drier climate than the rest of MLRA 6 (15-18 inches of precipitation)
(2) The southeast, south and west aspects
(3) Moderately deep to deep soils provide unrestricted rooting for most species

Influencing Water Features:

A plant's ability to grow on a site and overall plant production is determined by soil-water-plant relationships
1. Whether rain and melting snow runs off-site or infiltrates into the soil
2. Whether soil condition remain aerobic or become saturated and become anaerobic
3. Water drainage and how quickly the soil reaches wilting point

With adequate cover of live plants and litter, there are no restrictions on Loamy sites with water infiltrating into the soil. These sites are well drained and are saturated for only a short period.

Physiographic Features:

Most of MLRA 6 is in the Northern and Middle Cascade Mountains. This mountainous area consists of sharp alpine summits with some higher volcanic cones to the west, and lower lying foothills to the east. Strongly sloping mountains and U-shaped valleys are dominant in the north, with eroded basalt plateaus more typical in the south. The East Slope of the Cascades is a transitional area between the moist, rugged Cascade Mountains to the west and the drier, lower lying Columbia Basalt Plateau to the east. MLRA 6 has some of the landforms typical of both mountains and plateaus.

Physiographic Division: Pacific Mountains
Physiographic Province: Cascade-Sierra Mountains
Physiographic Sections: Northern Cascade and Middle Cascade Mountains

Landscapes: Mountains, canyons, plateaus and hills
Landform: Summits, shoulders, side-slopes

Elevation: Dominantly 1,100 to 4,400 feet
Central tendency: 2,800 to 4,000 feet
Slope: Total range: 0 to 90 percent
Central tendency: 15 to 50 percent
Aspect: Dominantly on southerly aspect, but occurs on all aspects

Geology:

MLRA 6 consists of Pre-Cretaceous metamorphic rocks cut by younger igneous intrusives. Tilted blocks of marine shale, carbonate, and other sediments occur in the far north, and some younger continental, river-laid sediments occur around Leavenworth, WA. Columbia River basalt is dominant in the southern portion of the state. Alpine glaciation has left remnants of glacial till, debris, and outwash in the northern part of this MLRA.

Climate

The climate across MLRA 6 is characterized by moderately cold, wet winters, and hot, dry summers, with limited precipitation due to the rain shadow effect of the Cascades. The average annual precipitation for most of the East Slope of the Cascades is 16-50 inches. Seventy-five to eighty percent of the precipitation comes late October through March as a mixture of rain and snow. The lowest precipitation occurs along the eastern edge, then increasing with rising elevation to the west. Most of the rainfall occurs as low-intensity, Pacific frontal storms during the winter, spring and fall. Rain turns to snow at the higher elevations. All areas receive snow in winter. Summers are relatively dry. The East Slopes experience greater temperature extremes and receive less precipitation than the west side of the Cascades. The shortest freeze-free periods occur along the western edge and the northern end of this MLRA, which are mountainous. The longest freeze-free periods occur along the Columbia River Gorge.

Mean Annual Precipitation:
Range: 16-22 inches
Central tendency: 16 – 18 inches
Soil moisture regime is xeric

Mean Annual Air Temperature:
Range: 43 to 52 degrees
Central tendency: 46 to 50 degrees
Soil temperature regime is mesic

Frost-free Period (days):
Total range: 80 to 150
Central tendency: 100 to 130
The growing season is early April through July.

Soil features

Edaphic:

Stony foothills south aspect, bitterbrush, 2800-4000 feet ecological site commonly occurs with Shallow Stony 2800-4000 feet, Very Shallow and Ponderosa pine ecological sites.

Representative Soil Features:

This ecological site components are dominantly Typic and Vitrandic taxonomic subgroups of Haploxerolls and Argixerolls great groups of the Mollisols. Soils are dominantly moderately deep and deep. Average available water capacity of about 3.5 inches (8.9 cm) in the 0 to 40 inches (0-100 cm) depth range.

Soil parent material is dominantly mixed volcanic ash mixed with colluvium in the upper part of the soil over colluvium and residuum.

The associated soils are Borgeau, Cubhill, Wynhoff and similar soils.

Dominate soil surface is ashy loam to stony ashy silt loam.

Dominant particle-size class is dominantly loamy-skeletal.

Fragments on surface horizon > 3 inches (% Volume):
Minimum: 0
Maximum: 2
Average: 0

Fragments within surface horizon > 3 inches (% Volume):
Minimum: 0
Maximum: 35
Average: 20

Fragments within surface horizon ≤ 3 inches (% Volume):
Minimum: 0
Maximum: 30
Average: 10

Subsurface fragments > 3 inches (% Volume):
Minimum: 10
Maximum: 35
Average: 15

Subsurface fragments ≤ 3 inches (% Volume):
Minimum: 5
Maximum: 50
Average: 35

Drainage Class: Well drained
Water table depth: Greater than 60 inches

Flooding:
Frequency: None

Ponding:
Frequency: None

Saturated Hydraulic Conductivity Class:
0 to 10 inches: Moderately high and high
10 to 40 inches: Moderately high and high

Depth to root-restricting feature (inches):
Minimum: 20
Maximum: Greater than 60 inches

Electrical Conductivity (dS/m):
Minimum: 0
Maximum: 0

Sodium Absorption Ratio:
Minimum: 0
Maximum: 0

Calcium Carbonate Equivalent (percent):
Minimum: 0
Maximum: 0

Soil Reaction (pH) (1:1 Water):
0 - 10 inches: 6.1 to 7.8
10 - 40 inches: 6.1 to 7.8

Available Water Capacity (inches, 0 – 40 inches depth):
Minimum: 1.1
Maximum: 6.3
Average: 3.5

Vegetation dynamics

Ecological Dynamics:

Stony foothills south aspect, bitterbrush, 2800-4000 feet produces about 1000-1400 pounds/acre of biomass annually.

This elevation range (2800-4000 feet) represents a transitional ecotone as the highest elevation for Threetip sagebrush and the lowest elevation for mountain big sagebrush. In this ecological site threetip sage is found only in the hottest and driest portions of the landscape.

Antelope bitterbrush, bluebunch wheatgrass and needle and thread are at the core of the Stony Foothills ecological site and warrant a degree of understanding.

Antelope bitterbrush is a very palatable, high quality shrub for big game and livestock. It is adapted to a wide range of soils and precipitation. Bitterbrush is usually 2-6 feet in height and up to 8 feet in width. Rodents normally cache bitterbrush seed within 50-75 feet of an existing seed source. Following a fire, the rodent seed caches become an important source of regeneration. Another important source of regeneration are pockets of unburned rangeland that provide much needed seed to the system.

With disturbances needle and thread and threetip sagebrush are the main increasers, while annual bromes and bulbous bluegrass are the main increases on this ecological site.

In the Reference Community bluebunch wheatgrass dominates the Stony foothills south aspect, bitterbrush, 2800-4000 feet ecological site. Needle and thread, shrubs and forbs are also important to this site. Both grasses are long-lived, mid-sized, cool-season bunchgrasses. Bluebunch wheatgrass is the classic erect bunchgrass, approximately waist high, with an awned spike inflorescence. Needle and thread is a very drought tolerant perennial bunchgrass. It prefers excessively drained sandy and coarse textured gravelly loam soils. Needle and thread produces erect, unbranched stems about 3 feet in height. The seeds have a 4 to 5-inch long twisted awn, and with wetting and drying the seed drills itself into the ground. Thus, needle and thread is one of the best natural seeders of all the native species.

Both grasses provide a crucial and extensive network of roots to the upper portions (up to 48” deep in soils with no root-restrictive horizons) of the soil profile. These roots create a massive underground source to stabilize the soils, provide organic matter and nutrients inputs, and help maintain soil pore space for water infiltration and water retention in the soil profile. The extensive rooting system of mid-sized bunchgrasses leave very little soil niche space available for invasion by other species. This drought resistant root can compete with, and suppress, the spread of exotic weeds.

The stability and resiliency of the reference communities is directly linked to the health and vigor of bluebunch wheatgrass and needle and thread. Refer to pages 8-9 for more details about bluebunch physiology. Research has found that the community remains resistant to medusahead if the site maintains at least 0.8 mid-sized bunchgrass plant/sq. ft. (K. Davies, 2008). It is bluebunch that holds the system together. If we lose the bluebunch or Idaho fescue the ecosystem crashes or unravels.

How one answers fire return intervals for bitterbrush communities depends on the frame of reference used. Currently conditions for Stony Foothills are communities often dominated by dense canopies of bitterbrush. These shrubs are 50-100 years old or older due to fire suppression. These bitterbrush plants do not readily re-sprout following fire. Germinating seeds, especially from rodent caches is the primary source to bitterbrush re-establishment. The framework of current conditions suggests a fire return interval of 50-100 years or longer.

Miller et al, paint a totally different picture for pre-settlement mountain big sage-bitterbrush-fescue communities. These communities were dominated by the herb layer. Shrubs were widely scattered and patchy. The fire regime was high frequency (10-20 years), low severity, low intensity. The landscape would have been a mosaic of burned and unburned patches. In any given fire some bitterbrush plants would have survived the fire. Also, bitterbrush plants were likely much younger (10-30 years old), more vigorous and more likely to sprout following fire. In recent years sprouting bitterbrush after low severity fire supports the notion of sprouting bitterbrush. Seedlings from rodent caches would have also been important for the recovery of the shrub layer.

The effect of fire on the main species is mixed for the Stony foothills south aspect, bitterbrush, 2800-4000 feet. Bitterbrush is very susceptible to fire kill and is considered a weak sprouter. Bluebunch wheatgrass and needle and thread are fire tolerant. Needle and thread is also a natural seeder. Both grasses help to keep the site resistant to change, while bitterbrush makes the site more at risk.

A low intensity, high frequency fire regime favors bitterbrush sprouting and rapid tillering by both Idaho fescue and bluebunch wheatgrass. A high intensity, low frequency fire regime hinders recovery – Idaho fescue plants may be devastated, bluebunch wheatgrass set back, and bitterbrush regeneration limited to seedlings.

Fires with light severity will remove less bitterbrush and open smaller patches for grass and forb recovery, whereas the more severe fires will remove almost all the bitterbrush and leave vast areas open to return to bunchgrass dominance. This is how the patchy distribution occurs. So, fire resets the competitive advantage back to the bunchgrasses by removing much of the overstory. This, in turn, maintains the stability and overall resilience of the site. However, this is not always true as some fires are spotty or do not burn hot enough to fully remove the bitterbrush. Rabbitbrush and horsebrush are sprouting shrubs and may also increase following fire.

The longer the site goes without fire and the more grazing pressure added to the bunchgrasses, the more bitterbrush cover increases, and the more bunchgrasses decline. This leaves the dense bitterbrush community phase more vulnerable to outside pressures. Invasive species take advantage of the available soil rooting spaces in

the interspaces. The once extensive grass roots are largely absent. Soils are no longer receiving the organic inputs, and there is less surface cover by grass litter. Both water infiltration into the soil, and water percolation through the soil, are affected, leaving open soil space that is drier and more vulnerable to wind and water erosion, and invasion by undesirable species. Once these undesirable species have colonized, the site is at high risk of crossing a threshold if a disturbance such as fire were to occur.

Grazing is another common disturbance that occurs to this ecological site. Grazing pressure can be defined as heavy grazing intensity, or frequent grazing during reproductive growth, or season-long grazing (the same plants grazed more than once). As grazing pressure increases the plant community unravels in stages:
1. Bluebunch wheatgrass declines, needle and thread and unpalatable forbs increase to dominant position
2. Both needle and thread and bluebunch wheatgrass decline to disappear, while unpalatable native forbs increase, and invasive annual grasses colonize site
3. With further decline invasive species dominate the site

Managing grasslands to improve the vigor and health of native bunchgrasses begins with an understanding of grass physiology. New growth each year begins from basal buds. Bluebunch wheatgrass plants rely principally on tillering, rather than establishment of new plants through natural reseeding. During seed formation, the growing points become elevated and are vulnerable to damage or removal.

If defoliated during the formation of seeds, bluebunch wheatgrass has limited capacity to tiller compared with other, more grazing resistant grasses (Caldwell et al., 1981). Repeated critical period grazing (boot stage through seed formation) is especially damaging. Over several years each native bunchgrass pasture should be rested during the critical period two out of every three years (approximately April 15–July 15). And each pasture should be rested the entire growing-season every third year (approximately March 1 – July 15).

In the spring each year it is important to monitor and maintain an adequate top growth: (1) so plants have enough energy to replace basal buds annually, (2) to optimize regrowth following spring grazing, 3) to protect the elevated growing points of bluebunch wheatgrass, and (4) to avoid excessive defoliation of Idaho fescue with its weak stems.

Bluebunch wheatgrass and Idaho fescue remain competitive if:
(1) Basal buds are replaced annually,
(2) Enough top-growth is maintained for growth and protection of growing points,
(3) Idaho fescue makes viable seed and
(4) The timing of grazing and non-grazing is managed over a several-year period. Careful management of late spring grazing is especially critical

For more grazing management information refer to Range Technical Notes found in Section I Reference Lists of NRCS Field Office Technical Guide for Washington State.

In Washington, bluebunch wheatgrass communities provide habitat for a variety of upland wildlife species.

Supporting Information:

Associated Sites:
Stony foothills south aspect, bitterbrush, 2800-4000 feet in MLRA 6 is associated with Shallow Stony 2800-4000 feet, Very Shallow and ponderosa pine sites

Similar Sites:
Stony Foothills, bitterbrush and Stony Foothills, South Aspect, bitterbrush in MLRA 8, and Stony Foothills, channeled scabland in MLRA 9 are similar.

Inventory Data References (narrative):
Data to populate Reference Community came from several sources: (1) NRCS ecological sites from 2004, (2) Soil Conservation Service range sites from 1980s and 1990s, (3) Daubenmire’s habitat types, and (4) ecological systems from Natural Heritage Program

Major Land Resource Area

MLRA 006X
Cascade Mountains, Eastern Slope

Stage

Provisional

Contributors

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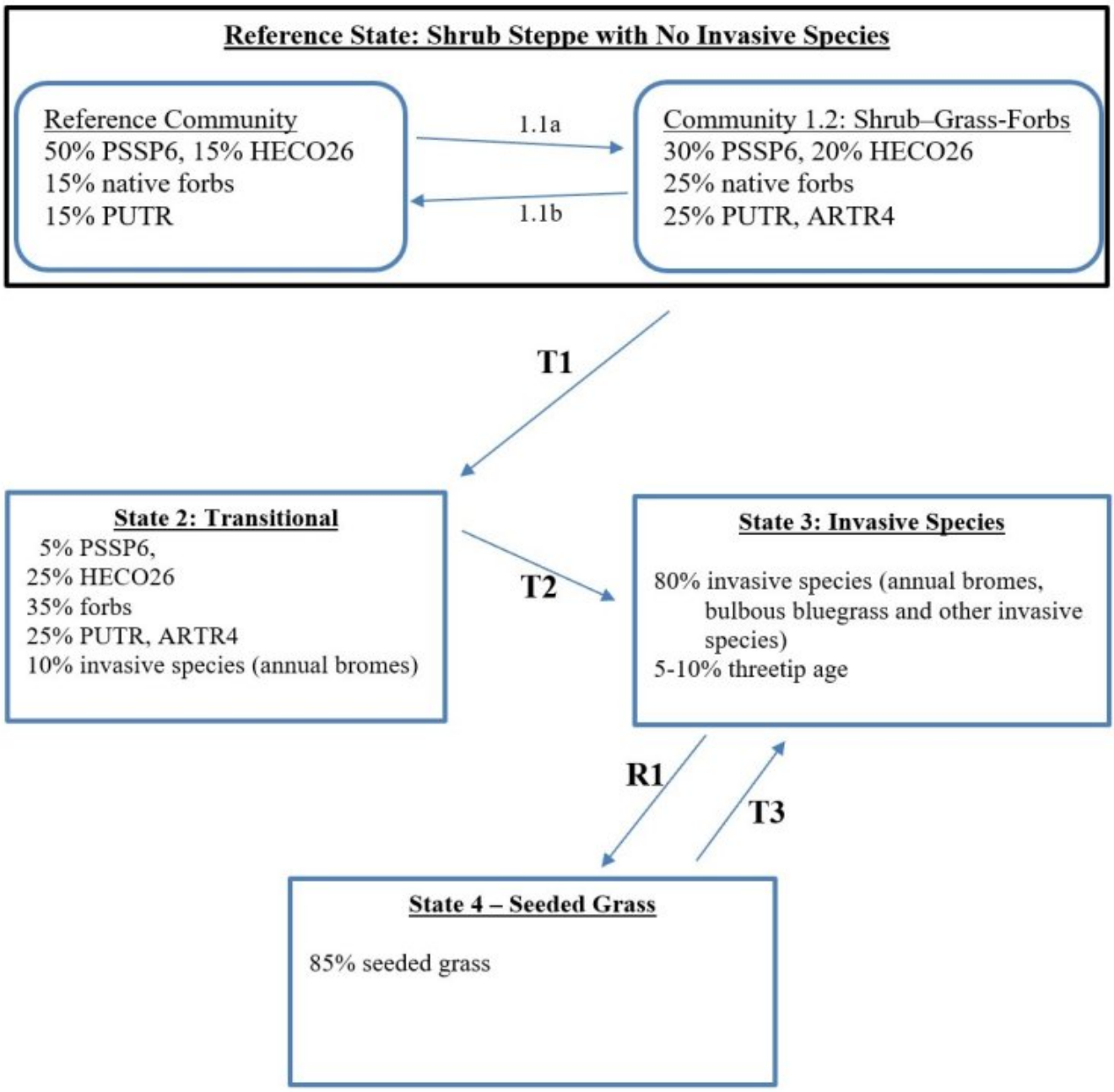
State and transition model

State and Transition Diagram for Stony foothills south aspect, bitterbrush, 2800-4000 feet for MLRA 6:

This state and transition model (STM) explain the general ecological dynamics for the Loamy ecological site. The STM illustrates the common plant communities that can occur on the site. Boxes around each state represent the ecological threshold, which if crossed, is not reversible without human intervention. Arrows within a state represent the pathway between plant communities, while the arrows between states represent the transition or recovery between the states. Plant species composition is represented as a percentage of total annual production (pounds). The composition of pristine sites can vary somewhat due to variations in site conditions.



Reference Community 1.1 for Stony Foothills South Aspect, 2800-4000 feet (MLRA 6)

Plant species composition is represented as a percentage of total annual production (pounds). The composition of pristine sites can vary somewhat due to variations in site conditions. Pounds listed below are the maximum allowable for Similarity Index. Many numbers have been rounded to not show more precision than our current state of knowledge.

		Similarity Index				Similarity Index
Non-Sprouting Shrubs – Subdominant (3-7% canopy)		10-20%	300 lbs.	**Sprouting Shrubs – Minor**		0-5% 75 lbs.
PUTR	bitterbrush			ARTR4	threetip sagebrush	
ARTRV	mountain big sagebrush			CEVE	snowbrush	
				Trees - Trace		
				PIPO	ponderosa pine	Trace
Dominant Mid-Size Bunchgrass		60%		**Other Mid-Size Bunchgrasses – Minor**		5% 75 lbs.
PSSP6	bluebunch wheatgr.	45%	650 lbs.	ACNE9	Nelson's needlegrass	
HECOC	needle and thread	15%	200 lbs.	KOMA	prairie junegrass	
Short Grasses		less than 5%	50 lbs.	**Grass like**		
POSE	Sandberg bluegrass					
Native Forbs – Subdominant						15% 200 lbs.
BASA3	arrowleaf balsamroot			CALOC	lily – mariposa, sego	
LUPIN	lupine			ORTHO	owl clover	
ACMI2	yarrow			CASTI2	paintbrush	
ERIOG	buckwheat species			ASTRA	milk vetch / locoweed	
ERIGE2	fleabane			GEUM	prairie smoke	
ANTEN	pussytoes			ALLIU	onion	
PENST	penstemon			ARNIC	arnica	
MICRO6	microseris			AGGL	agoseris	
HIERA	hawkweed			COLLO	collomia	
DELPH	larkspur			POTEN	cinquefoil	
CREPI	hawksbeard			PHLO2	longleaf phlox	
PHHO	spiny phlox			LOMAT	lomatium / biscuitroot	
LIPU11	granite gilia			PLPA2	woolly plantain	
LIRU4	stoneseed			FRPU2	yellow fritillary	
					Below	Normal Above
Estimated Production (pounds / acre)					1000	1200 1400

State 1
Reference State: Shrub Steppe with No Invasive Species

State 1 Narrative: State 1 represents shrub steppe with no invasive or exotic weed species. Each functional, structural group has one or more native species. Reference State Community Phases: 1.1 Reference Bitterbrush – Bluebunch wheatgrass 1.2 Shrub–Grass–Forb Bitterbrush – Bluebunch Wheatgrass – Native Forbs Dominate Reference State Species: Bluebunch wheatgrass, needle and thread, bitterbrush At-risk Communities: Potentially every community is at risk as seeds of invasive move around by wind and animals.

Community 1.1
Reference Community

Bitterbrush – Bluebunch wheatgrass

Community 1.2
Shrub – Grass - Forb

Bitterbrush – Bluebunch Wheatgrass – Native Forbs

Pathway 1.1a
Community 1.1 to 1.2

1.1a Result: shift from bunchgrass dominated Reference Community 1.1 to Community 1.2 Shrub – Bunchgrass – Forb. Moderate reduction in bunchgrasses and a moderate increase in bitterbrush, sagebrush and unpalatable native forbs Primary Trigger: Grazing pressure (heavy grazing intensity, season long grazing or frequent late spring grazing) to bluebunch wheatgrass. Ecological process: consistent defoliation pressure to bluebunch wheatgrass results in poor vigor and shrinking crowns. Shrubs and forbs gain the competitive edge and take advantage of released resources and available niche space to expand via new seedlings. Indicators: increasing shrub canopy, increasing forb cover and declining bluebunch wheatgrass cover.

Pathway 1.1b
Community 1.2 to 1.1

1.1b Result: shift from Community 1.2 Shrub – Bunchgrass – Forb to bunchgrass dominated Reference Community 1.1. Primary Trigger: Light and spotty fire coupled with good grazing management (proper timing and intensity) post-fire Ecological process: the fire kills some of the bitterbrush plants and this releases resources and niche space. With defoliation pressure removed bluebunch wheatgrasses gains the competitive edge and expands via tillering. Indicators: increasing cover of native bunchgrasses, decreased shrub canopy and forb cover

State 2
Transitional

State 2 Narrative: State 2 represents a minor invasion by invasive species. All the native functional, structural groups are still represented by one or more species. Native species are present and dominant, but invasive species have gained a foothold that they do not relinquish. Grazing pressure weakens the stand of native species allowing the invasive species to colonize and establish themselves in the community. Once a community has been invaded by annual bromes or other invasive species the chance of going back to State 1 is small. Dominate State 2 Species: Native forbs, shrubs and bunchgrasses are somewhat balanced in State 2 with the decline of the bunchgrasses.

State 3
Invasive Species

State 3 Narrative: State 3 represents sites dominated by invasive species and has crossed a biological threshold. As State 1 or State 2 unravels the dominant bunchgrasses decline while invasive species become more and more prominent. Virtually all the native functional, structural groups are missing in State 3. Community Phases for State 3: 3.1 Annual Grass Dominate State 3 Species: annual bromes or other invasive species

State 4
Seeded Grass

State 4 Narrative: State 4 represents a stand of desirable introduced grasses such as intermediate wheatgrass or Secar Snake River wheatgrass. The State 3 community has been eliminated and the site seeded to desirable grasses such as intermediate wheatgrass. State 4 remains stable as long as a full stand is maintained (1.0 plant / sq. ft. or greater of the desired bunchgrasses) Community Phases for State 4: Seeded Grasses Dominate State 4

Species: Desirable seeded grasses with or without legumes

Transition T1
State 1 to 2

T1 Result: transition from Reference State (shrub steppe with no invasive species) to Transitional State 2 (shrub steppe w/ some invasive species). State 2 has the same communities but with minor additions of invasive species such as annual bromes or bulbous bluegrass. This is a continuation of the degradation that started with Pathway 1.1a. Primary Trigger: grazing pressure (heavy grazing intensity, season long grazing or frequent late spring grazing) to bluebunch wheatgrass and other palatable species. Ecological process. Most sites in the Reference State have some scattered annual grass seed on site. This seed is waiting for enough moisture to germinate and to compete with the native species for space, light and moisture. Consistent defoliation pressure to bluebunch wheatgrass results in poor vigor, shrinking crowns and plant mortality. This releases resources and niche space which allows invasive species to colonize the site. Indicators: The occurrence of annual grasses on sites where they had been absent.

Transition T2
State 2 to 3

T2 Result: Transition from Transitional State 2 with some invasive species to State 3 which is dominated by annuals. This transition is a continuation of the degradation which started with Pathway 1.1a and Transition T2 and, occurs once the cover of bluebunch wheatgrass declines to less than 10% while invasive species cover is at least 40%. Primary Trigger: moderate severity fire and chronic grazing pressure (heavy grazing, season-long grazing, or late spring grazing) to bluebunch wheatgrass and other palatable species. Ecological Process: fire kills bitterbrush, but threetip sage sprouts. Defoliation pressure to bluebunch wheatgrass results in poor vigor, shrinking crowns and plant mortality. As bluebunch wheatgrass and other palatable species decline, and more and more of the soil surface and rooting surface become open to annual bromes and other opportunistic weeds. Invasive species take advantage of the released resources and available niche space to colonize and expand. The site has lost its primary species that stabilize and protect the soil from wind and water erosion and has also lost the ability to retain sufficient soil moisture for many of the native perennial species. Indicators: Decreasing cover of bluebunch wheatgrass and increasing cover of invasive annual species. Increasing distance between perennial species.

Restoration pathway R1
State 3 to 4

R1 Transition from State 3 (a community dominated by invasive annual species) to State 4, which is predominately desirable seeded grasses. This restoration transition does not occur without significant time and inputs to control weeds, prepare a seedbed, seed desirable species, and post-seeding weed control and management. This requires a commitment of two years or more for weed control. Care must be taken to maintain soil structure so that the seedbed has many safe-sites for the seed. Seed placement must be managed to achieve seed-soil contact at very shallow depth (about 1/8 inch is desired). Proper grazing management is essential to maintain the stand post-seeding. The actual transition occurs when the seeded species have successfully established and are outcompeting the annual species for cover and dominance of resources.

Transition T3
State 4 to 3

T3 Result: shift from seeded grass State 4 to State 3 which is dominated by invasive annual species. Primary Trigger: chronic grazing pressure (heavy grazing intensity, season long grazing or frequent late spring grazing) to seeded grasses. Ecological process: defoliation pressure to seeded grasses results in poor vigor, shrinking crowns and plant mortality. As this continues invasive species have the competitive advantage and expand to a position of dominance. Little of the resources remain for the desirable species. Indicators: shrinking crowns and mortality of desirable species, increasing caps gaps between seeded plant crowns, increasing cover by annual grasses. References: Boling M., Frazier B., Busacca, A., General Soil Map of Washington, Washington State University, 1998 Daubenmire, R., Steppe Vegetation of Washington, EB1446, March 1968 Davies, Kirk, Medusahead Dispersal and Establishment in Sagebrush Steppe Plant Communities, Rangeland Ecology & Management, 2008 Environmental Protection Agency, map of Level III and IV Ecoregions of Washington, June 2010 Miller, Baisan,

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Citations