Ecological site group DX035X01GESG12
Chinle Valley Sandy Uplands

Last updated: 10/12/2022
Accessed: 05/02/2024

Key Characteristics

- Chinle Valley
- Sandy
- Uplands

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

This group occurs in an upland position as gently rolling plains and mesas, high stream terraces, fan terraces, and stable dunes of undulating plateaus and structural benches, mostly level stabilized sand sheets and dunes that have formed on plateaus and mesas of sandstone geologic formations. It neither receives a significant amount of run-in moisture nor experiences an excess of runoff moisture. Slopes range from 0 to 15 percent. Elevations range from 4,700 to 6,500 feet.

Climate

50-60% of moisture falls as rain Jul-Sept and is the most effective moisture for plant growth. The remaining moisture comes as snow during the winter. The mean annual precipitation ranges from 6 – 17 inches, but it is very erratic, often varying substantially from year to year.

Mean temperatures for the hottest month (Jul) is 72 degrees F; for the coldest month (Jan) is 32 degrees F. Extreme temperatures of 105 degrees F and -26 degrees F have been recorded. Long periods with little or no effective moisture are relatively common.

Cool season plants begin growth in early spring and mature in the early summer. Warm season plants take advantage of summer rains and grow from July through September.

Soil features

Soils on this group are deep and well-drained with no plant root restricting layers, and somewhat excessively to excessively well drained. The surface texture ranges from sand to course sandy loam. The substratum is loamy fine sand, loamy sand or sand. The soil ranges from neutral to moderately alkaline (pH 6.6 to 8.4). Permeability is rapid and the soil can absorb all the moisture the climate supplies but has a very low available water capacity.

Vegetation dynamics

The plant communities found on an ecological site are naturally variable. Composition and production will vary with yearly conditions, location, aspect, and the natural variability of the soils. The historical climax plant community represents the natural potential plant communities found on relict or relatively undisturbed sites. Other plant communities described here represent plant communities that are known to occur when the site is disturbed by factors such as grazing, fire, or drought.

Production data provided in this site description is standardized to air-dry weight at the end of the summer growing season. The plant communities described in this site description are based on near normal rainfall years.

NRCS uses a Similarity Index to compare existing plant communities to the plant communities described here. Similarity Index is determined by comparing the production and composition of a plant community to the production and composition of a plant community described in this site description. To determine Similarity Index, compare the production (air-dry weight) of each species to that shown in the plant community description. For each species, count no more than the maximum amount shown for the species, and for each group, count no more than the maximum shown for the group. Divide the resulting total by the total normal year production shown in the plant community description. If rainfall has been significantly above or below normal, use the total production shown for above or below normal years. If field data is not collected at the end of the summer growing season, then the field data must be corrected to the end of the year production before comparing it to the site description. The growth curve can be used as a guide for estimating production at the end of the summer growing season.

The State and Transition model shows the most common occurring plant communities likely to be encountered on this ecological site. This model may not show every possible plant community, but only those that are most prevalent and observed through field inventory. As more data is collected and research is available, these plant communities may be revised, removed, and even added to reflect the ecological dynamics of this site.

Major Land Resource Area

MLRA 035X
Colorado Plateau

Subclasses

- DX035X03A113–Sandy
- R035XA118AZ–Sandy Upland 10-14" p.z.
- R035XB035NM–Sandy Upland 6-10"
- R035XB206AZ–Sandy Upland 6-10" p.z. Warm
- R035XC315AZ–Sandy Upland 10-14" p.z.
- R035XC330AZ–Sandy Terrace 10-14" p.z. Stony
- R035XC373AZ–Sandy Upland 10-14" p.z. Warm
- R035XC377AZ–Sandy Slopes 10-14" p.z.
- R035XF607AZ–Sandy Upland 13-17" p.z.
- R035XY115UT–Desert Sand (Sand Sagebrush)
- R035XY212UT–Semidesert Sand (Fourwing Saltbush)
- R035XY217UT–Semidesert Sandy Loam (Spiny Hopsage)

Correlated Map Unit Components

22397546, 22397533, 22397499, 22397498, 22397390, 22397392, 22397394, 22397536, 22397482, 22397384, 22397381, 22397366, 22397369, 22397521, 22397190, 22397191, 22397364, 22397365, 22397493, 22397374, 22397517, 22397399, 22397398, 22397397, 22397405, 22397373, 22397442, 22397446, 22397447, 22397439, 22397424, 22397387, 22397525, 22397338, 22397463, 22397465, 22397635, 22397410, 22397411, 22397421, 22397549, 22397551, 22397552, 22397495, 22397419, 22397449, 22397270, 22397615, 22397593, 22397600, 22397343, 22397265, 22999422, 22999428, 22999450, 22999477, 22999578, 22999649, 22999661, 22999674, 22999805, 22999852, 22999864, 22999863, 22999887, 22598013, 22598033, 22598055, 22598060, 22597885, 22598074, 22597900, 22598371, 22598096, 22600856, 22601101, 22601330, 22600893, 22601128, 22600906, 22600909, 22601554, 22601125

Stage

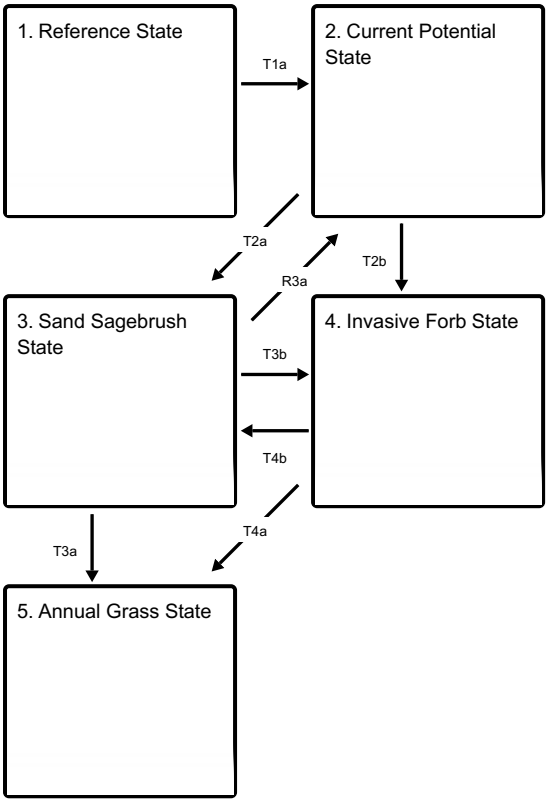
Provisional

Contributors

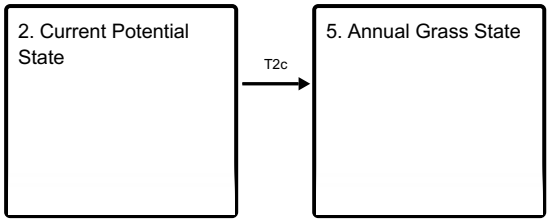
Curtis Talbot

State and transition model

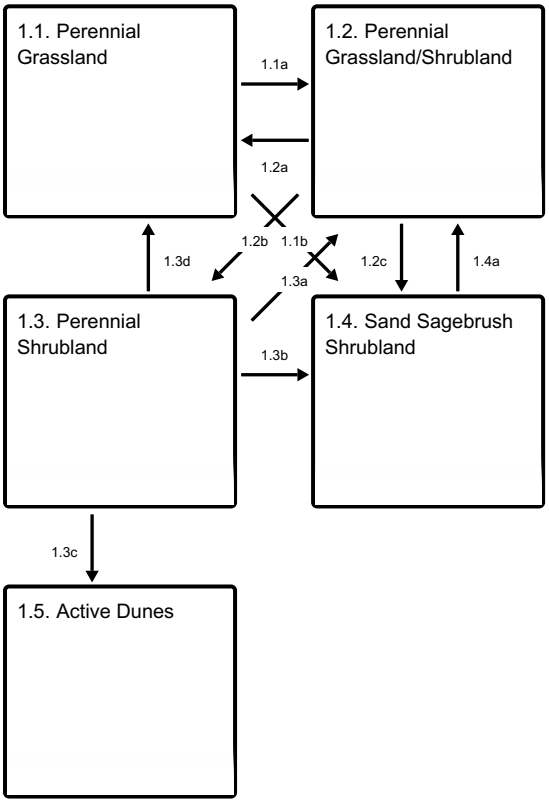
Ecosystem states



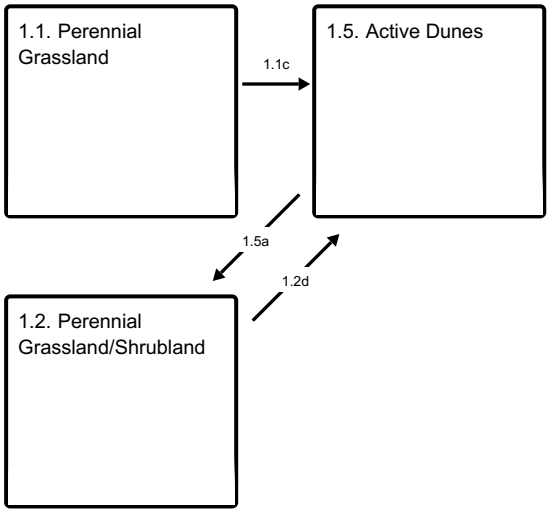
States 2 and 5 (additional transitions)



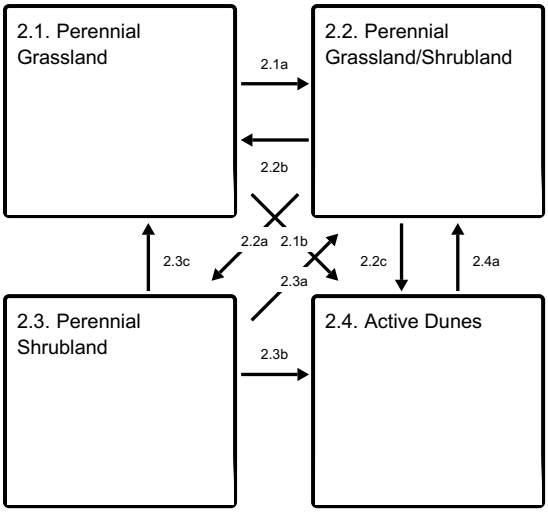
State 1 submodel, plant communities



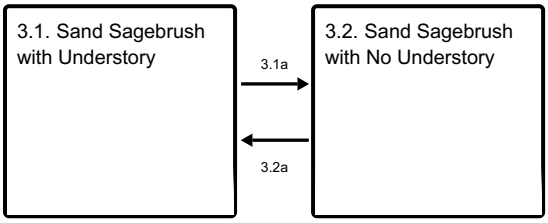
Communities 1, 5 and 2 (additional pathways)



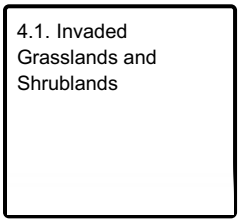
State 2 submodel, plant communities



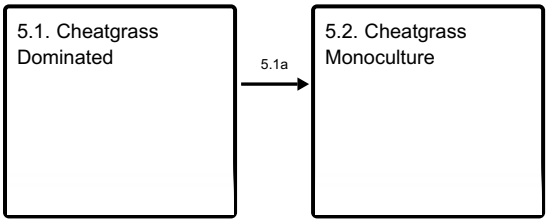
State 3 submodel, plant communities



State 4 submodel, plant communities



State 5 submodel, plant communities



State 1
Reference State

This state represents the natural range of variability that dominates the dynamics of this ecological site. This state includes the biotic communities that would become established if all successional sequences were completed under the natural disturbance regime. The state is dominated by perennial warm and cool season grasses and a diverse shrub community. Utah juniper has been known to invade this site when it is in close proximity to a juniper stand. Due to the aggressive competitiveness of Utah juniper, blowout areas are common where these species occur. Primary disturbance mechanisms for this site include fire, grazing by native herbivores, prolonged rodent activity, insect herbivory, alluvial deposits and changes in the sites drainage patterns. These disturbances coupled with weather events dictate the dynamics that occur within the natural range of variability. The reference state is self sustaining and resistant to change due to high resistance to natural disturbances and high resilience after natural disturbances. When natural disturbances occur, the rate of recovery is relatively rapid due to niches being filled with highly adapted native vegetation. Reference State: Community phases influenced by infrequent fire, native herbivore grazing, insect herbivory, alluvial deposits, time without disturbance, and climate. Indicators: A well developed native perennial warm and cool season grass community with a diverse shrub overstory, when present. Feedbacks: Establishment of non-native invasive species in the understory. Infrequent but regular fires that maintain

the perennial bunch grass understory and the establishment of shrubs. At-risk Community Phase: All communities are at risk for invasion by non-native plants; however plant community 1.3 and 1.4 are most at risk due to decreased species cover and diversity in the understory. 1.4 also is at risk due to changes in disturbance regime. Trigger: Establishment of non-native plant species

Community 1.1
Perennial Grassland

This community phase is characterized by perennial grasses where needle-and-thread is the dominant plant species. Indian ricegrass, sand dropseed, sandhill muhly, blue grama, and James galleta may also be present. Perennial warm and cool season grasses (30-50% cover) are very common while shrubs make up only 1-9% of the canopy cover, measured as first raindrop impact. Fourwing saltbush and/or winterfat form the dominant visual aspect, and generally cutler mormontea is present. Other grass, shrubs, and forbs may or may not be present and cover is variable. Biological crusts are common (20-30% cover) are characterized by continuous moss and lichen pinnacles, and bare ground (10-20% cover) is minimal.

Community 1.2
Perennial Grassland/Shrubland

This plant community is characterized by both native shrubs and perennial warm and cool season grasses. Needle-and-thread, Indian ricegrass, sand dropseed, blue grama, and James galleta may be present. Perennial warm and cool season grasses (20-45% cover) are common and shrubs make up 10-14% of the canopy cover, measured as first raindrop impact. Fourwing saltbush and/or winterfat form the dominant visual aspect, and generally cutler mormontea and sand sagebrush are present. Other grass, shrubs, and forbs may or may not be present and cover is variable. Biological crusts are common (20-30% cover) and characterized by continuous moss and lichen pinnacles. Bare ground (10-20% cover) is minimal.

Community 1.3
Perennial Shrubland

This plant community is characterized by a dominance of native perennial shrubs, where warm and cool season perennial grasses are still present in the understory. Needle-and-thread, Indian ricegrass, sand dropseed, blue grama, and James galleta may be present. Perennial warm and cool season grasses (10-45% cover) are variable and shrubs make up 15-30% of the canopy cover, measured as first raindrop impact. Fourwing saltbush and/or winterfat form the dominant visual aspect, and generally Cutler's jointfir and sand sagebrush are present. Other grass, shrubs, and forbs may or may not be present and cover is variable. Biological crusts are common (20-30% cover) are characterized by continuous moss and lichen pinnacles, and bare ground (10-20% cover) is minimal. This plant community is more at risk that other plant communities in the reference state due to the lack of understory.

Community 1.4
Sand Sagebrush Shrubland

This plant community is characterized by a dominance of sand sagebrush with a perennial grass understory. Due to sand sagebrush’s resilience and ability to establish after a disturbance this community phase may be very persistent. This shrub is an avid resprouter and thus after disturbances, such as fire or alluvial sand deposits, it is able to reestablish relatively fast when compared to other vegetation (McWilliams, 2003). Once established it can proliferate and dominate the site reducing the ability of other perennial shrubs to obtain the nutrients needed for survival. Needle-and-thread, Indian ricegrass, sand dropseed, blue grama, and James galleta may be present. Other grass, shrubs, and forbs may or may not be present and cover is variable. Biological crusts (0-15% cover) are classified as crustless or by light cyanobacteria in the interspaces, with occasional lichen and moss pinnacles with little to no continuity, depending on severity and age of the alluvial deposit. Bare ground is more common in this community phase (10-40% cover).

Community 1.5
Active Dunes

This plant community is characterized by dune vegetation. Dominant perennial shrubs include Cutler mormontea, sand buckwheat, resinbush, and purple sage. Dominant perennial cool season grasses include Indian ricegrass and dominant perennial warm season grasses include sandhill muhly. Other perennial grasses, shrubs, and forbs may or may not be present and cover is variable. This community is typically represented by small patches where localized surfaces disturbances have occurred within one of the other reference state plant communities. Bare ground (30-60% cover) is common, and biological crust (0-25%) cover is typically characterized as crustless to light cyanobacteria in the interspaces.

Pathway 1.1a
Community 1.1 to 1.2

This pathway occurs as natural events favor the increased establishment of shrubs, including drought and/or time without disturbances. Drought favors the establishment of shrubs due to their ability to out-compete native perennial grasses for moisture. Time allows shrubs, which have longer recovery periods, to establish.

Pathway 1.1b
Community 1.1 to 1.4

This pathway occurs when events favor the establishment of sand sagebrush. Events typically include a flood with alluvial deposits. This changes the water drainage patterns of a site and results in a dominance of sand sagebrush due to its ability to establish and flourish on sites with shorter disturbance regimes (McWilliams, 2003).

Pathway 1.1c
Community 1.1 to 1.5

This pathway occurs when events favor an increase in active dunes and common dune vegetation. Events could include any type of natural surface disturbance that would increase erosion and soil movement, such as prolonged rodent activity, a severe drought that reduces plant cover, excessive trampling by wildlife, etc.

Pathway 1.2a
Community 1.2 to 1.1

This pathway occurs as events favor the increased establishment of perennial warm and cool season grasses with a decrease in shrub cover. Events typically include fire, which reduces shrub cover and allows for increased establishment of grasses, and insect herbivory. Orthoptera, Lepidoptera, and Hemiptera are known to feed on fourwing saltbush and have been associated with shrub die-offs in the late 1980’s (Howard, 2003).

Pathway 1.2b
Community 1.2 to 1.3

This pathway occurs as events favor the increased establishment of shrubs. Events may include drought or time without fire disturbances. Drought favors the establishment of shrubs due to its ability to out-compete native perennial grasses for moisture. Time without fire allows shrubs, which have longer recovery periods, to establish.

Pathway 1.2c
Community 1.2 to 1.4

This pathway occurs when events favor the establishment of sand sagebrush. Events typically include a flood with alluvial deposits. This changes the water drainage patterns of a site and results in a dominance of sand sagebrush due to its ability to establish and flourish on sites with shorter disturbance regimes.

Pathway 1.2d
Community 1.2 to 1.5

This pathway occurs when events favor an increase in active dunes and common dune vegetation. Events could include any type of natural surface disturbance that would increase erosion and soil movement, such as prolonged rodent activity, a severe drought that reduces plant cover, excessive trampling by wildlife, etc.

Pathway 1.3d
Community 1.3 to 1.1

This pathway occurs when a fire completely removes the shrub overstory and results in an increase in the perennial grasses and forbs.

Pathway 1.3a
Community 1.3 to 1.2

This pathway occurs as natural events favor the increased establishment of perennial warm and cool season grasses with a decrease in shrub cover. Events typically include patchy fire, which reduces shrub cover and allows for increased establishment of grasses, and insect herbivory. Orthoptera, Lepidoptera, and Hemiptera are known to feed on fourwing saltbush and have been associated with shrub die-offs in the late 1980's (Howard, 2003).

Pathway 1.3b
Community 1.3 to 1.4

This pathway occurs when events favor the establishment of sand sagebrush. Events typically include a flood with alluvial deposits. This changes the water drainage patterns of a site and results in a dominance of sand sagebrush due to its ability to establish and flourish on sites with shorter disturbance regimes.

Pathway 1.3c
Community 1.3 to 1.5

This pathway occurs when events favor an increase in active dunes and common dune vegetation. Events could include any type of natural surface disturbance that would increase erosion and soil movement, such as prolonged rodent activity, a severe drought that reduces plant cover, excessive trampling by wildlife, etc.

Pathway 1.4a
Community 1.4 to 1.2

This pathway occurs as time without disturbances or a change in water drainage patterns stabilize the site and allow for the increased establishment of fourwing saltbush, winterfat, and perennial warm and cool season grasses.

Pathway 1.5a
Community 1.5 to 1.2

This pathway occurs as natural events such as time without surface disturbances favors the stabilization of the site and increased establishment of fourwing saltbush, winterfat, and perennial warm and cool season grasses.

State 2
Current Potential State

This state is similar to the reference state except that non-native plants are now present in all plant community phases. The primary disturbance mechanisms can be natural or human induced. Events, such as improper livestock grazing, prolonged rodent activity, changes in historic fire regimes, OHV overuse, insect herbivory, or drought may influence this site. A shift in species composition will affect the nutrient cycling, soil-water relationships, hydrology, and soil stability. Dominant grasses include both warm and cool season; however many times heavy spring grazing will remove the cool season grasses and heavy late summer and early fall grazing will remove the warm season grasses. Utah juniper is also still a common invader of the shallow soil components, creating blowout areas and increasing erosion. This state is losing resistance to disturbances and resilience after disturbance. Invasive plants are beginning to fill the niches and establish on the site. Current Potential State: Plant communities influenced by both natural and man influenced events, including rodent activity, OHV overuse, livestock grazing, insect herbivory, fire, time with out disturbances, and climatic fluctuations. Indicators: A perennial cool and warm season grass understory with fourwing saltbush forming the dominant visual aspect, when present. Non-native species are now present in all plant communities. Feedbacks: Extended drought, improper livestock grazing, or

other disturbance that changes the ecological dynamics of the site. Infrequent but regular fires or properly managed domestic livestock grazing to maintain the understory and the establishment of shrubs. At-risk Community Phase: All communities are at risk; however plant community 2.3 is most at risk due to its limited understory. Trigger: Disturbance that facilitates the dominance of invasive forbs and/or grasses.

Community 2.1
Perennial Grassland

This community phase is characterized by perennial grassland where needle-and-thread is the dominant plant species. Indian ricegrass, sand dropseed, blue grama, and James galleta may also be present. Perennial warm and cool season grasses (20-45% cover) are very common while shrubs make up only 1-9% of the canopy cover, measured as first raindrop impact. Fourwing saltbush and/or winter fat form the dominant visual aspect, and generally Cutler's jointfir is present. Commonly seen invasive plant species include cheatgrass, Russian thistle, annual Cryptantha, annual stickseed, and tansy mustard. Other grasses, shrubs, and forbs may or may not be present and cover is variable. Biological crusts are less common than in the reference state (0-25% cover) and are characterized by light cyanobacteria and isolated moss and lichen pinnacles. Bare ground (10-40% cover) is variable.

Community 2.2
Perennial Grassland/Shrubland

This plant community is characterized by both native shrubs and perennial warm and cool season grasses. Needle-and-thread, Indian ricegrass, sand dropseed, blue grama, and James galleta may be present. Perennial warm and cool season grasses (10-30% cover) are variable and shrubs make up 10-14% of the canopy cover, measured as first raindrop impact. Fourwing saltbush and/or winterfat form the dominant visual aspect, and generally Cutler's jointfir and sand sagebrush are present. Commonly seen invasive plant species include cheatgrass, Russian thistle, annual Cryptantha, annual stickseed, and tansy mustard. Other grass, shrubs, and forbs may or may not be present and cover is variable. Biological crusts are variable (5-30% cover) and characterized by cyanobacteria and isolated lichen and moss pinnacles with little to no continuity. Bare ground (10-40% cover) is variable.

Community 2.3
Perennial Shrubland

This plant community is characterized by a dominance of native perennial shrubs, where warm and cool season perennial grasses are still present in the understory. Needle-and-thread, Indian ricegrass, sand dropseed, blue grama, and James galleta may be present. Perennial warm and cool season grasses (20-45% cover) are fairly common and shrubs make up 15-30% of the canopy cover, measured as first raindrop impact. Fourwing saltbush and/or winterfat form the dominant visual aspect, and generally Cutler's jointfir is present. Commonly seen invasive plant species include cheatgrass, Russian thistle, annual Cryptantha, annual stickseed, and tansy mustard. Other grass, shrubs, and forbs may or may not be present and cover is variable. Biological crusts are variable (5-40% cover) are characterized by light cyanobacteria and isolated moss the lichen pinnacles with little to no continuity and bare ground (5-30% cover) is variable.

Community 2.4
Active Dunes

This plant community is characterized by dune vegetation. Dominant perennial shrubs include Cutler's jointfir , sand buckwheat, resinbush, and purple sage. Dominant perennial cool season grasses include Indian ricegrass and dominant perennial warm season grasses include sandhill muhly. Commonly seen invasive plant species include cheatgrass, Russian thistle, annual Cryptantha, annual stickseed, and tansy mustard. Other perennial grasses, shrubs, and forbs may or may not be present and cover is variable. This community is typically represented by small patches where localized surfaces disturbances have occurred within the other current potential plant communities. Bare ground (30-60% cover) is common, and biological crust (0-25%) cover is typically characterized as crustless to light cyanobacteria in the interspaces.

Pathway 2.1a
Community 2.1 to 2.2

This pathway occurs as events favor the increased establishment of shrubs, including drought time with out fire disturbances, and grazing livestock in such a way that removes the perennial grass and forb understory and facilitates the increased establishment of shrubs.

Pathway 2.1b
Community 2.1 to 2.4

This pathway occurs when events favor an increase in active dunes and common dune vegetation. Events could include any type of natural surface disturbance that would increase erosion and soil movement, such as prolonged rodent activity, a severe drought that reduces plant cover, excessive trampling by wildlife and livestock, OHV overuse, etc.

Pathway 2.2b
Community 2.2 to 2.1

This pathway occurs as natural events favor the increased establishment of shrubs. Events may include drought, time without a fire disturbance, and grazing livestock in such a way that removes the grass and forb understory and causes an increase in shrub cover and production.

Pathway 2.2a
Community 2.2 to 2.3

This pathway occurs as natural events favor the increased establishment of perennial warm and cool season grasses with a decrease in shrub cover. Events typically include fire, insect herbivory, and grazing in such a way to reduce shrub cover and production, resulting in an increase in the grass and forb understory.

Pathway 2.2c
Community 2.2 to 2.4

This pathway occurs when events favor an increase in active dunes and common dune vegetation. Events could include any type of natural surface disturbance that would increase erosion and soil movement, such as prolonged rodent activity, a severe drought that reduces plant cover, excessive trampling by wildlife or livestock, OHV overuse, etc.

Pathway 2.3c
Community 2.3 to 2.1

This pathway occurs as a fire or other disturbances completely removes the shrub canopy and allows for a subsequent increase in the grass and forb plant community diversity, cover, and production.

Pathway 2.3a
Community 2.3 to 2.2

This pathway occurs as events, such as fire, insect herbivory, or grazing livestock in such a way to decrease shrub cover and production, favor the increased establishment of perennial warm and cool season grasses with a decrease in shrub cover.

Pathway 2.3b
Community 2.3 to 2.4

This pathway occurs when events favor an increase in active dunes and common dune vegetation. Events could include any type of natural surface disturbance that would increase erosion and soil movement, such as prolonged rodent activity, a severe drought that reduces plant cover, excessive trampling by wildlife or livestock, OHV overuse, etc.

Pathway 2.4a

Community 2.4 to 2.2

This pathway occurs as natural events such as time without disturbance favors the stabilization of the site and increased establishment of fourwing saltbush, winterfat, and perennial warm and cool season grasses.

State 3
Sand Sagebrush State

This state is characterized by the dominance of sand sagebrush, where invasive and desirable species may or may not be present in the understory. Primary disturbance mechanisms include improper livestock grazing and drought which reduces the understory limiting it to occurring directly under the shrub canopy. This creates large bare interspaces which are susceptible erosion. Time without disturbances may cause this site to reestablish some of its understory. Due to sand sagebrush's resilience and ability to establish after a disturbance this state may be very persistent. This shrub is an avid resprouter and thus after disturbances, such as fire or alluvial sand deposits, it is able to reestablish relatively fast when compared to other vegetation (McWilliams, 2003). Once established it can proliferate and dominate the site reducing the ability of other perennial shrubs to obtain the nutrients needed for survival. Sand Sagebrush State: Plant communities influenced by time without disturbances, drought, and livestock grazing. Indicators: A site dominated by sand sagebrush, where invasive and desirable species may or may not be present in the understory. Feedbacks: Extended drought, improperly managed livestock grazing, or other disturbance that result in a reduction of the understory and subsequent increased occurrence of invasive plant species. Properly managed livestock grazing and normal precipitation fluctuations that allow for the maintenance of the understory and shrub canopy. At risk Community: All communities are at risk; however these sites may be very stable do to the behavior of sand sagebrush and its resilience after disturbances. Plant community 3.2 is most at risk due to absence of a developed understory and its increased erosion potential. Trigger: Cheatgrass invasion, creating a decrease in the fire return interval (every 5-10 years)

Community 3.1
Sand Sagebrush with Understory

This plant community phase is characterized by a dominance of sand sagebrush where invasive plants are dominating the understory. Native desirable vegetation is usually present in minimal amounts. Needle-and-thread, Indian ricegrass, sand dropseed, blue grama, and James galleta may be present. Commonly seen invasive plant species include cheatgrass, Russian thistle, annual Cryptantha, annual stickseed, and tansy mustard. Other grass, shrubs, and forbs may or may not be present and cover is variable. Biological crusts (0-20% cover) are classified as crustless or by light cyanobacteria in the interspaces, with occasional lichen and moss pinnacles with little to no continuity, depending on severity and age of the alluvial deposit.

Community 3.2
Sand Sagebrush with No Understory

This plant community phase is characterized by a dominance of sand sagebrush with very little understory. Many times the only understory species present in cheatgrass. Other grass, shrubs, and forbs may or may not be present and cover is variable, and plants are typically found under the shrub canopy. Biological crusts (0-20% cover) are classified as crustless or by light cyanobacteria in the interspaces, with occasional lichen and moss pinnacles with little to no continuity, depending on severity and age of the alluvial deposit. Bare ground is more common in this community phase (30-50% cover).

Pathway 3.1a
Community 3.1 to 3.2

This pathway occurs as events favor the increased establishment of sand sagebrush with a marked decrease in the understory vegetation. Events may include improper livestock grazing, drought, or continued surface disturbances such as alluvial deposits.

Pathway 3.2a
Community 3.2 to 3.1

This pathway occurs as time without disturbances favor the reestablishment of the understory.

State 4
Invasive Forb State

This state is characterized by the dominance of invasive forbs/shrubs. These species may include, but are not limited to Russian thistle, cheatgrass, tansy mustard, broom snakeweed, annual stickseed, or annual Cryptantha. One or more invasive species has increased to a point where they influence or drive the disturbance regime and nutrient cycle. Russian thistle and/or cheatgrass are the most likely of these species to establish and dominate. Russian thistle is a prolific reproducer—one plant can produce up to 250,000 seeds, which are dispersed by the wind causing the dead plant to “tumble” across the landscape. While generally considered an unwanted weed, Russian thistle may actually help disturbed sites recover more quickly. If topsoil is present, Russian thistle roots are invaded by mycorrhizal fungi and because this plant does not form associations with the fungi the root and plant are killed. This causes increased mycorrhizal fungi in the soil and an increased chance for other plants to establish through the aid of these fungi associations. Yet, managers must be aware that that without proper management other invasive annuals, such is cheatgrass may become established instead of the desirable native species. If topsoil is missing the mycorrhizal fungi, Russian thistle can persist for relatively long periods of time (Howard, 1992). Cheatgrass has an entirely other effect on the soil/plant/water relationships. Research has shown that plant species differ substantially in the effects on soil water content and temperature, and in their effects on the frequency and intensity of disturbance. After cheatgrass has invaded a site fundamental nutrient cycling processes, root pores, mycorrhizal associations, microbial species, and soil organic material changes (Chapin et al. 1997; Belnap and Phillips, 2001). These alterations may eventually create ecologically impoverished sites that are very difficult to restore to functionally diverse perennial herbaceous and woody communities. The competitiveness of the invasive species and the ability of these species to quickly establish after a disturbance make this state extremely resistance to change and resilient after a disturbance. Invasive Forb State: Community phases influenced by improper grazing and weather cycles. Indicators: A complete understory of invasive forbs and/or broom snakeweed where native perennial shrubs, grasses, and forbs are minimally present. Feedbacks: Improper livestock grazing and weather cycles that maintain the dominance of invasive forbs/shrubs with minimal decrease in occurring native perennial grasses, shrubs, and forbs. Increased occurrence of cheatgrass, decreasing the fire return interval. Flooding and alluvial deposits that facilitates the establishment of sand sagebrush. Trigger: The increased establishment of cheatgrass, caused by a decrease in the fire return interval, which facilitates the continued removal of other grasses, shrubs, and forbs.

Community 4.1
Invaded Grasslands and Shrublands

This plant community is characterized by a shrub overstory with an invasive forb and grass understory. The native and/or introduced perennial grass canopy cover is minimal. Invasive forbs make up a large portion of the understory. Russian thistle is present and the most productive species on the site. Other invasive species include stickseed, annual Cryptantha, tansy mustard, and broom snakeweed. Minimal amounts of cheatgrass are present. Bare ground (10-25% cover) is moderate, and biological crusts (25-30% cover) are characterized by light cyanobacteria and/or isolated lichen and moss pinnacles. Litter deposition (10-15% cover) is typically greater than in the previous states.

State 5
Annual Grass State

This state’s ecological processes are driven by the dominance of cheatgrass, where native and invasive plant species may or may not be present. Cheatgrass dramatically affects the soil/plant/water relationships of a site. Research has shown that plant species differ substantially in the effects on soil water content and temperature, and in their effects on the frequency and intensity of disturbance. After cheatgrass has invaded a site the fundamental nutrient cycling processes, root pores, mycorrhizal associations, microbial species, and soil organic material changes (Chapin et al. 1997; Belnap and Phillips, 2001). These alterations may eventually create ecologically impoverished sites that are very difficult to restore to functionally diverse perennial herbaceous and woody communities. The competitiveness of cheatgrass and its ability to quickly establish after a disturbance make this state extremely resistance to change and resilient after a disturbance. Annual Grass State: Community phases maintained, in a self-sustaining manner, by frequent fire. Indicators: A site where ecological processes are driven by cheatgrass Feedbacks: A self sustaining disturbance regime of frequent fire.

Community 5.1
Cheatgrass Dominated

This plant community is characterized by dominance of cheatgrass, where other native species are present but no longer drive the ecological dynamics of the site. Bare ground is minimal (5-15% cover) due to the increase in litter and cheatgrass' dense establishment. Fire can carry through this community. Biological crusts (1-5% cover) are characterized by light cyanobacteria in the interspaces.

Community 5.2
Cheatgrass Monoculture

This plant community is characterized by a complete monoculture of cheatgrass, where other grasses and shrubs do not occur. Invasive annual forbs may or may not be present, depending on current climatic conditions. This plant community is self-enhancing through frequent fire (every 5-10 years). Bare ground (5-15%) is minimal and biological crusts (1-5%) are characterized by light cyanobacteria in the interspaces.

Pathway 5.1a
Community 5.1 to 5.2

This pathway is characterized by frequently occurring fires (every 5-10 years) that allows for establishment of a cheatgrass monoculture.

Transition T1a
State 1 to 2

Transition from Reference State (State 1) to Current Potential State (State 2). This transition is from the native perennial bunchgrass understory in the reference state to a state that has non-native invasive plants present in the understory. This transition occurs as natural and/or management actions favor a decline in native perennial grasses and an increase in invasive plant species. Possible events include poorly managed domestic livestock, extended droughts, fire, etc. Cheatgrass, however, has been known to establish in intact perennial vegetation communities that have experienced little disturbances either caused naturally or by human activities. Once non-native plants have established, a threshold had been crossed.

Transition T2a
State 2 to 3

Transition from Current Potential State (State 2) to Sand Sagebrush State (State 3). This transition occurs when events favor the establishment and dominance of sand sagebrush. Events typically include a flood with alluvial deposits. This changes the water drainage patterns of a site and results in a dominance of sand sagebrush due to its ability to establish and flourish on sites with shorter disturbance regimes (McWilliams, 2003). This transition results in a new state rather than another plant community like in the reference state, due the presence of invasive species present in the current potential state. This transition causes the site's ecological dynamics to not only be controlled by sand sagebrush, but also the invasive forbs and grasses that will be present in the understory.

Transition T2b
State 2 to 4

Transition from Current Potential State (State 2) to Invaded State (State 4). This transition occurs when events favor the increased establishment and dominance of invasive plant species. Events include any type of surface disturbance, such as fire, improper domestic livestock grazing, OHV overuse, and drought. Once invasive species drive the ecological dynamics a threshold has been crossed.

Transition T2c
State 2 to 5

Transition from Current Potential State (State 2) to Annual Grass State (State 5). This transition is from the current potential state into a state dominated by cheatgrass. This transition occurs as events favor the increased

establishment and dominance of cheatgrass. Typically this occurs as a series of fires which lead to an increase in cheatgrass and a subsequent decrease in the fire return interval. Once cheatgrass drives the ecological dynamics of the site a threshold has been crossed.

Restoration pathway R3a
State 3 to 2

Restoration from Sand Sagebrush State (State 3) to Current Potential State (State2). This restoration pathway occurs as sites stabilize and fourwing saltbush, winterfat, and Cutler mormontea are able to reestablish on the sites. Events triggering this event usually are changes in the sites drainage pathways or time without disturbances. This pathway may take many years to accomplish, and may not be possible with current knowledge.

Transition T3b
State 3 to 4

Transition from Sand Sagebrush State (State 3) to Invasive Forb State (State 4). This transition occurs if community 3.1 does not progress into community 3.2. Removal of the sand sagebrush by drought or drainage pattern changes may facilitate a transition into state 4. Once invasive forbs regain control over the ecological dynamics a threshold has been crossed.

Transition T3a
State 3 to 5

Transition from Sand Sagebrush State (State 3) to Annual Grass State (State 5). This transition occurs as fire removes the shrub canopy. Cheatgrass typically invades the interspaces and once this species dominates a site, the amount and continuity of fine fuels increases until fire can start to eliminate the shrub/forb/perennial grass component. Once cheatgrass drives the ecological dynamics a threshold has been crossed.

Restoration pathway T4b
State 4 to 3

Transition from Invasive Forb State (State 4) to Sand Sagebrush State (State 3). This transition occurs when events favor the establishment and dominance of sand sagebrush. Events typically include a flood with alluvial deposits. This changes the water drainage patterns of a site and results in a dominance of sand sagebrush due to its ability to establish and flourish on sites with shorter disturbance regimes (McWilliams, 2003).

Transition T4a
State 4 to 5

Transition from Invasive Forb State (State 4) to Annual Grass State (State 5). This transition occurs as events favor the replacement of the invasive forbs with cheatgrass. Sites that are dominated by tansy mustard in the invaded state may actually facilitate this transition, due to its ability to provide the litter needed for the germination of cheatgrass. The fire return interval decreases due to increased fine fuel accumulations facilitating the dominance of cheatgrass. Once cheatgrass dominates and drives the ecological dynamics of the site a threshold has been crossed.

Citations