Ecological site EX043B15I953
Montane Deciduous Clayey Outwash Terrace 20-24" PZ Cryic Northern Rocky Mountain Front

Last updated: 3/04/2024
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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): 043B–Central Rocky Mountains

This ecological site currently resides in the Major Land Resource Area (MLRA) 43B Central Rocky Mountains. The area of MLRA 43B is expansive and is further divided into Land Resource Units (LRU). A detailed description of MLRA 43B can be found at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_053624
This ecological site resides within the eastern portion of Glacier National Park which resides in MLRA 43B and LRU A – Northern Rocky Mountain Front.

LRU notes

The landscape is mountains and the landforms include scarp slopes, dip slopes, mountain slopes, drainageways, bog, cirque, U-shaped valley and associated moraine and outwash features. Elevations range 1,000-3,175 meters (3,300-10,500 feet) (mean elevation is 1,900 m. or 6,200 ft.). The climate is cold and wet with mean annual precipitation of 1,050 mm (41 in.) and mean annual air temperature of 3 degrees C. (37 degrees F.) with a soil temperature regime of cryic and soil moisture regime of udic or ustic. The geology of the area is dominated by Appenkunny and Grinnell argillite, Kootenai formation, Tertiary sedimentary rocks, Missoula group quartzite, glacial drift alluvium, Siyeh limestone and undifferentiated rock. The soils are dominantly moderately deep to very deep that formed from a variety of sedimentary rock parent materials on moderately steep to very steep mountain slopes. Soils fall into three soil orders: Inceptisols, Mollisols, and Alfisols. Most soils are loamy-skeletal and many, especially in the eastern part, contain significant amounts of calcium carbonate influencing both physical and chemical soil characteristics (horizons of calcium carbonate accumulation and corresponding alkaline pH values). Rock outcrop, rubble land, and surface rock fragments are common. There are few lakes but has numerous major drainages including Dearborn, Sun, Teton, Birch, Badger, Two Medicine, St. Maries, South and Middle Fork Flathead headwaters, Blackfoot headwaters. This is a snow dominated system. Wind is a major force shaping climatic patterns and vegetation structure. This area includes forested areas dominated by either Douglas fir, subalpine fir or white bark pine, and range areas dominated by rough fescue, Richardson's needlegrass and bluebunch wheatgrass and assorted forbs.
This is related to the EPA land classification framework of: Level 3- 41 Canadian Rockies. Specifically, it includes Level 4-41a Northern Front.
This area is related predominantly to the USFS Provinces M333Cf Northern Rocky Mountain Front.

Classification relationships

NPS Plant Community Name:
Populus tremuloides/Heracleum maximum (CEGL000595)

Ecological site concept

Ecological Site Concept
The 43B Montane deciduous clayey outwash terrace ecological site is found on low to moderate slopes (most range from 5-10 percent, and a few range between 20-35 percent) with southerly (southeastern, southern, southwestern) aspects on backslope, footslope, or toeslope positions of lateral (or ground) moraines from 1,400-1,900 meters (4,600-6,300 ft.) elevation. It is dominated by quaking aspen with an understory of tall-, medium-, and short-statured shrubs, diverse tall-statured forb and grass species, and low-growing herbaceous species. The tall shrub serviceberry is present, along with the medium-height shrub common snowberry, and the low- to medium-height rose species shrubs. Infrequently, there can be moderate canopy cover of Utah honeysuckle, baneberry, prickly currant, russet buffaloberry, and creeping barberry. The understory has the tall forb cow parsnip, western sweet cicely, and the grass mountain brome. Low-growing herbaceous species include sticky geranium, western meadow-rue, and the nitrogen-fixing American vetch. Other grass and forb species also occur. There is a common but very low cover of conifers present at this site, including subalpine fir and Engelmann spruce. The soils associated with this ecological site are very deep and moderately well or well drained. The parent material on these lateral moraine and ground moraine landforms is predominantly glacial till. Subsurface textures are typically in the fine particle-size class families. Dark soil surface horizons enriched with organic matter indicate that the most common soil order for these soils are Mollisols. Co-occurring soils that have a light-colored surface horizon or ochric epipedon are typically in the Alfisols soil order. Taxonomic subgroups that apply to these soils are the following: Typic Argicryolls, Eutric Haplocryalfs or Typic Glossocryalfs. All of these soils have a zone of clay accumulation called an argillic horizon, and may have a very thin surface layer of organic material that is 0-5 cm thick. The diagnostic soil features include a mollic epipedon or ochric epipedon, argillic horizon, and albic horizon or glossic horizons. These soils have higher clay content than surrounding soils. The physical properties of tiny clay particles provide abundant micro-pore space and allow the soil to hold water for longer periods of time than more sandy soils. As a result, this site will retain moisture for longer during summer dry periods. The complex landforms with many concave and convex positions that these sites occupy allow for convergent flow areas that are moister and concave pockets that are more protected from wind and collect snow. In the spring snowmelt recharges the soil profile and what cannot be stored leaves as runoff, making these soils wet within the rooting zone of quaking aspen during the early part of the growing season. There is additional flow-in/recharge to soil moisture into convergent areas on the landscape through the upslope catchment areas.

Associated sites

EX043B15I954	**Montane Very Deep Meadow 20-24" PZ Cryic Northern Rocky Mountain Front** This 43B Montane Very Deep Meadow ecological site is found in the montane zone, with an elevation range of 1,400-2,000 meters (4,600-6,500 ft.), on backslope positions with moderate slopes of 4-15 percent and southwesterly aspects on marginal ground moraines and complex landslides on lateral moraines. Infrequently, this site is found on alluvial fans, hogbacks, knobs, ledges and knolls. These are large patch sized meadows. The 43B Montane Very Deep Meadow ecological site has soils that are predominantly very deep and well drained. Surface textures are typically gravelly loam and subsurface layers fall into the fine-loamy particle-size family. These soils are classified in the Mollisols soil order having a thick dark surface with significant enrichment of organic matter and high base saturation. The 43B Montane Very Deep Meadow ecological site has a reference community of Rough fescue (Festuca campestris), shrubby cinquefoil (Dasiphora fruticosa), Idaho fescue (Festuca idahoensis), yarrow (Achillea millefolia), northern bedstraw (Galium boreale) and Ross's sedge (Carex rossii).

Similar sites

F043BP908MT	**Upland Aspen Woodland Group** These sites are similar in that the reference community is dominated by deciduous trees, particularly quaking aspen and the soils are loamy in texture. The sites are distinguished by the geographic scale, in that this site is very broad and the F043BX953MT is limited to the eastern portion of Glacier N.P., and sustains high winds down the Continental Divide that limit tree stature.

Table 1. Dominant plant species

Tree	(1) *Populus tremuloides*
Shrub	(1) *Amelanchier alnifolia* (2) *Symphoricarpos albus*

Herbaceous	(1) *Heracleum maximum* (2) *Osmorhiza occidentalis*

Legacy ID

F043BX953MT

Physiographic features

The 43B Montane deciduous clayey outwash terrace ecological site is found on low to moderate slopes (most range from 5-10 percent, and a few range between 20-35 percent) with southerly (southeastern, southern, southwestern) aspects on backslope, footslope, or toeslope positions of lateral (or ground) moraines from 1,400-1,900 m (4600-6300 feet) elevation.

Figure 1. Landscape view of this ecological site, notice ring of younger regeneration aspen in the foreground.

Table 2. Representative physiographic features

Landforms	(1) Mountains > Lateral moraine (2) Mountains > Ground moraine
Elevation	4,593–6,233 ft
Slope	5–35%
Aspect	SE, S, SW

Climatic features

This ecological site is found in the cryic soil temperature regime and the udic soil moisture regime. Cryic soils have average annual temperature less than 8 degrees C, with less than 5 degrees C difference from winter to summer. Udic soil moisture regime denotes that the rooting zone is usually moist throughout the winter and the majority of summer.
SUMMARY ST. MARY CLIMATE STATION:
Mean Average Precipitation 31-63 inches
Mean Average Annual Temperature 34-43 degrees
Frost free days: 30-70
Relative Effective Annual Precipitation: 30-65 inches

Table 3. Representative climatic features

Frost-free period (characteristic range)	44 days
Freeze-free period (characteristic range)	96 days
Precipitation total (characteristic range)	24-25 in

Frost-free period (actual range)	44 days
Freeze-free period (actual range)	96 days
Precipitation total (actual range)	24-25 in
Frost-free period (average)	44 days
Freeze-free period (average)	96 days
Precipitation total (average)	25 in

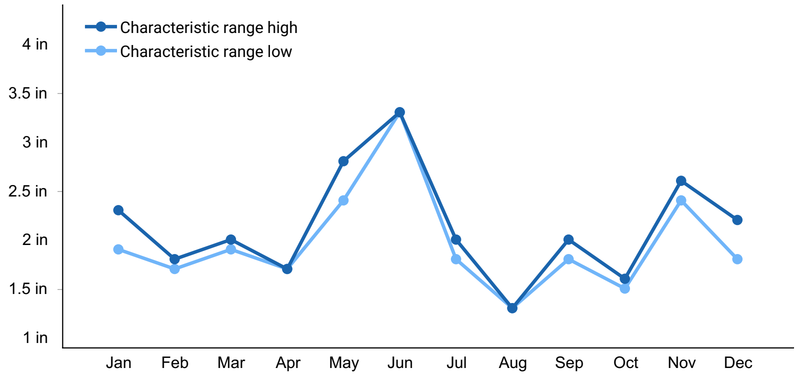


Figure 2. Monthly precipitation range

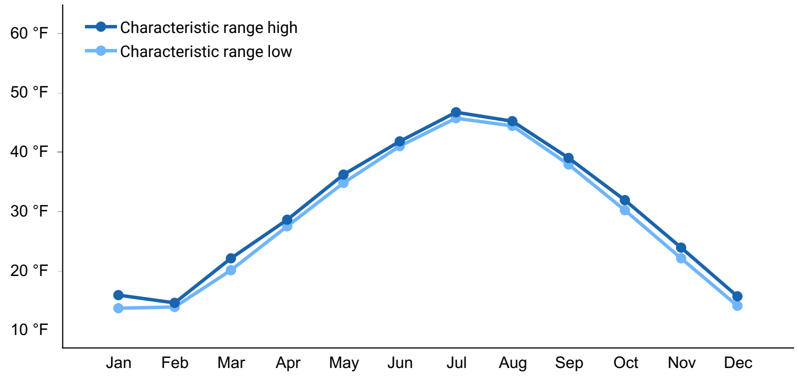


Figure 3. Monthly minimum temperature range

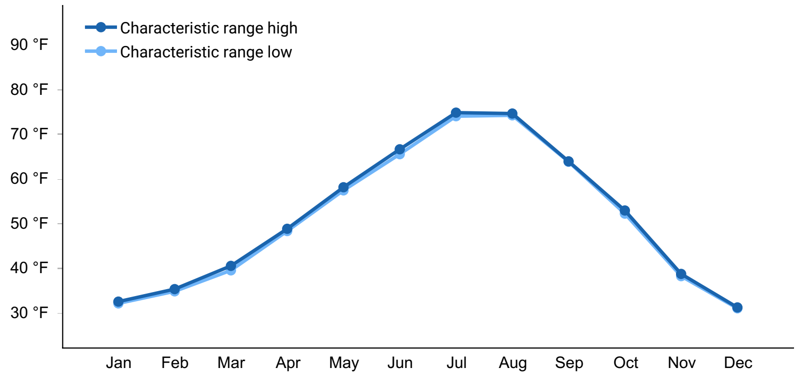


Figure 4. Monthly maximum temperature range

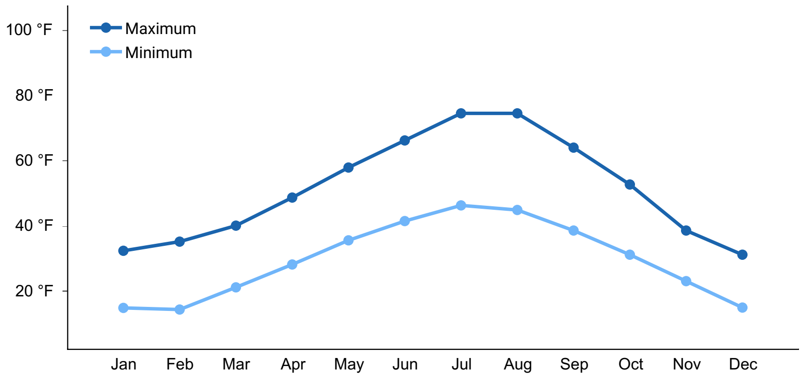


Figure 5. Monthly average minimum and maximum temperature

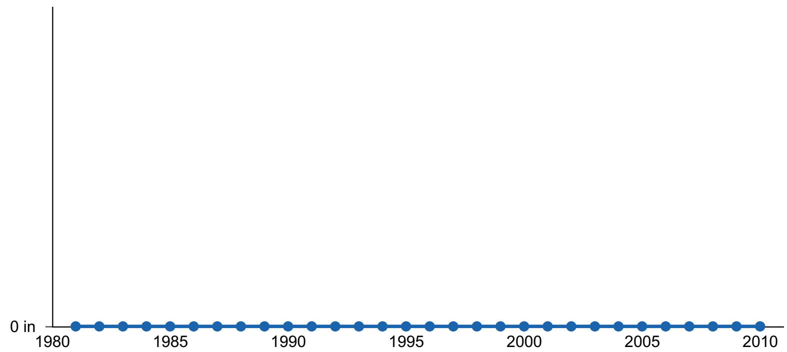


Figure 6. Annual precipitation pattern

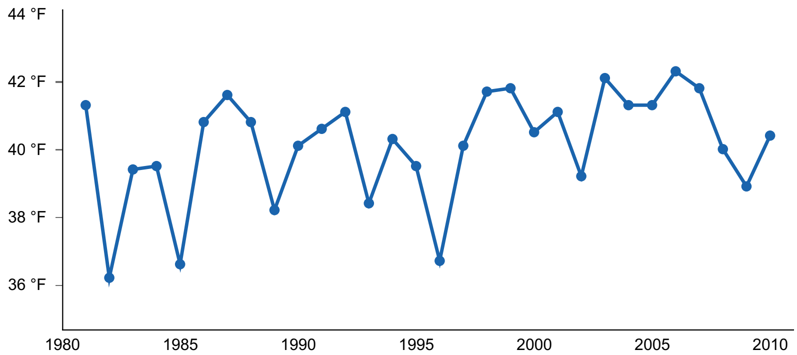


Figure 7. Annual average temperature pattern

Climate stations used

- (1) ST. MARY 1 SSW [USW00004130], Babb, MT
- (2) EAST GLACIER [USC00242629], East Glacier Park, MT

Influencing water features

Soil features

Representative Soil Features
The soils associated with this ecological site are very deep and moderately well or well drained. The parent material on these lateral moraine and ground moraine landforms is predominantly glacial till. Subsurface textures are typically in the fine particle-size class families. Dark soil surface horizons enriched with organic matter indicate that the most common soil order for these soils are Mollisols. Co-occurring soils that have a light colored surface horizon or ochric epipedon are typically in the Alfisols soil order. Taxonomic subgroups that apply to these soils are the following: Typic Argicryolls, Eutric Haplocryalfs or Typic Glossocryalfs. All of these soil have a zone of clay accumulation called an argillic horizon, and may have a very thin surface layer of organic material that is 0-5 cm thick. The diagnostic soil features include a mollic epipedon or ochric epipedon, argillic horizon, and albic horizon or glossic horizons.

These soils have higher clay content than surrounding soils. The physical properties of tiny clay particles provide abundant micro-pore space and allow the soil to hold water for longer periods of time than more sandy soils. As a result, this site will retain moisture for longer during summer dry periods. The complex landforms with many concave and convex positions that these sites occupy allow for convergent flow areas that are moister and concave pockets that are more protected from wind and collect snow. In the spring snowmelt recharges the soil profile and what cannot be stored leaves as runoff, making these soils wet within the rooting zone of quaking aspen during the early part of the growing season. There is additional flow-in/recharge to soil moisture into convergent areas on the landscape through the upslope catchment areas. (Soil Survey Staff, 2015). For more information on soil taxonomy, please follow this link:
http://http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/class/?cid=nrcs142p2_053580

CORRELATED SOIL SERIES & TAXONOMIC CLASS NAME
Hollandlake Loamy-skeletal, mixed, superactive Eutric Glossocryalfs
Mikesell Fine, smectitic Eutric Haplocryalfs
Vulture Fine-loamy, mixed, superactive Typic Argicryolls

Figure 8. View of soils associated with this ecological site, noting dark surface layers.

Table 4. Representative soil features

Parent material	(1) Till–metamorphic rock (2) Till–metasedimentary rock
Surface texture	(1) Clay loam (2) Gravelly loam (3) Loam
Family particle size	(1) Fine
Drainage class	Moderately well drained to well drained
Permeability class	Moderate to slow
Soil depth	60–100 in
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (2.6-6.9in)	Not specified
Soil reaction (1:1 water) (4.5-7in)	Not specified

Ecological dynamics

Ecological Dynamics

This ecological site is found within the same elevational zone as Douglas fir but in moister site locations.

State 1.0: Historic reference state.
There is no presence of weedy invasive species within the community phases of this state.

The 43B Montane Decidous Clayey Outwash Terrace ecological site is dominated by quaking aspen with an understory of tall-, medium-, and short-statured shrubs, diverse tall-statured forb and grass species, and low-growing herbaceous species. These mature aspen clones are adapted to the seasonal wetness in the soils of this site, and allow relatively high levels of light to penetrate which is characteristic of aspen groves that leads to a high diversity of forbs, grasses, and shrubs. There is an infrequent and very low cover of Engelmann spruce present at the site. The tall shrub serviceberry is present, along with the medium-height shrub common snowberry, and the low- to medium-height rose species shrubs. Infrequently, there can be moderate canopy cover of Utah honeysuckle, baneberry, prickly currant, russet buffaloberry, and creeping barberry. The understory has the tall forb cow parsnip, western sweet cicely, and the grass mountain brome. Low-growing herbaceous species include sticky geranium, western meadow-rue, and the nitrogen-fixing American vetch. Other grass and forb species also occur. There is a common but very low cover of conifers present at this site, including subalpine fir and Engelmann spruce.
This site relates to the Mueggler (1988) aspen community type of quaking aspen/Saskatoon serviceberry-mountain snowberry/tall forb type, and, less commonly, the quaking aspen/Saskatoon serviceberry-mountain snowberry/mountain brome type. Mueggler (1988) considered the quaking aspen/Saskatoon serviceberry-mountain snowberry/tall forb type type to be primarily a climax community type with very little conifer presence that will likely remain dominated by quaking aspen. It also relates to the Hansen Riparian and Wetlands of Montana classification system Quaking aspen/Western sweet-cicely habitat type. The wood production of this community type was somewhat below the average for all aspen community types found by Mueggler (1988), with an average basal area of 116 sq. ft. /acre (range is 88-144); the site index (the potential for forest trees to grow at a particular site i.e. the average age of dominate and/or codominant trees of an even-aged, undisturbed site at a base age) averaged 46 feet at 80 years (range is 37-55); and the volume growth at stand maturity was 34 cubic ft./acre/yr. (22-46). Our sites fall within the range of Mueggler's (1988) values with a basal area of 80-180 sq. ft./acre, a site index of 50-70 feet at 80 years, and Cumulative Mean Annual Increment (defined as the mean annual growth per year a tree or stand of trees has experienced to a specified age) of 25-50 cubic ft./acre/yr. The understory is not only diverse, but Mueggler (1988) states it is fairly productive, with average annual air-dry production of 1,180 lbs. /acre (833-1,527 lbs. /acre). Half of this production was forbs, with a quarter to graminoids and a quarter to shrubs. We did not take production data and cannot compare these values.
Predominantly, the soils of this ecological site are well drained. Rarely, some sites occur that are poorly drained and within the taxonomic subgroup oxyaquic haplocryalfs and sometimes as a typic cryaquoll. Vegetatively, these sites are generally the same with the same species occurring in both, but sometimes in slightly different proportions. The poorly drained sites may have slightly higher canopy cover of rose species and common snowberry. Whereas, the well-drained sites may have higher cow parsnip and mountain brome. It relates to the Hansen classification of Montana Riparian and Wetland habitat types in Quaking aspen/ Western sweet-cicely habitat type. As well, these sites predominantly fall within the Mueggler classification system of quaking aspen in Quaking aspen/Saskatoon serviceberry-common snowberry/Tall Forb type, and less commonly Quaking aspen/Saskatoon serviceberry-common snowberry/mountain brome type.

Fire, conifer invasion, and disease are primary disturbances in this ecological site, along with grazing and browsing by wildlife and livestock. Aspen regenerates primarily through root suckering after mature stems die. Therefore, aspen seems to require disturbance from fire, flooding, landslides, or avalanches to maintain dominance and vigor (Shepperd et al. 2001, 2006). Recent studies, however, show that aspen can regenerate and be maintained without major disturbances. Kurzel et al. (2007) described four categories for aspen regeneration: 1.) Catastrophic, resulting from severe, coarse-scale disturbances; 2.) a fine-scale gap phase after small treefalls; 3.) Continuous, in which no new canopy openings are required; and 4.) Episodic, in which there are large pulses of regeneration unrelated to coarse-scale disturbance. Physiologically, aspen responds to the death of a mature stem by lowering a root-growth repressing hormone, thus allow root growth to occur (Bartos and Amacher, 1998). Aspen stands are a preferred area for conifer seedlings to establish due to moisture and a combination of shading and light. However, if the understory has high graminoid cover particularly rhizomatous grass species, then establishment of conifers would be difficult. Conifer infilling combined with a lack of disturbance can lead to the eventual dominance of conifer species through shading, which is not tolerated by aspen. If enough above-ground aspen ramets die off, the rootstock will also die and aspen may be lost from the site (Sheppard et al., 2006). Fire will kill conifers and regenerate aspen through root suckering. At this site there is sufficient disturbance to maintain and perpetuate aspen. If heavy, prolonged grazing of this ecological site occurred, then a decrease of tall forbs and graminoid and shrub species would follow. Mueggler (1988) states that this grazing disclimax site would have diminished shrub, tall forb, and tall grass species and could be found in the Quaking aspen/Saskatoon serviceberry-common snowberry/mountain brome, Quaking aspen/common snowberry/mountain brome, and Quaking aspen/mountain brome habitat types. Prolonged, severe grazing, browsing, and trampling of this site would lead to a significant decrease or elimination of the shrubs, forbs, and grass species that define the site, with an increase in increaser species and non-native species. Hansen also described a grazing disclimax phase with prolonged heavy or severe grazing, browsing and trampling that is very similar to that described by Mueggler (1995). Drought also is a contributing factor in aspen health and mortality in the western interior of Canada. After the severe regional drought of 2001-2002, Hogg (2008) found a net mean increment in living biomass that normally was 2.2 tons per hectare per year subsequently decreased to near zero. Productivity and biomass was positively related to multiyear values of climate moisture index and mineral soil silt content. Mortality/dieback was correlated with minimum annual climate moisture index. Strand (2009) found that marked declines of aspen likely are due to changes in fire regimes, herbivory, drought, and interspecific competition with conifer species. Wet microsites had significantly slower successional rates of conifer establishment than upland mixed aspen/conifer stands. In her studies of the Owyhee Plateau in Idaho, Strand found that fire return intervals for upland aspen-conifer areas of 50-70 years are desirable for maintenance of aspen. The sudden dieback and deterioration of mature aspen stands has occurred throughout North America. Shepperd (2008) describes sudden aspen decline as rapid (1-2 years) mortality of mature trees with a lack of new sprouting after overstory mortality. Frey et al. (2004) attributed this to insect defoliation, drought, and thaw-freeze events as factors initiating dieback in mature aspen stands. Pathogens, nutrition, and successional changes may be involved in the decline in vigor and may contribute to the dieback process. Within the western United States there has been a 50-96% decline in total aspen forest acreage since European settlement (Bartos, 2001). The USFS FIA unit in Ogden, UT suggests that within Montana and Idaho aspen acreages are down 64 percent and 61 percent, respectively. In a study by that FIA unit, in western Montana, it was found that Montana and northern Idaho appear to be experiencing aspen decline, though not sudden aspen decline. Factors attributing to this decline were stated as the absence of fire, advancing succession with increased conifer encroachment, and the aspen's increased susceptibility to diseases and insects. Aspen stands often are invaded by conifer with the absence of fire, and the conifer will predominate after 80-120 years (Mueggler, 1994). Stands that have over 50% conifers will affect the below-ground root system of aspen (Sheppard et al., 2001). Heavy ungulate grazing detected where regeneration was present also resulted in stands unable to regenerate themselves. Drought could be a factor with climate change. East of the Continental Divide (CD), most stands (58 percent) were considered stable, 33 percent appeared to be expanding, and 8 percent were retreating or diminishing. As well, 78 percent of plots without conifers present were east of the Continental Divide, and these were recorded as not succeeding to some other tree species. The plots with severe conifer competition were on the west side of the Divide. The general condition of aspen stands in USFS Region 1 was found to be healthy. Plots east of the CD had a significantly greater proportion of aspen, with spike tops likely from sooty-bark canker and the greater incidence of wood borer damage east of the CD. The majority of live aspen trees had only minor crown dieback, except that plots east of the CD had a higher proportion of trees with moderate crown dieback. Dieback could be attributed to foliar insects, diseases, or late spring freezes. There was no evidence of sudden aspen decline in this report. Damages recorded included dieback, wood borer, defoliating insects, foliage disease, bark wounds, sooty bark canker, Cytospora canker, and Phellinus stem decay. Wood boring beetles including poplar borer, bronze poplar borer, and poplar dicera were the most common. Damage was significantly greater east of the CD and at plots at higher elevations and more northern locations. Defoliating insects included large aspen tortrix, aspen one leaf tier (caterpillar of moths), aspen two leaf tier, leafrollers, and forest tent caterpillars. The principal diseases were sooty-bark canker and Cytospora canker. Ink spot and Marssonina leaf blight were the common foliar diseases, and stem decay by Phellinus tremulae occurred. Root disease was rare but did occur in this study. Animal browsing and foliar diseases were the most damage-causing agents for aspen sprouts.

Quaking aspen (*Populus tremuloides*) is a native deciduous tree that has a shallow root system with wide-spreading lateral roots and vertical sinker roots descending from the laterals (Jones, 1985). It forms clones connected by a common parent root system. Clones can be either male or female. Stems can live to be 150 years old in the West. Aspen is not shade–tolerant, and it does not tolerate long-term flooding or waterlogged soils. It regenerates from seed and by sprouting from the roots. Sprout development is suppressed by apical dominance. Once the stem is removed by cutting, burning, girdling, or defoliation, the apical dominance is lost and sprouting begins. Seedling establishment is less common in the West due to dry periods following rainfall that kill newly germinated seedlings. Germination and seedling survival require a moist mineral seedbed with adequate drainage, moderate temperatures, and freedom from competition. Aspen is adapted to fire and is highly competitive on burned sites

(DeByle, 1987). It has thin bark with little heat resistance, and the root systems of top-killed stems sprout rapidly and profusely for several years after fire. Following a fire, a new even-aged aspen stand can develop within a decade. It is self-thinning, which develops a mature forest of healthy trees. Quaking aspen stands tend to have high plant productivity, and have been linked to greater soil nutrient availability because aspen litter has greater nutrient content and faster decomposition than conifer needles, which increases the aspen's nutrient inputs and cycling rates (Preston et al, 2009). Aspen stands also tend to have significantly lower leaf area index values than conifer-dominated stands. This increases light penetration and snow accumulation, which results in greater light and water availability. Climate change may effect this ecological site due to aspen's physiological sensitivity to temperature extremes and drought (Hogg et al., 2008), but could be offset by increased fire cycles, which favor aspen and cause conifer mortality, which would increase aspen regeneration. Mature conifers tend to be more tolerant to climatic extremes than aspen and may shift the competitive advantage towards conifers in mixed aspen-conifer stands. Conifer seedlings establish under aspen due to increased moisture under aspen trees and moisture holding soil and litter compared to the hydrophobic needles of conifers (St. Clair, 2013).
Quaking aspen is subjected to various diseases and insect pathogens. Some of the more common and serious cankers are the sooty-bark (Encoelia pruinosa), black (Ceratocystis fimbriata), Cryptosphaeria (Cryptosphaeria populina), and the Cytospora canker (Cytospora chrysosperma). These cankers enter through wounds in the bark and create abnormal growth and blackish cankers. The gravest canker, the sooty-bark type, can kill a tree in just 1-10 years. These are natural and essential to aspen ecology, creating openings in the canopy and understory, and regenerating new cycles of aspen as a mature tree dies. Aspen is prone to the root disease Armillaria species, which can weaken or even kill trees and cause windthrow. Boring insects and beetles can attack aspen, leaving wounds which later can become entry points for stem cankers. Foliage diseases occur, such as ink spot (Ciborina whetzelii), aspen tortrix (Choristoneura conflictana), and western tent caterpillar (Malacosoma californicum). White trunk rot fungus (Phellinus tremulae) also is a problem for aspen because it decays the base of the tree (Ostry and Walters, 1983).

This ecological site has high value for livestock and wildlife grazing, browsing, bedding and cover. They are important big game winter and summer grounds. Deer and elk browse young quaking aspen suckers and occasionally feed on the bark of older trees. Use by elk in spring, fall and winter is often moderate to heavy (Kufeld, 1973). It is also a preferred species by moose (Costain, 1989). Beaver can heavily use this site. Common nesting and feeding bird species include flickers, chickadees, sap suckers and woodpeckers (Flack, 1976). Quaking aspen also stabilizes stream banks and provides overhanging cover. This site can be altered due to heavy grazing, browsing, and trampling by livestock and wildlife. Quaking aspen suckers can be significantly decreased with heavy browsing, thereby affecting the regeneration of quaking aspen. Mueggler (1988) found that if this site is grazed by sheep, then grasses such as blue wildrye (*Elymus glaucus*), mountain brome (*Bromus marginatus*), and Kentucky bluegrass (*Poa pratensis*) increase, whereas tall and low shrub species are likely to decrease under prolonged heavy grazing. Black raspberry (*Rubus occidentalis*), Lathyrus species, and tall ragwort (*Senecio serra*) tend to increase substantially if grazed by cattle. Soil compaction can occur with heavy use. Introduction of non-native weedy species can occur with livestock grazing.

The following is a summarization by species of wildlife interpretations found in the appendices of Hansen (1995): Quaking aspen is a facultative upland (FACU) on the wetland indicator classification status, meaning these are nonhydrophyte plants and that it usually occurs in non-wetlands, but may occur in wetlands. It has good sheep forage palatability (highly relished and consumed to a high degree), and fair palatability for cattle and horses (Hansen, 1995). It has medium protein and energy value during fall and winter, which means that it retains usable energy and digestible protein values moderately well. It provides good cover value for elk, mule and whitetail deer, upland game bird, small non-game bird, and small mammals, but gives poor cover for waterfowl. It has only fair food value for elk and mule and whitetail deer, and is poor for antelope. It has good food value for bird species, except for waterfowl.

Western serviceberry is a FACU wetland-designated species that has moderate energy and protein values in the fall and winter. It has good sheep forage palatability, but is poor value for cattle and horses. It has good food value for mule and whitetail deer and antelope, but is rated poor for elk. It has poor food value for waterfowl, but has fair value for all other bird species. Its cover value is fair for mule and whitetail deer, but provides poor cover for elk. It has good cover value for waterfowl, but is rated poor for all other bird species.

Common snowberry is given a wetland indicator designation of FACU, has medium energy value and medium protein value. It has fair forage palatability for cattle and sheep, but is rated poor for horses. It is considered fair in food value for elk, mule and whitetail deer, and antelope. It has fair food value for upland game birds, waterfowl, small non-game birds, and small mammals. It has fair cover value for mule and whitetail deer, but is rated poor for elk, which means it is rarely or never utilized for cover when available. It provides good cover for upland game birds, waterfowl, small non-game birds, and small mammals.

Cow parsnip is a FACU wetland-designated species with low energy and protein value in the fall and winter seasons. It has good forage palatability for cattle, sheep, and horses. It has good food value for elk, mule and whitetail deer, but is rated poor for antelope. It provides fair food value for upland game birds and waterfowl, but has poor value for small non-game birds and small mammals.

Western sweet cicely is a FACU wetland-designated species with low energy and protein value in the fall and winter seasons.

Community phase 1.1: Reference state
This phase has mature, tall, straight round topped aspen trees. The understory is fairly open.
Community Phase 1.2: Herbaceous Phase: Immediately Post-Fire Disturbance
Post-fire regeneration of aspen root suckers with understory plant cover may be high. Site has full sunlight. Few older aspen may survive a mixed severity fire, but generally only dead skeleton trees remain.
Community Phase 1.3: Aspen Intermediate Aged Forest
Competitive exclusion phase of forest succession with thick, dense, pole-sized ASPEN trees.
Community Phase 1.4: Mature Aspen Forest
Forest proceeds from the thick, dense, pole-sized forest in phase 1.3 with small gap dynamics of singe tree death and regeneration, to a more open stand on tall, straight mature aspen trees.

Community Phase Pathway 1.1A: Post fire return of the aspen stand to the herbaceous and shrub stage.

Community Phase Pathway 1.1B: Post fire succession with growth of resprouting aspen to saplings.

Community Phase Pathway 1.1C: Further post fire succession with growth of aspen saplings to pole sized trees.

Community Phase Pathway 1.1D: Transition of pole sized and large trees to a mature, more open forest of aspen trees.

State 2.0
Current reference state, include a minor amount of weedy invasive species present in any community phase.
COMMUNITY PHASE 2.1: Quaking aspen/Saskatoon serviceberry-common snowberry/common cowparsnip-western sweetroot/mountain brome.
Overstory of clones of older aspen with maximum height for the site, with straight, clear stems with short, high rounded crowns. Understory vegetation is a lush, diverse mixture of shrubs, grasses and tall forbs. Our sites were considered reference in the field, although the actual ages from the tree corers show that they are slightly younger than what scientific literature consider reference (i.e. 60+ vs. 70+ years old). Our reference sites generally have all age cohorts filled to a degree including tree, pole, saplings, and seedlings. The tree heights are generally shorter than stated in references for other areas and this is due to high winds east of the Continental Divide, we postulate. The overstory heights for aspen were in height class 7 (40-80 feet tall) or height class 6 (13-40 feet tall). Canopies were moderately to highly closed, ranging from 45-60% total canopy closure. Our reference sites did not fall within any recent fire perimeters (1967-2007, NPS shapefile). Only half of the reference sites fell within the NPS stand age map for fire history and these were in the 1834-1859 age cohort meaning that there has been approximately 150 years since fire. This coincides with the age of the majority of aspen acreage throughout the western United States (N. DeByle et al 1987). It is generally accepted that a fire frequency of 100 to 300 years is appropriate for regenerating and maintaining western aspen forests (DeByle and Winokur 1985). The only fire on the east side of the Continental Divide that burned areas with the NPS Vegetation classification of mixed conifer-deciduous community were the Red Eagle fires of 1998 and 2006. The other sites were not covered in the stand age shapefile either. Our sites would fall in the aspen fire regime classification postulated by Shinneman et al (2013) as either class 1=fire –independent, stable aspen that rarely experience fire significantly into their stands because they are located within hydrologic or edaphic niches or topographically isolated sites. These have multiple ages of cohorts. Class 2= Fire-influenced, stable aspen that do burn occasionally but are not dependent. Fires are mixed-severity or occasionally crown replacing with right conditions resulting in mixed or even-aged cohorts. Kurzel et al (2007) found that aspen may persist without fire by episodic regeneration in which decadent stands may be replaced by

regenerating stands. Aspen individuals rarely last more than 120 years before giving way to younger cohorts. Gap dynamics in which treefalls create small openings in the canopy, also occur and facilitate regeneration. The understory is lush and diverse with shrub, grass and forb species (canopy cover data, 8 sites, all sites regardless of Mueggler designation). Frequently occurring species include the tall shrub serviceberry, the medium statured shrubs common snowberry and white spirea, the tall forbs cow parsnip, western meadowrue and false green hellebore and the lowest layer has mountain brome and vicia species.

Community Phase 2.2: Herbaceous Phase: Immediately Post-Fire Disturbance
Post-fire regeneration of aspen root suckers with understory plant cover may be high. Site has full sunlight. Few older aspen may survive a mixed severity fire, but generally only dead skeleton trees remain.

Community Phase 2.3: Aspen Intermediate Aged Forest
Competitive exclusion phase of forest succession with thick, dense, pole-sized aspen trees.

Community Phase 2.4: Mature Aspen Forest
Forest proceeds from the thick, dense, pole-sized forest in phase 1.3 with small gap dynamics of singe tree death and regeneration, to a more open stand on tall, straight mature aspen trees.

Community Phase Pathway 2.1A: Post fire return of the aspen stand to the herbaceous and shrub stage.

Community Phase Pathway 2.1B: Post fire succession with growth of resprouting aspen to saplings.

Community Phase Pathway 2.1C: Further post fire succession with growth of aspen saplings to pole sized trees.

Community Phase Pathway 2.1D: Transition of pole sized and large trees to a mature, more open forest of aspen trees.

Mueggler Aspen/tall forb sites. Community Phase 2.1 overstory and understory species with constancy and average cover values, 5 sites. Species with high constancy occur often, those with low constancy are rare. The average canopy cover is the average of the values for which it occurred. Therefore, species that are rare (only occurred once) show the canopy cover value for the one time it was found. Minimum and maximum canopy cover show the range of cover that the species was found. The most frequently occurring species in this canopy cover dataset include red baneberry, serviceberry, mountain brome, cow parsnip, western sweetroot, white spirea, common snowberry, western meadowrue. Other tall forb species encountered include green false hellebore, arrowleaf ragwort, Richardson’s geranium, sticky purple geranium, western showy aster and Lyall’s angelica.

Mueggler Aspen/mountain brome type sites. Community Phase 2.1 overstory and understory species with constancy and average cover values, 3 sites. Species with high constancy occur often, those with low constancy are rare. The average canopy cover is the average of the values for which it occurred. Therefore, species that are rare (only occurred once) show the canopy cover value for the one time it was found. Minimum and maximum canopy cover show the range of cover that the species was found. Species occurring with high frequency include serviceberry, mountain brome, strawberry species, northern bedstraw, sweet cicely, rose species, common snowberry, western meadowrue, vicia species and alpine leafybract aster.

Forest Production Summary of community phase 2.1.
FOREST OVERSTORY
Forest canopy Canopy cover range 35-60%
Average basal area:
Quaking aspen 80-180 Total ft2/acre
Lodgepole pine 50 Total ft2/acre
Site Index: 50-70 feet at 80 years
CMAI: 25-50 cubic feet per acre per year

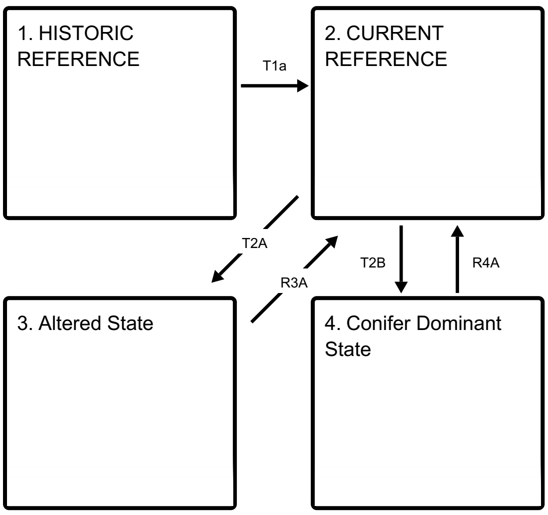
Table 5. Foliar cover summary of community phase 2.1, at 4 sites.
TOTAL ANNUAL FOLIAR COVER OVERSTORY =40-100%
TOTAL ANNUAL FOLIAR COVER UNDERSTORY =79.1%
Foliar cover is high (94%) and ground cover is predominantly litter (91%) with soil underneath. The ground cover also has very low cobbles (2%), gravel (3%) and moss (2%) and a trace of stones. Species with highest foliar cover

are aspen, common snowberry, white spirea, serviceberry and western meadowrue. This is a multi-storied canopy structure with moderately tall trees (aspen 953 cm or 375 inches tall and subalpine fir 450 cm or 177 inches tall). A tall shrub and forb layer (30-40 inches tall) includes alderleaf buckthorn, blue wildrye, Lyall's angelica, western sweetroot and common snowberry. The next layer is 20-30 inches tall and includes white spirea, serviceberry, thimbleberry and western showy aster. The next layer is 10-20 inches tall and includes pinegrass, Rocky mountain maple, fireweed and Geyer's sedge. The lowest layer up to 10 inches tall includes heartleaf arnica and viola species.

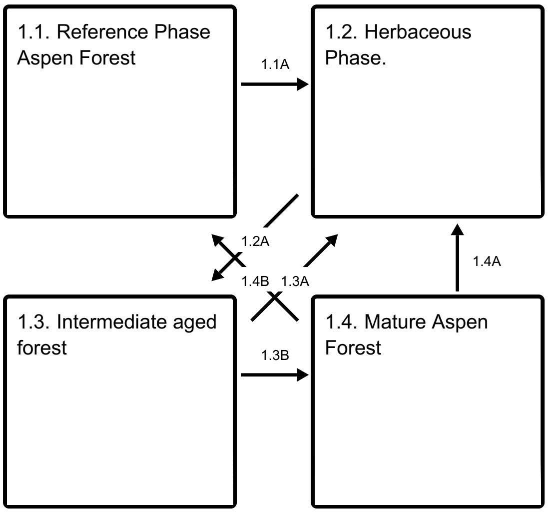
State 3.0
This State is a result of severe grazing. It is not possible to return to State 1 without human intervention. Ceasing grazing will not restore the vegetation community. Successful reproduction of quaking aspen will not occur due to browsing. Native shrub and forb species are severely limited due to grazing. There is an increase in non-native and increaser species.
State 4.0
This State is a result of conifer encroachment.
Transition T1A from State 1 to State 2: The presence of weedy plant species has changed the Historic Reference State to that of the Current Reference State.
Transition T2A from State 2 to State 3: This would occur with severe grazing and browsing. If the grazing and browsing pressure were removed for a significant amount of time, then a restoration pathway could occur.
Restoration R3A from State 3 to State 2: Cessation of severe grazing and browsing.
Transition T2B from State 2 to State 4: This would occur with severe grazing and browsing that allowed conifer encroachment and establish to give conifers the competitive advantage over aspen.
Restoration R4A from State 4 to State 2: Cessation of severe grazing and browsing and human intervention to reduced and suppress conifer establishment.

State and transition model

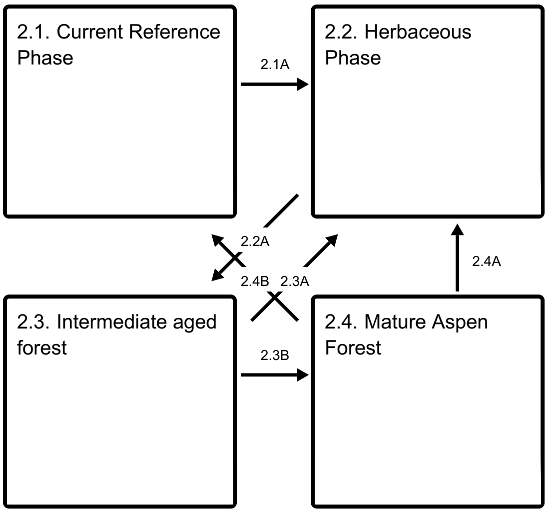
Ecosystem states



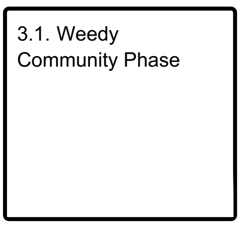
State 1 submodel, plant communities



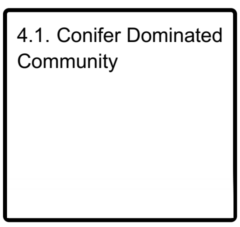
State 2 submodel, plant communities



State 3 submodel, plant communities



State 4 submodel, plant communities



State 1
HISTORIC REFERENCE

1.0 Historic Reference State- no weeds 43B Aspen

Community 1.1
Reference Phase Aspen Forest

Plant Community 1.1 Reference Phase Aspen Forest. Aspen/ Saskatoon serviceberry/ snowberry/ cowparsnip-western sweetroot Tree Age= 70+

Community 1.2
Herbaceous Phase.

Plant Community 1.2 Herbaceous Phase. Tree age: up to 30 years

Community 1.3
Intermediate aged forest

Plant Community 1.3 Intermediate aged forest Tree age: 30-50 years

Community 1.4
Mature Aspen Forest

Plant Community 1.4 Mature Aspen Forest Tree age: 50-70 years

Pathway 1.1A
Community 1.1 to 1.2

1.1A Fire

Pathway 1.2A
Community 1.2 to 1.3

1.2A Time ~30 years post fire

Pathway 1.3A
Community 1.3 to 1.2

1.3A Fire

Pathway 1.3B
Community 1.3 to 1.4

1.3B Time ~50 years post fire

Pathway 1.4B
Community 1.4 to 1.1

1.4B Time ~70+ years post fire

Pathway 1.4A
Community 1.4 to 1.2

1.4A Fire

State 2
CURRENT REFERENCE

2.0 Current Reference State- minor weeds 43B Aspen

Community 2.1
Current Reference Phase

Figure 9. Landscape view of ecological site, notice short stature of aspen trees due to severe winds experienced on the east side of the Continental Divide.

Figure 10. Landscape view focusing on lush understory of this ecological site

Figure 11. Evidence of wildlife damage prevalent on aspen stands encountered.

Plant Community 2.1 Current Reference Phase Aspen/ Saskatoon serviceberry/ snowberry/ cowparsnip- western sweetroot Minor weedy species present. Tree Age= 70+

Forest overstory. The overstory heights for aspen were in height class 7 (40-80 feet tall) or height class 6 (13-40 feet tall). Canopies were moderately to highly closed, ranging from 45-60% total canopy closure.

Forest understory. . The understory is lush and diverse with shrub, grass and forb species (canopy cover data, 8 sites). Frequently occurring species include the tall shrub serviceberry, the medium statured shrubs common snowberry and white spirea, the tall forbs cow parsnip, western meadowrue and false green hellebore and the lowest layer has mountain brome and vicia species.

Dominant plant species

- quaking aspen (*Populus tremuloides*), tree
- Saskatoon serviceberry (*Amelanchier alnifolia*), shrub
- common snowberry (*Symphoricarpos albus*), shrub
- common cowparsnip (*Heracleum maximum*), other herbaceous
- western sweetroot (*Osmorhiza occidentalis*), other herbaceous

Table 5. Ground cover

Tree foliar cover	30-50%
Shrub/vine/liana foliar cover	10-30%
Grass/grasslike foliar cover	10-30%
Forb foliar cover	10-30%
Non-vascular plants	0-5%
Biological crusts	0-2%

Litter	60-80%
Surface fragments >0.25" and <=3"	0-5%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	0-10%

Table 6. Soil surface cover

Tree basal cover	2-20%
Shrub/vine/liana basal cover	2-20%
Grass/grasslike basal cover	2-10%
Forb basal cover	2-10%
Non-vascular plants	0-5%
Biological crusts	0-2%
Litter	60-80%
Surface fragments >0.25" and <=3"	0-5%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	0-10%

Table 7. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	5-10%	0-20%	0-20%	5-30%
>0.5 <= 1	5-10%	10-30%	0-20%	5-30%
>1 <= 2	5-10%	10-30%	0-20%	5-10%
>2 <= 4.5	5-10%	0-10%	–	–
>4.5 <= 13	5-20%	–	–	–
>13 <= 40	5-30%	–	–	–
>40 <= 80	5-20%	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Community 2.2
Herbaceous Phase

Plant Community 2.2 Herbaceous Phase Minor weedy species present. Tree age: up to 30 years

Community 2.3
Intermediate aged forest

Plant Community 2.3 Intermediate aged forest aspen. Minor weedy species present. Tree age: 30-50 years

Community 2.4
Mature Aspen Forest

Plant Community 2.4 Mature Aspen Forest. Minor weedy species present. Tree age: 50-70 years

Pathway 2.1A
Community 2.1 to 2.2

2.1A Fire

Pathway 2.2A
Community 2.2 to 2.3

2.2A Time ~30 years post fire

Pathway 2.3A
Community 2.3 to 2.2

2.3A Fire

Pathway 2.3B
Community 2.3 to 2.4

2.3B Time ~50 years post fire

Pathway 2.4B
Community 2.4 to 2.1

2.4B Time ~70 years post fire

Pathway 2.4A
Community 2.4 to 2.2

2.4A Fire

State 3
Altered State

3.0 Altered State-weeds dominate

Community 3.1
Weedy Community Phase

Plant Community 3.1 Aspen/Woods Rose/Kentucky bluegrass timothy/dandelion-strawberry.

State 4
Conifer Dominant State

4.0 Conifer Dominant State

Community 4.1
Conifer Dominated Community

Plant Community 4.0 Ponderosa pine-Douglas fir (Aspen)/ Saskatoon serviceberry/ snowberry/ cowparsnip-western sweetroot Minor weedy species present.

Transition T1a
State 1 to 2

T1A Presence of weedy plant species

Transition T2A
State 2 to 3

T2A Severe grazing and browsing with no ability to return to State 1 without Human Intervention ceasing grazing will not restore vegetation community. Successful reproduction of aspen Severely limited due to browsing, native shrub and forb species Severely limited due to grazing and browsing. Increase in non-native and increaser Species.

Transition T2B
State 2 to 4

T2B Severe grazing and browsing that allowed conifer encroachment

Restoration pathway R3A
State 3 to 2

R3A Cessation of severe grazing and browsing.

Restoration pathway R4A
State 4 to 2

R4A Cessation of severe grazing and browsing and human intervention to reduce and suppress conifer establishment.

Additional community tables

Table 8. Community 2.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Forb					
1				–	
	western meadow-rue	THOC	*Thalictrum occidentale*	–	0–15
	western showy aster	EUCO36	*Eurybia conspicua*	–	0–10
	Lyall's angelica	ANAR3	*Angelica arguta*	–	0–10
	western sweetroot	OSOC	*Osmorhiza occidentalis*	–	0–8
	fireweed	CHAN9	*Chamerion angustifolium*	–	0–6
	heartleaf arnica	ARCO9	*Arnica cordifolia*	–	0–5
	starry false lily of the valley	MAST4	*Maianthemum stellatum*	–	0–4
	violet	VIOLA	*Viola*	–	0–4
	northern bedstraw	GABO2	*Galium boreale*	–	0–3
	bride's bonnet	CLUN2	*Clintonia uniflora*	–	0–3
	Virginia strawberry	FRVI	*Fragaria virginiana*	–	0–3
	Indian paintbrush	CASTI2	*Castilleja*	–	0–2
	American vetch	VIAM	*Vicia americana*	–	0–2
	common dandelion	TAOF	*Taraxacum officinale*	–	0–2
	western blue virginsbower	CLOC2	*Clematis occidentalis*	–	0–1
	desertparsley	LOMAT	*Lomatium*	–	0–1
	yellow penstemon	PECO6	*Penstemon confertus*	–	0–1
	alpine leafybract aster	SYFO2	*Symphyotrichum foliaceum*	–	0–1
	white thistle	CIHO	*Cirsium hookerianum*	–	0–1

	sulphur-flower buckwheat	ERUM	*Eriogonum umbellatum*	–	0–1
	vetch	VICIA	*Vicia*	–	0–1
	darkwoods violet	VIOR	*Viola orbiculata*	–	0–1
	common yarrow	ACMI2	*Achillea millefolium*	–	0–1
	alpine pussytoes	ANAL4	*Antennaria alpina*	–	0–1
	Richardson's geranium	GERI	*Geranium richardsonii*	–	0–1
	nineleaf biscuitroot	LOTR2	*Lomatium triternatum*	–	0–1
	stinging nettle	URDI	*Urtica dioica*	–	0–1
	green false hellebore	VEVI	*Veratrum viride*	–	0–1
	common cowparsnip	HEMA80	*Heracleum maximum*	–	0–1
Grass/Grasslike					
2				–	
	blue wildrye	ELGL	*Elymus glaucus*	–	0–10
	pinegrass	CARU	*Calamagrostis rubescens*	–	0–10
	Geyer's sedge	CAGE2	*Carex geyeri*	–	0–4
	mountain brome	BRMA4	*Bromus marginatus*	–	0–3
	smooth brome	BRIN2	*Bromus inermis*	–	0–2
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	–	0–2
	bluejoint	CACA4	*Calamagrostis canadensis*	–	0–1
	wildrye	ELYMU	*Elymus*	–	0–1
	Idaho fescue	FEID	*Festuca idahoensis*	–	0–1
	timothy	PHPR3	*Phleum pratense*	–	0–1
	northern singlespike sedge	CASC10	*Carex scirpoidea*	–	0–1
Shrub/Vine					
3				–	
	common snowberry	SYAL	*Symphoricarpos albus*	–	0–40
	white spirea	SPBE2	*Spiraea betulifolia*	–	0–30
	Saskatoon serviceberry	AMAL2	*Amelanchier alnifolia*	–	0–15
	alderleaf buckthorn	RHAL	*Rhamnus alnifolia*	–	0–10
	thimbleberry	RUPA	*Rubus parviflorus*	–	0–5
	Rocky Mountain maple	ACGL	*Acer glabrum*	–	0–5
	red baneberry	ACRU2	*Actaea rubra*	–	0–2
	shrubby cinquefoil	DAFR6	*Dasiphora fruticosa*	–	0–2
	sagebrush	ARTEM	*Artemisia*	–	0–1
	creeping barberry	MARE11	*Mahonia repens*	–	0–1
	Maryland sanicle	SAMA2	*Sanicula marilandica*	–	0–1
	Greene's mountain ash	SOSC2	*Sorbus scopulina*	–	0–1
Tree					
4				–	
	quaking aspen	POTR5	*Populus tremuloides*	–	0–55
	subalpine fir	ABLA	*Abies lasiocarpa*	–	0–5

Table 9. Community 2.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
quaking aspen	POTR5	*Populus tremuloides*	Native	35–60	30–70	–	–
subalpine fir	ABLA	*Abies lasiocarpa*	Native	–	0–5	–	–
lodgepole pine	PICO	*Pinus contorta*	Native	–	0–5	–	–
Engelmann spruce	PIEN	*Picea engelmannii*	Native	–	0–2	–	–

Table 10. Community 2.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
mountain brome	BRMA4	*Bromus marginatus*	–	–	3–37.5
bluejoint	CACA4	*Calamagrostis canadensis*	–	–	5
blue wildrye	ELGL	*Elymus glaucus*	–	–	5
Richardson's geranium	GERI	*Geranium richardsonii*	–	–	0.5–3
Geyer's sedge	CAGE2	*Carex geyeri*	–	–	1–3
pinegrass	CARU	*Calamagrostis rubescens*	–	–	2
sedge	CAREX	*Carex*	–	–	0.5
Forb/Herb					
claspleaf twistedstalk	STAM2	*Streptopus amplexifolius*	–	–	37.5
common cowparsnip	HEMA80	*Heracleum maximum*	–	–	3–37.5
greenflowered wintergreen	PYCH	*Pyrola chlorantha*	–	–	18
western sweetroot	OSOC	*Osmorhiza occidentalis*	–	–	5–15
western meadow-rue	THOC	*Thalictrum occidentale*	–	–	3–15
Lyall's angelica	ANAR3	*Angelica arguta*	–	–	7–10
green false hellebore	VEVI	*Veratrum viride*	–	–	2–8
violet	VIOLA	*Viola*	–	–	0.5–5
heartleaf arnica	ARCO9	*Arnica cordifolia*	–	–	5
aster	ASTER	*Aster*	–	–	3
black hawthorn	CRDO2	*Crataegus douglasii*	–	–	3
yellow avalanche-lily	ERGR9	*Erythronium grandiflorum*	–	–	3
northern bedstraw	GABO2	*Galium boreale*	–	–	3
bracted lousewort	PEBR	*Pedicularis bracteosa*	–	–	0.5–3
feathery false lily of the valley	MARA7	*Maianthemum racemosum*	–	–	3
starry false lily of the valley	MAST4	*Maianthemum stellatum*	–	–	0.5–3
sweetcicely	OSBE	*Osmorhiza berteroi*	–	–	3
fireweed	CHAN9	*Chamerion angustifolium*	–	–	0.5–3
American vetch	VIAM	*Vicia americana*	–	–	3
vetch	VICIA	*Vicia*	–	–	0.5–3
Pacific trillium	TROV2	*Trillium ovatum*	–	–	3
stinging nettle	URDI	*Urtica dioica*	–	–	1–3
threeleaf foamflower	TITR	*Tiarella trifoliata*	–	–	3
common dandelion	TAOF	*Taraxacum officinale*	–	–	0.5–3

arrowleaf ragwort	SETR	*Senecio triangularis*	–	–	3
darkwoods violet	VIOR	*Viola orbiculata*	–	–	2
western showy aster	EUCO36	*Eurybia conspicua*	–	–	2
bride's bonnet	CLUN2	*Clintonia uniflora*	–	–	1
spearleaf arnica	ARLO6	*Arnica longifolia*	–	–	1
Virginia strawberry	FRVI	*Fragaria virginiana*	–	–	0.5
fragrant bedstraw	GATR3	*Galium triflorum*	–	–	0.5
Asian forget-me-not	MYAS2	*Myosotis asiatica*	–	–	0.5
sticky purple geranium	GEVI2	*Geranium viscosissimum*	–	–	0.5
cinquefoil	POTEN	*Potentilla*	–	–	0.5
common yarrow	ACMI2	*Achillea millefolium*	–	–	0.5
Pacific anemone	ANMU	*Anemone multifida*	–	–	0.5
onion	ALLIU	*Allium*	–	–	0.5
thistle	CIRSI	*Cirsium*	–	–	0.5
lanceleaf springbeauty	CLLA2	*Claytonia lanceolata*	–	–	0.5
curly dock	RUCR	*Rumex crispus*	–	–	0.5
saxifrage	SAXIF	*Saxifraga*	–	–	0.5
common tansy	TAVU	*Tanacetum vulgare*	–	–	0.5
clover	TRIFO	*Trifolium*	–	–	0.5
Fern/fern ally					
horsetail	EQUIS	*Equisetum*	–	–	5
field horsetail	EQAR	*Equisetum arvense*	–	–	1
Shrub/Subshrub					
Saskatoon serviceberry	AMAL2	*Amelanchier alnifolia*	–	–	3–62.5
common snowberry	SYAL	*Symphoricarpos albus*	–	–	5–37.5
rose	ROSA5	*Rosa*	–	–	15
Utah honeysuckle	LOUT2	*Lonicera utahensis*	–	–	15
white spirea	SPBE2	*Spiraea betulifolia*	–	–	3–7
thimbleberry	RUPA	*Rubus parviflorus*	–	–	3–7
Greene's mountain ash	SOSC2	*Sorbus scopulina*	–	–	3
creeping barberry	MARE11	*Mahonia repens*	–	–	3
twinberry honeysuckle	LOIN5	*Lonicera involucrata*	–	–	3
prickly currant	RILA	*Ribes lacustre*	–	–	1
red baneberry	ACRU2	*Actaea rubra*	–	–	0.5–1

Other references

References

Arno, S., Ramona Hammerly. Northwest trees.2007.

Bartos, D.L. 2001. Landscape dynamics of aspen and conifer forests. In: Sheppard, W.D., D. Binkley,

Bartos. D.L., T.J. Stohlgren, and L.G. Eskew (Comps.). Sustaining aspen in western landscapes:Symposium proceedings; 13–15 June 2000; Grand Junction, CO. USDA Forest Service ProceedingsRMRS-P-18, 460p. Rocky Mountain Research Station, Fort Collins, CO: 5–14.

Bartos, D.L. and M.C. Amacher. 1998. Soil properties associated with aspen to conifer succession. Rangelands 20: 25-28.

Bartos, D.L. and R.B. Campbell. 1998. Decline of quaking aspen in the Interior West – Examples from Utah. Rangelands 20: 17–24

Costain, Brent. "Habitat use patterns and population trends among Shiras moose in a heavily logged region of northwest Montana." (1989).

DeByle, N.V. and R.P. Winokur (Eds.). Aspen: Ecology and Management in the western United States. USDA Forest Service General Technical Report RM-119, 283 p. Rocky Mountain Forest and Range Experiment Stations, Fort Collins, CO: 87–106.

DeByle, N. C. Bevins and W. Fischer. Wildfire occurrence in Aspen in the Interior Western United States. West. J. Appl. For. 2(3):73-76, July 1987.

Flack, JA Douglas. "Bird populations of aspen forests in western North America." Ornithological monographs 19 (1976): iii-97.

Frey, Brent. V. Lieffers, E. Hogg, S. Landhausser. 2004. Predicting landscape patterns of aspen dieback: mechanisms and knowledge gaps. Can. J. For. Res. 34: 1379–1390 (2004)

Hansen, P.L., Robert Pfister, Keith Boggs, Bradley Cook, John Joy and Dan Hinckley. Classification and management of Montana's riparian and wetland sites. 1995. University of Montana, Missoula Montana. Miscellaneous Publication No. 54.

Hogg, E. J. Brandt, M. Michaelian. 2008. Impacts of a regional drought on the productivity, dieback, and biomass of western Canadian aspen forests. Can.J.For.Res. 38: 1373-1384.

Johnson, D.W., J.S. Beatty and T.E. Hinds. 1995. Cankers on western quaking aspen. USDA U.S.F.S.

Kufeld, Roland C., Olof C. Wallmo, and Charles Feddema. "Foods of the Rocky Mountain mule deer." Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo. USDA Forest Service Research Paper RM-111 (1973).

Kurzel, B. P., T. T. Veblen, and D. Kulakowski. 2007. A typology of stand structure and dynamics of Quaking aspen in northwestern Colorado. Forest Ecology and Management, v. 252, no. 1-3, p. 176-190. 10.1016/j.foreco.2007.06.027.

Mueggler, W.F. 1994. Sixty years of change in tree numbers and basal area in central Utah aspen stands. USDA Forest Service Research Paper INT-RP-478. Intermountain Research Station, Ogden, UT. 11p

Mueggler, W. Aspen community types of the Intermountain Region. USFS GTR INTO-250. 1988.

NatureServe, 2007. U.S. National Vegetation Classification Standard: Terrestrial Ecological Classifications. Waterton-Glacier International Peace Park, Local and Global Association Descriptions.

Ostry, M.E. and J.W. Walters. 1983. How to identify and minmize white trunk rot of aspen. USFS USFS North Central Research Station.

Shepperd, Wayne D., Binkley, Dan, Bartos, Dale. Stohlgren, Thomas, and Eskew, Lane G., 2001. Sustaining aspen in western landscapes: Symposium Proceedings; 13-15 June 2000; Grand Junction, CO. Proceedings RMRS-P-18. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 460 pg.

Shepperd, Wayne D. 1981. Stand characteristics of Rocky Mountain aspen. In: DeByle, Norbert V., ed. Symposium proceedings--situation management of two Intermountain species: aspen and coyotes. Volume 1. Aspen; 1981 April 23-24; Logan, UT. Logan, UT: Utah State University, College of Natural Resources: 22-30.

Shepperd, Wayne D. 1986. Silviculture of aspen forests in the Rocky Mountains and Southwest. RM-TT-7. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 38 p.

St. Clair, Samuel. The role of facilitation and competition in the development and resilience of aspen forests. Forest Ecology and Managment 299: 91-99.

Sheppard, W.D., D.L. Bartos, and S.A. Mata. 2001. Above and below ground effects of aspen clonal regeneration and succession to conifers. Canadian Journal of forest Research 31: 739-745.

Shinneman, D. J. et al. (2013). Fire Regimes of Quaking Aspen in the Mountain West. Forest Ecology and Management, 299,22-34

Soil Survey Staff. 2015. Illustrated guide to soil taxonomy. U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center, Lincoln, Nebraska.

Steed, B. and H. Kearns. 2010. Forest health protection No. Report 10-03. damage agents and condition of mature aspen stands in Montana and Northern Idaho.

Strand, E.K. et al. / Forest Ecology and Management 257 (2009) 1705–1715. Quantifying successional rates in western aspen woodlands: current conditions, future predictions.

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Stephaine Shoemaker

Approval

Kirt Walstad, 3/04/2024

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	04/19/2024
Approved by	Kirt Walstad
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

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

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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:**