

Ecological site R028AY124UT Desert Loam (Shadscale)

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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.

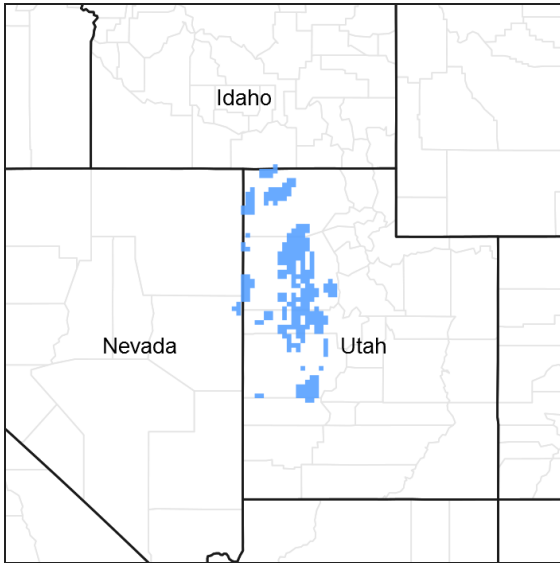


Figure 1. Mapped extent

Areas shown in blue indicate the maximum mapped extent of this ecological site. Other ecological sites likely occur within the highlighted areas. It is also possible for this ecological site to occur outside of highlighted areas if detailed soil survey has not been completed or recently updated.

MLRA notes

Major Land Resource Area (MLRA): 028A--Ancient Lake Bonneville

This site occurs in MLRA 28A, LRU A, the northern part of MLRA 28A. This LRU has a mesic soil temperature regime and a typical aridic soil moisture regime. Typically most precipitation occurs in the winter. Mean annual precipitation is between 4 to 8 inches. The north desert ecological zone typically has no big sagebrush (*Artemisia tridentata* spp.), but typically is dominated by shadscale (*Atriplex confertifolia*), winterfat (*Krascheninnikovia lanata*), saltbushes (*Atriplex* spp), Indian ricegrass (*Achnatherum hymenoides*), and bottlebrush squirreltail (*Elymus elymoides*). Unlike the southern LRUs, there is typically very little if any galleta (*Pleuraphis jamesii*) grass.

Classification relationships

MLRA 28A, LRU A, northern desert ecological zone

Ecological site concept

This site is dominated by shadscale in reference condition. It is typically found on the low slopes of lake terraces, fan remnants, alluvial fans, and lake plains.

Associated sites

R028AY001UT	Alkali Bottom (Alkali Sacaton)
R028AY104UT	Desert Alkali Bench (Bud Sagebrush)
R028AY140UT	Desert Silt Flat (Winterfat)

Similar sites

R028AY119UT	Desert Flat (Shadscale)
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Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) <i>Atriplex confertifolia</i>
Herbaceous	Not specified

Physiographic features

This site occurs on gently sloping lake terraces, fan remnants, alluvial fans and lake plains. It can be found between 4300 to 6000 feet. There is no flooding or ponding that occurs on this site.

Table 2. Representative physiographic features

Landforms	(1) Lake terrace (2) Fan remnant (3) Alluvial fan
Flooding frequency	None
Ponding frequency	None
Elevation	1,311–1,829 m
Slope	0–5%

Climatic features

The climate is cold and snowy in the winter and warm and dry in the summer. The average precipitation is 5 to 8 inches. Approximately 70 percent comes as rain from March through October. On the average, June through September are the driest months and March through May are the wettest months.

Mean Annual Air Temperature: 45-50

Mean Annual Soil Temperature: 50-54

Table 3. Representative climatic features

Frost-free period (average)	76 days
Freeze-free period (average)	117 days
Precipitation total (average)	305 mm

Climate stations used

- (1) GROUSE CREEK [USC00423486], Grouse Creek, UT

Influencing water features

No flooding or ponding occur on this site.

Soil features

Characteristic soils in this site are over 60 inches deep and well drained. They formed in alluvium and lacustrine sediments derived mainly from limestone and basalt parent materials. The surface horizon is fine sandy loam textures and 3 inches thick. About 0-10 percent of the soil surface is covered by rock fragments. The volume of rock fragments in the soil profile is 0 to 15 percent.

These soils are moderately through strongly calcareous. Rock fragments range from 0 to 15 percent throughout the profile and may occur on the surface as "desert pavement." The subsoil and underlying materials are slightly to strongly saline. Reaction is moderately to very strongly alkaline. Available water capacity is 2 to 6 inches.

Natural geologic erosion in potential is approximately 1.0 tons/acre/year.

Table 4. Representative soil features

Parent material	(1) Estuarine deposits–limestone (2) Lacustrine deposits–quartzite
Surface texture	(1) Fine sandy loam (2) Silt loam (3) Very fine sandy loam
Drainage class	Well drained
Permeability class	Slow to moderately rapid
Soil depth	152 cm
Surface fragment cover <=3"	0–11%
Surface fragment cover >3"	0%
Available water capacity (0-101.6cm)	3.81–17.02 cm
Calcium carbonate equivalent (0-101.6cm)	0–40%
Electrical conductivity (0-101.6cm)	0–16 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0–13
Soil reaction (1:1 water) (0-101.6cm)	7.9–9
Subsurface fragment volume <=3" (Depth not specified)	0–13%
Subsurface fragment volume >3" (Depth not specified)	0%

Ecological dynamics

The plant communities and ecological dynamics associated with this site are presented in a State and Transition Model (STM) diagram and are described in more detail in the narratives that follow. These plant communities may not represent every possibility, but are probably the most prevalent and recurring plant communities. As more monitoring data are collected, some phases or states may be revised, removed, and/or new ones added. None of these plant communities should necessarily be thought of as "Desired Plant Communities." The descriptions of plant communities in this document represent the current knowledge and experience at the time of this revision.

STMs are used to illustrate how a reference community (i.e. vegetation prior to Euro-American settlement but long after the arrival of Native Americans) and associated soil-vegetation relationships evolve when subjected to different environmental conditions and drivers of change (e.g. climate, land use, natural disturbances). The STM consists of the historic "Reference State" and potential "alternative states." Each state may have one or more community "phases" to represent how system dynamics fluctuate within the "limits" of the state (Briske et al. 2008). The ecological resilience (i.e. stability) of a state can be maintained when negative feedbacks exist. Conversely, when system dynamics are disturbed enough through positive feedbacks, whether natural or human-caused, new

conditions and processes may develop, resetting the trajectory of the site to an alternative stable state. Transitions between states occur when ecological “thresholds” are crossed. The ability to return to the prior state and reverse the transition would not occur without active restoration practices (i.e. “restoration pathways”). The drivers of change between phases and states are labeled in the diagram as codes (see legend beneath the diagram).

STMs provide a more mechanistic view of the ecological site, which land managers can use to distinguish current conditions from “desired” conditions, and to assess state vulnerability relative to ecological thresholds. Increased awareness of how soil-vegetation patterns and processes vary over space and time promotes greater opportunities to focus adaptive management and restoration efforts.

As ecological condition deteriorates due to overgrazing, Indian ricegrass, squirreltail, bud sagebrush, and winterfat decrease while shadscale and rabbitbrush increase.

When the potential natural plant community is burned, Indian ricegrass, shadscale, and winterfat decrease while rabbitbrush and Sandberg bluegrass increase.

Annual forbs and annual grasses are most likely to invade this site.

State and transition model

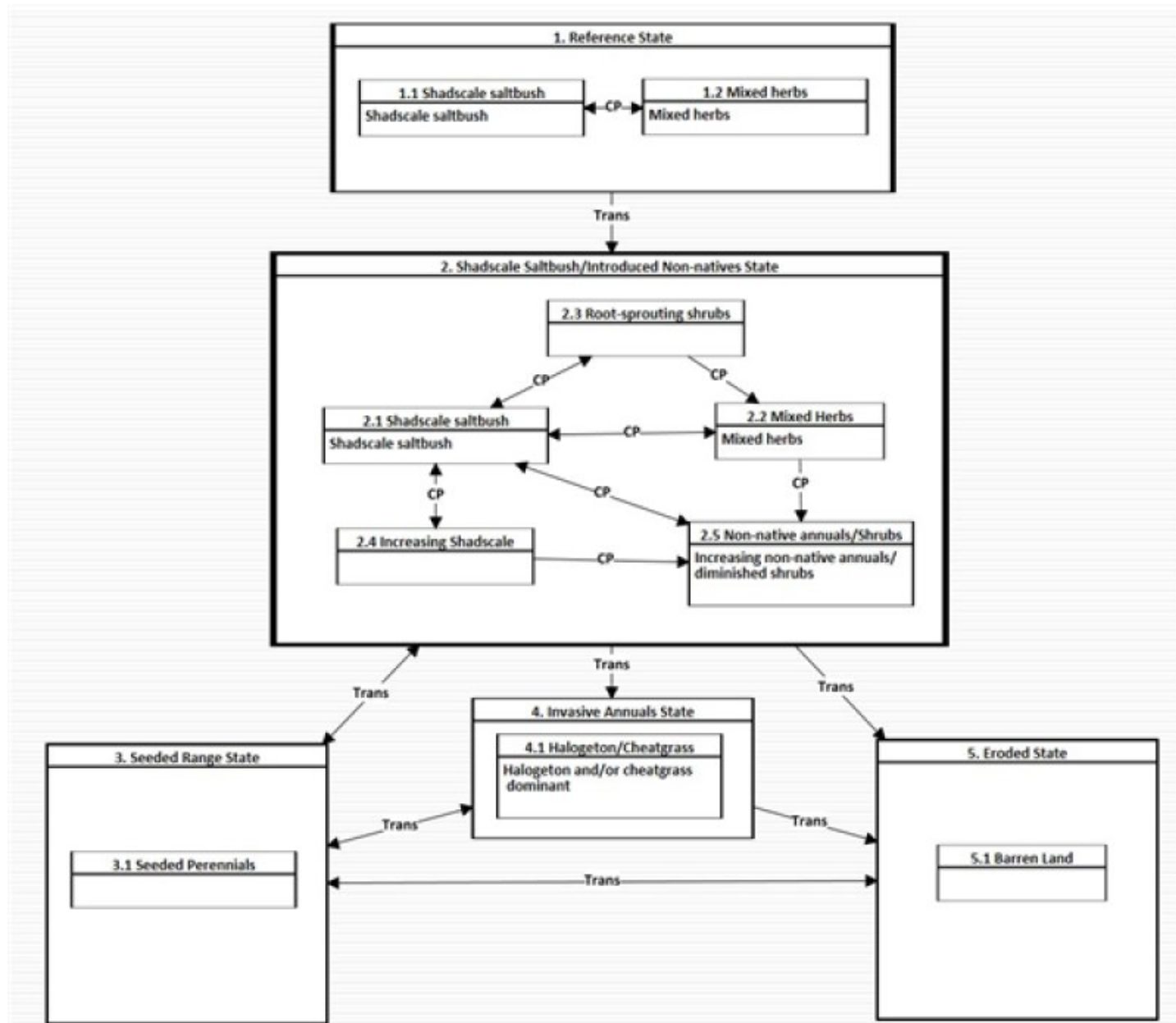


Figure 6. R028AA124UT STM

Diagram Legend

T 1-2	The introduction of exotic flora and fauna, possible extinctions of native flora or fauna, along with climate change, will cause State 1 to transition to State 2.
T 2-3	Seeded range
T 2-4	Heavy continuous season long grazing
T 2-5	Extreme wildfire and wind
T 3-4	Heavy continuous season long grazing or wildfire
T 3-5	Extreme wildfire and wind
T 4-5	Extreme wildfire and wind
R 3-2	If a period of time passes without fire (or other significant disturbance), grazing practices are compatible with productivity, and there is evidence of re-establishment of native shrubs and perennial grasses, it is possible that the Seeded Range State can be restored to the former Shadscale Saltbush/ Introduced Non-native Herbs State.
R 4-3	Seeding and prescribed grazing
R 5-3	Range seeding, prescribed grazing, fencing
CP 1.1-1.2	Drought or wet conditions and/or insects/pathogens reduce shadscale cover
CP 1.2-1.1	Time
CP 2.1-2.2	Drought or wet conditions and/or insects/pathogens reduce shadscale cover
CP 2.1-2.3	Wildfire
CP 2.1-2.4	Uncontrolled grazing in the fall/winter
CP 2.1-2.5	Uncontrolled grazing spring/summer
CP 2.2-2.1	Time

CP 2.2-2.5	Uncontrolled grazing spring/summer
CP 2.3-2.1	Time
CP 2.3-2.2	Unusually wet climate/soil anoxia and/or insects and pathogens
CP 2.4-2.1	Prescribed grazing
CP 2.4-2.5	Wildfire
CP 2.5-2.1	Prescribed grazing

Figure 7. R028AA124UT STM Legend

State 1

Reference State

The Reference State includes the plant communities best adapted to the unique combinations and factors associated with this ecological site prior to Euro-American settlement. Thus, the plant communities of the Reference State are believed to be non-existent or rare. The Desert Loam ecological site is driven primarily by climatic changes ranging from multi-year drought to years when precipitation levels are high. In response, the vegetation vacillates between a community co-dominated by shadscale saltbush (*Atriplex confertifolia*) and Indian ricegrass (*Achnatherum hymenoides*) to one dominated by a mix of perennial grasses and forbs. Historically, fire was not part of this system (West 1983, Brooks and Chambers 2011). The environmental conditions are hot and dry (i.e. 8-10" precipitation zone). Infiltration rates can be slow and potential water loss through evaporation relatively high compared to other coarser-textured soils (i.e. "inverse texture principle," Noy-Meir 1973). However, due to a small representation of fine rock fragments (0-15%) contained within and on the soil surface, and higher production of perennial grasses, the Desert Loam (Shadscale) site is less susceptible to erosion than the associated Desert Flat (Shadscale) site.

Community 1.1

Shadscale Saltbush

The dominant aspect of the plant community is Indian ricegrass and shadscale. The composition by air dry weight is approximately 45 percent perennial grasses, 15 percent forbs, and 40 percent shrubs. Shadscale and Indian ricegrass represent the dominant aspect of this plant community. The composition by air dry weight is approximately 45 percent perennial grasses, 15 percent forbs, and 40 percent shrubs. Winterfat (*Krascheninnikovia lanata*), and bud sagebrush (*Picrothamnus desertorum*) are common, with fourwing saltbush (*A. canescens*), black sagebrush (*Artemisia nova*), and horsebrush (*Tetradymia* spp.) occurring as sub-dominants. Other herbaceous species include squirreltail (*Elymus elymoides*), James' galleta (*Pleuraphis jamesii*), globemallow (*Sphaeralcea* spp.), Torrey's milkvetch (*Astragalus calycosus*) and cushion buckwheat (*Eriogonum ovalifolium*). Microphytic crusts commonly occur in the interspaces between shrubs, providing stabilization and nitrogen fixation to the soil (West 1990).

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	177	240	303
Shrub/Vine	157	213	269
Forb	59	80	101
Total	393	533	673

Table 6. Ground cover

Tree foliar cover	0%
Shrub/vine/liana foliar cover	5-15%
Grass/grasslike foliar cover	10-20%
Forb foliar cover	2-5%
Non-vascular plants	0%
Biological crusts	0%
Litter	0%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	0%

Table 7. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	–	–	–	–
>0.15 <= 0.3	–	10-20%	15-25%	0-10%
>0.3 <= 0.6	–	–	–	–
>0.6 <= 1.4	–	–	–	–
>1.4 <= 4	–	–	–	–
>4 <= 12	–	–	–	–
>12 <= 24	–	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

Figure 9. Plant community growth curve (percent production by month).
UT1161, PNC. Excellent Condition.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	5	25	50	10	0	0	5	5	0	0

Community 1.2

Mixed Herbs

Grasses including Indian ricegrass, squirreltail, and James' galleta (*Pleuraphis jamesii*) and forbs such as globemallow (*Sphaeralcea* spp.), will be the first to decline after extended drought, but are better equipped to take advantage of any transient precipitation, and will dominate the site once a wet period returns. A mixed herb community characterized by Indian ricegrass, squirreltail, western wheatgrass (*Pascopyrum smithii*), and globemallow, will re-occupy the recently opened niches.

Pathway 1.1a

Community 1.1 to 1.2

Although shadscale is able to tolerate some drought through partial shedding of leaves, multiple years of drought will kill shadscale, winterfat, and bud sagebrush, particularly in more decadent stands (West 1979). Any shrubs remaining following an extreme droughty period are typically weakened and thus more susceptible to invasion by insects, such as round-headed root borers, scales, grasshoppers, and other pathogens (Haws et al. 1990). During drought, native forbs and grasses will also decrease, but once a wet period returns to a drought-denuded stand,

herbs are the first plants to re-occupy recently opened niches.

Pathway 1.1b **Community 1.1 to 1.2**

An extremely wet period such as an El Niño-Southern Oscillation event and subsequent anoxic soil conditions will kill shadscale, and any other secondary shrubs. Prolonged periods of high soil moisture are believed to increase the susceptibility of shadscale to parasites and disease, such as water mold, root rot, and vascular wilt fungi (Wallace and Nelson 1990).

Pathway 1.2a **Community 1.2 to 1.1**

Time, without significant disturbance and a return to a favorable climate, will allow shadscale and bud sagebrush to re-establish.

State 2 **Shadscale Saltbush/Introduced Non-native Herbs State**

State 2 is a description of the ecological site following Euro-American settlement, and the subsequent introduction of several non-native plants and animals. Climate change may also cause State 1 to shift into State 2, regardless of the land management practice. The plant community is very similar to State 1 with the exception that several introduced species including cheatgrass (*Bromus tectorum*), Russian thistle (*Salsola* spp.), halogeton (*Halogeton glomeratus*), tall tumbled mustard (*Sisymbrium altissimum*), redstem stork's bill (*Erodium cicutarium*), and curvseed butterwort (*Ceratocephala testiculata*) are likely to be present. Once established, there is no practical method to effectively remove these plants from the site. Additionally, microphytic crusts are likely to be diminished or absent depending on disturbance history. Although shadscale-dominated sites are typically characterized by lower precipitation, in some years the amount and timing of precipitation fluctuates. When precipitation is higher than normal, these sparsely vegetated sites are less effective at utilizing the increased resource (i.e. available water), and therefore are considered more susceptible to invasive species (i.e. fluctuating resource hypothesis) (Davis et al. 2000, Brooks and Chambers 2011). In some areas, invasive grasses have increased enough to fill interspaces between shrubs allowing the site to carry fire, an extremely unusual event in historic salt desert shrublands (West 1994, Brooks and Chambers 2011). Shadscale is used for forage by all classes of livestock, as well as mule deer and pronghorn antelope. Historically, lower desert communities including the Desert Flats were used for grazing of sheep during winter months. Prior to the Taylor Grazing Act of 1934, many of these areas were overgrazed and depending on the intensity, type of livestock, and season of use, the community was set onto various trajectories (Kitchen and Hall 1996).

Community 2.1 **Shadscale Saltbush**

Shadscale saltbush is the dominant component of this community. Bud sagebrush, Indian ricegrass, and squirreltail may be sparsely represented in the understory. Non-native species are present but do not dominate. Microphytic crusts are scarce.

Community 2.2 **Mixed herbs**

In this community Indian ricegrass is likely to be dominant. Squirreltail and a mix of annual forbs may also be present.

Community 2.3 **Root-sprouting shrubs**

Root-sprouting shrubs such as rubber rabbitbrush, yellow rabbitbrush, and green molly, will characterize this community. Indian ricegrass along with invasive annuals are likely to be present in the understory. Microphytic crusts may persist following low intensity fires provided there is enough precipitation and the burned area is

protected from subsequent disturbance (Johansen et al 1984).

Community 2.4

Increasing Shadscale

Following a period of intensive fall grazing, shadscale will dominate the plant community with only a minor component of mixed herbs present in the understory.

Community 2.5

Increasing non-native annuals/Diminished shrubs

Some shrubs may be present, but invasive annuals (e.g. cheatgrass, Russian thistle, halogeton) are increasing and could potentially dominate the site without management attention. Other annuals such as tall tumbled mustard, redstem stork's bill, and curvseed butterwort are also common. Native grasses and forbs are minimal or absent. Sites may have compacted soils and/or experienced soil loss. These degraded conditions put the community at greater risk for crossing an ecological threshold.

Pathway 2.1a

Community 2.1 to 2.2

With prolonged drought, shadscale's resistance to insects (e.g. round-headed root borers, scales, grasshoppers) and other pathogens will decrease, causing the shrub component to decline (Haws et al. 1990). Although the herbaceous component will be the first to go with drought, grasses and forbs are also the first to re-occupy the site when the rains return.

Pathway 2.1b

Community 2.1 to 2.2

An extremely wet period such as an El Niño-Southern Oscillation event and subsequent anoxic soil conditions can kill shadscale and other shrubs due to exposure to soil-borne parasites and diseases such as water mold, root rot, and vascular wilt fungi (Wallace and Nelson 1990).

Pathway 2.1c

Community 2.1 to 2.3

An increase of cheatgrass and other annual forbs can produce enough fine fuels to carry wildfires across these landscapes (West 1994, Brooks and Chambers 2011). Fire will temporarily remove shadscale and bud sagebrush. Other root-sprouting shrubs such as rubber rabbitbrush (*Ericameria nauseosa*), yellow rabbitbrush (*Chrysothamnus viscidiflorus*), and green molly (*Bassia americana*) will increase with invasive annual species dominating the understory.

Pathway 2.1d

Community 2.1 to 2.4

Uncontrolled fall grazing while shadscale is dormant will favor shadscale, particularly if the grazing is done by sheep. Shadscale will increase to nearly pure stands. Some annual herbs may be present in the understory, but bud sagebrush will decrease (Harper et al. 1990, Kitchen and Hall 1996). In heavily trampled areas, microphytic crusts are reduced or absent. Topsoil is easily lost and infiltration is reduced.

Pathway 2.1e

Community 2.1 to 2.5

Uncontrolled spring or summer grazing is injurious to shadscale. Shadscale and bud sagebrush will diminish, while non-native annuals such as cheatgrass, halogeton, and Russian thistle will increase and potentially dominate the site (Harper et al. 1990, Kitchen and Hall 1996). Microphytic crusts are reduced or absent. Topsoil may be lost and infiltration reduced from the compaction of soils.

Pathway 2.2a

Community 2.2 to 2.1

Time, without significant disturbance and a return to a favorable climate, will allow shadscale and bud sagebrush to re-establish.

Pathway 2.2b

Community 2.2 to 2.5

Uncontrolled spring grazing will reduce perennial bunchgrasses allowing non-native annuals (e.g. cheatgrass, halogeton, and Russian thistle) to increase and potentially dominate the site (Harper et al. 1990, Kitchen and Hall 1996). Additionally, topsoil can be lost and infiltration reduced from the compaction of soils.

Pathway 2.3a

Community 2.3 to 2.1

Time, without significant disturbance and a return to a favorable climate, will allow shadscale and bud sagebrush to re-establish.

Pathway 2.3b

Community 2.3 to 2.2

An extremely wet period such as an El Nino-Southern Oscillation event and subsequent anoxic soil conditions will kill most shrubs due to exposure to soil-borne parasites and diseases such as water mold, root rot, and vascular wilt fungi (Wallace and Nelson 1990).

Pathway 2.4a

Community 2.4 to 2.1

If grazing practices are adjusted by matching stocking rates to current site productivity, shifting the season of use to later season (spring) grazing to reduce shadscale, and if the site has not experienced accelerated soil erosion, warm-season bunchgrasses such as Indian ricegrass and James' galleta (*Pleuraphis jamesii*) will increase.

Pathway 2.4b

Community 2.4 to 2.5

Provided the buildup of fine annual fuel is sufficient, disturbance by wildfire will kill shadscale. Post-fire, cheatgrass and other early spring annuals will increase outcompeting the perennial warm season grasses and push the community toward a more degraded phase (Community Phase 2.5), the most "at risk" for crossing an ecological threshold. Subsequent fires may become more frequent and intense, removing any remaining shrubs. It is possible however, if invasive annuals are kept under control and enough root-sprouting shrubs are present, the community may move toward a root-sprouting shrub phase (Community Phase 2.3) post-fire.

Pathway 2.5a

Community 2.5 to 2.1

If grazing practices are adjusted by matching stocking rate to current site productivity, shifting the season of use to early and/or mid-winter grazing when shadscale is dormant, and if the site has not experienced accelerated soil erosion, both shadscale and the warm-season bunchgrasses (e.g. Indian ricegrass and James' galleta) will increase. Protecting the site from unnecessary disturbance may limit further encroachment by annuals.

State 3

Seeded Range State

The Seeded Range State exists where managers decided to re-seed in order to address management concerns such as the need to increase forage production, control soil erosion, and/or suppress wildfire. Re-vegetation efforts often utilize non-native perennial herbs that mimic the structure and function of but are more competitive than native

species (Brooks and Chambers 2011, Davies et al. 2010, DiTomaso and Smith 2012, Hirsch and Monaco 2011, Newhall et al. 2004). Therefore, these areas are often dominated with non-native perennial grasses (e.g. crested wheatgrass). Forage kochia is an introduced semi-shrub that is commonly used in revegetation and fire suppression (Monaco et al. 2003). In some cases, monocultures of the seeded species were created. However, more recent seedings have included a broader suite of species (and cultivars) to increase germination rate and assist succession and recovery of the native shadscale community (State 2). Depending on grazing levels, drought, and seed source availability, shadscale and a mix of other native species will re-establish over time. State 3 can be maintained when livestock grazing is compatible with current site productivity, but continued heavy livestock grazing will negatively impact resiliency. Non-native annuals such as cheatgrass and tall tumblemustard are common invaders in these areas.

Community 3.1

Seeded perennials

Depending on the objectives of the seeding effort, this community may be characterized by a single species (e.g. crested wheatgrass, forage kochia), or by a mix of seeded perennial species (native and/or non-native) including a variety of cool and/or warm season grasses (e.g. wheatgrasses, wildryes, Indian ricegrass, squirreltail, and sand dropseed (*Sporobolus cryptandrus*)). Provided the disturbances are minimal, livestock stocking rates match current site productivity, and seed sources exist, shadscale, rubber rabbitbrush, and other native species may begin to re-establish. Non-native annuals are likely to be present. If the climate is conducive, seeded ranges can be maintained when grazing practices are compatible with current site productivity.

State 4

Invasive Annuals State

The Invasive Annuals State is a degraded condition as a result of long-term heavy grazing and invasion by annuals. Halogeton and/or cheatgrass are typically dominant.

Community 4.1

Halogeton and/or cheatgrass dominant

Halogeton and/or cheatgrass are the primary species in this community. Russian thistle may also be present after fire, if topsoil has remained intact, but will likely diminish within 3 to 4 years post-fire without further disturbance (Young 1991). Conversely, if topsoil has been lost, Russian thistle can persist for nearly a decade (Allen 1989). Once established, exotic species can permanently alter soil properties and processes, even after the invasive species is removed or controlled (Allen et al. 2011, Kulmatiski et al. 2008). Soils invaded by cheatgrass typically have faster decomposition rates, with varying responses in total phosphorus (P) and nitrogen (N) availability and (N) cycling (Ehrenfeld 2003). Belnap et al. (2005) also noted shifts in and lower biomass of key taxa within the microbial community in cheatgrass dominated areas that can directly affect nutrient cycling and ultimately modify soil structure and plant growth. Halogeton, the succulent halophytic summer annual, will translocate and accumulate salts in plant tissues, which then leach back into near-surface soils from leaf litter and dead roots. Secondary effects from the increased soil salinity may limit infiltration rates and capillary rise of water, inhibit nitrifying microorganisms, and ultimately cause the soil crust to harden and depress plant growth (Eckert and Kinsinger 1960, Kitchen and Jorgensen 2001, Allen et al. 2011). Under such impoverished soil conditions, natural regeneration of native shrubs is unlikely and may impede the outcome of revegetation efforts (Harper et al. 1996, Grant and Paschke 2012). Due to the abundance of fine fuels cycling through this system annually, the site will become more prone to wildfire. Fire return intervals can shorten and perpetuate an invasive annuals state.

State 5

Eroded State

The Eroded State is a highly degraded condition as a result of extreme wildfire and very powerful, persistent winds removing most if not all vegetation. In some areas, multiple inches of soil may be lost, while deposition and dunning may occur in other areas.

Community 5.1

Barren lands

Extreme fire will remove most if not all vegetation. Microphytic crusts are very rare, but if present before the fire, may be found beneath surviving shrubs. High winds could cause further erosion or burial in some areas. Until some vegetation is in place to hold or catch less stable soil particles, persistently high winds can create positive feedbacks of continued soil erosion through the process of saltation. If coarser, less stable sediments from upwind are blown over finer-grained (e.g. lacustrine) deposits, the abrasion to the surface can trigger soil particles downwind to detach and add to the total horizontal sediment flux (Gillette et al. 1996, Miller et al. 2012).

Transition T1A

State 1 to 2

The introduction of exotic flora and fauna, possible extinctions of native flora or fauna, along with climate change, will cause State 1 to transition to State 2. Reversal of this change back to State 1 is impracticable. These soils are easily disturbed by trampling. Compacted areas are more susceptible to wind or water erosion. Perennial vegetation decreases while bare ground increases leading to further runoff and soil loss.

Transition T2a

State 2 to 3

Over the years, land managers have seeded rangelands for a variety of reasons. Historical tilling and removal of shadscale through chemical or mechanical means, followed by seeding of non-native perennial grasses such as crested wheatgrass (*Agropyron cristatum*) was done to increase forage production. In areas where annuals have invaded and fire is of concern, drilling and re-seeding with forage kochia (*Bassia prostrata*) to create fuel-breaks (i.e. "greenstripping") has also been employed (Monaco et al. 2003).

Transition T2b

State 2 to 4

Heavy continuous season- (or year-) long grazing will worsen the fragile conditions of Community Phase 2.5 (Increasing non-native annuals/ Diminished shrubs) and create positive feedbacks to further degradation. Other Community Phases of State 2 (i.e. 2.1, 2.2, 2.3, and 2.4) could possibly sustain longer periods with heavy grazing, but this would eventually lead to Community Phase 2.5, and ultimately pass an ecological threshold into State 4. Annual species, particularly halogeton and cheatgrass, benefit from continued disturbance. Soils will become more compacted and susceptible to erosion.

Transition T2c

State 2 to 5

The unusual event of extreme wildfire and intense winds will move State 2 to a completely unvegetated and eroded state. If there is no plant cover and high winds continue, resident soils will be displaced and upwind soils may move in creating dune environments. Seed establishment is not possible under these conditions creating a positive feedback that is difficult to reverse.

Restoration pathway R3a

State 3 to 2

If a period of time passes without fire (or other significant disturbance), grazing practices are compatible with productivity, and there is evidence of re-establishment of native shrubs and perennial grasses, it is possible that the Seeded Range State can be restored to the former Shadscale Saltbush/ Introduced Non-native Herbs State.

Transition T3a

State 3 to 4

If the Seeded Range State receives heavy continuous season- (or year-) long grazing, this will reduce the seeded and/or re-establishing perennial species (herbs and shrubs) and continue to disturb the soils, potentially creating a positive feedback where annual species, such as halogeton and cheatgrass, are the few species able to persist. Soils will be more compacted and susceptible to erosion.

Transition T3b

State 3 to 4

Depending on the intensity, frequency, and availability of exotic annuals, wildfire may reduce the seeded and/or re-establishing perennial species (herbs and shrubs), and push the community into one dominated by invasive annuals.

Transition T3c

State 3 to 5

The unusual event of extreme wildfire and intense winds will move the Seeded Range State to a completely unvegetated and eroded state. If vegetation cover is low and winds are high, resident soils may continue to erode and upwind soils may move to create dune environments. Seed establishment is not possible under these conditions thus creating a positive feedback that is difficult to reverse.

Restoration pathway R4a

State 4 to 3

Depending on the degree plant-soil feedbacks have changed (see: Community Phase 4.1), the potential to transition the Invasive Annuals State to a seeded range state may be practicable if the species selected for seeding are known to tolerate the “invader-cultured soil” (Grant and Paschke 2012, Newhall et al. 2004), provided a favorable climate and appropriate grazing practices are imposed. “Greenstripping” with forage kochia to facilitate the establishment of persistent vegetation and fire-breaks has been successfully employed as well (Monaco et al. 2003). Regardless of the land treatment, the landscape setting including the juxtaposition of particular landforms and soil properties should be considered carefully. Depending on the spatial extent and connectivity of the disturbance, land treatments can have variable impacts on aeolian sediment fluxes (i.e. wind erosion), particularly in areas with persistent high winds and fragile soils (Miller et al. 2012). For example, upwind soil and vegetation conditions are important factors when predicting and mitigating potential downwind erosion dynamics (Miller et al. 2012).

Transition T4a

State 4 to 5

The unusual event of extreme wildfire and intense winds will move the Invasive Annuals State to a completely unvegetated and eroded state. If there is no vegetation cover and winds are high, resident soils will continue to erode, or in some cases other soils can be blown in creating dune environments. Seed establishment is not possible under these conditions thus creating a positive feedback that is difficult to reverse.

Restoration pathway R5a

State 5 to 3

It may be possible to transition the Eroded State to a seeded range state, provided the seeded species are capable of surviving in these extremely harsh conditions (Newhall et al. 2004), the area receives enough precipitation, and careful consideration is made to the landscape setting (i.e. juxtaposition of certain landforms and soil properties) (Miller et al. 2012). The spatial extent and connectivity of land treatments, particularly in areas with high winds and fragile soils, can directly influence aeolian sediment flux through saltation. Upwind soil and vegetation conditions are important factors when predicting and mitigating potential downwind erosion dynamics (Miller et al. 2012). Arranging drill rows perpendicularly to prevailing winds, installing fences to catch sediments, and limiting grazing disturbances would be important mitigation measures to reduce erosion. Herbicides should be used with caution, as the cover of exotic annual plants can provide protection for perennial seedlings as they re-establish.

Additional community tables

Table 8. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Shrub/Vine					
0	Primary Shrubs			140–224	
	shadscale saltbush	ATCO	<i>Atriplex confertifolia</i>	84–112	–
	winterfat	KRLA2	<i>Krascheninnikovia lanata</i>	28–56	–
	bud sagebrush	PIDE4	<i>Picrothamnus desertorum</i>	28–56	–
3	Secondary Shrubs			17–28	
	black sagebrush	ARNO4	<i>Artemisia nova</i>	6–17	–
	fourwing saltbush	ATCA2	<i>Atriplex canescens</i>	6–17	–
	green molly	BAAM4	<i>Bassia americana</i>	6–17	–
	yellow rabbitbrush	CHVI8	<i>Chrysothamnus viscidiflorus</i>	6–17	–
	Nevada jointfir	EPNE	<i>Ephedra nevadensis</i>	6–17	–
	Nuttall's horsebrush	TENU2	<i>Tetradymia nuttallii</i>	6–17	–
Grass/Grasslike					
0	Primary Grasses			185–252	
	Indian ricegrass	ACHY	<i>Achnatherum hymenoides</i>	112–140	–
	squirreltail	ELEL5	<i>Elymus elymoides</i>	56–84	–
	James' galleta	PLJA	<i>Pleuraphis jamesii</i>	17–28	–
1	Secondary Grasses			17–28	
	blue grama	BOGR2	<i>Bouteloua gracilis</i>	6–17	–
	needle and thread	HECO26	<i>Hesperostipa comata</i>	6–17	–
	western wheatgrass	PASM	<i>Pascopyrum smithii</i>	6–17	–
	Sandberg bluegrass	POSE	<i>Poa secunda</i>	6–17	–
	sand dropseed	SPCR	<i>Sporobolus cryptandrus</i>	6–17	–
Forb					
2	Forbs			56–84	
	Torrey's milkvetch	ASCA9	<i>Astragalus calycosus</i>	17–28	–
	cushion buckwheat	EROV	<i>Eriogonum ovalifolium</i>	17–28	–
	shaggy fleabane	ERPU2	<i>Erigeron pumilus</i>	17–28	–
	scarlet globemallow	SPCO	<i>Sphaeralcea coccinea</i>	17–28	–

Animal community

This site is suited for sheep and cattle grazing during winter and spring.

Wildlife using this site include rabbit, coyote, fox, pronghorn antelope, and mule deer (seasonal).

This is a short list of the more common species found. Many other species are present as well and migratory birds are present at times.

Hydrological functions

The soils are in hydrologic groups B and C with runoff curves ranging from 61 and 74 to 86 respectively depending of hydrologic condition.

Recreational uses

Resources that have special aesthetic and landscaping value are wildflowers. Some recreational uses of this site

are hiking and hunting.

Wood products

None

Other information

Threatened and endangered species include plants and animals.

Type locality

Location 1: Box Elder County, UT	
General legal description	Type Location: 25 Miles South of Park Valley, Box Elder County, Utah Benchlands Immediately South of Bovine Point and Bordering Red Dome

Contributors

David J. Somorville

DJS

Lisa Langs Stoner

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)	Shane A. Green (NRCS), V. Keith Wadman (NRCS Ret.)
Contact for lead author	shane.green@ut.usda.gov
Date	05/24/2005
Approved by	Shane A. Green
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

- 1. Number and extent of rills:** Minor rill development will be evident in reference communities on this site. Development will be more pronounced following significant storm or snow melt events. The presence of rills may also be more apparent where run-on from adjacent upland sites or exposed bedrock concentrate flows. Small rill development will be moderately short (< 6') and somewhat widely spaced (10' – 15'). Evidence of rills will decrease in the months following major weather events as they heal.

-
- 2. Presence of water flow patterns:** Evidence of stable overland water flow is apparent in the reference community; increased flow activity may be observed immediately following significant weather events. Flow patterns are normally <20 feet long, follow natural contours, and are typically spaced 10 to 15 feet apart.
-

3. **Number and height of erosional pedestals or terracettes:** Very slight evidence of pedestals or terracettes caused by accelerated water erosion may be evident in the reference community. 1–2 inches of depositional mounding under Shadscale canopies is normal and may not be water erosion caused.
-
4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare ground ranges from 40% - 50% in the reference community. Ground cover (the inverse of bare ground) typically includes: coarse fragments – 0 - 10%; plant canopy – 20% to 30%; litter – 10% to 20%, and cryptogamic crusts – 2% to 5%.
-
5. **Number of gullies and erosion associated with gullies:** Very few. Some gully channels are a normal component of desert environments. Gullies associated with reference areas will typically have stable, partially vegetated sides and bottoms with no evidence of head-cutting. Some evidence of disturbance may be evident following significant weather events or when gullies convey runoff from higher elevation rocky or naturally eroding areas.
-
6. **Extent of wind scoured, blowouts and/or depositional areas:** Some minor evidence of wind generated soil movement is present in reference communities. Wind caused blowouts are not present. Slight depositional mounding in perennial grass bunches and under Shadscale canopies is a normal characteristic of this site.
-
7. **Amount of litter movement (describe size and distance expected to travel):** Most litter resides in place within or under plant canopies. Some movement of the finest material (< 1/8" or less) may move (1' – 2') in the direction of prevailing winds or down slope if being transported by water. Little accumulation is observed behind obstructions.
-
8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** This site should have a soil stability rating of 4 to 5. Surface textures are typically loams or sandy loams containing < 10% rock fragments.
-
9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Soil surface is 1 - 4 inches deep and structure varies from thin or medium platy to fine granular. The A-horizon color varies from 10YR 7/3 to 10YR 6/2. Soils have an Ochric epipedon that extends 3 – 14 inches into the soil profile. The A horizon is normally deeper and better developed under plant canopies. Where surface soil is lost, increased clay and silt percentages are common in the remaining soil material.
-
10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** The presence of healthy perennial bunchgrasses and Shadscale in the reference community provides for the best infiltration and least runoff from storm events and snow melt. As perennial vegetation decreases and bare ground increases, runoff increases and soil loss is accelerated.
-
11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** None. Soils are deep to very deep. Some soils have an argillic horizon (clay accumulation) in subsoil layers could be mistaken for compaction.
-

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: Dominant: Non-sprouting shrubs (e.g. Shadscale and Bud sage) 20 – 30%, > tall cool season grasses (e.g. Bottlebrush squirreltail and Indian ricegrass) 20 – 40%.

Sub-dominant: Sub-dominant: Sprouting shrubs (e.g. Winterfat and Nevada jointfir) 10- 15% > Rhizomatous grasses (e.g. Galleta and Western wheatgrass) 3 - 5%.

Other: Others: Shrubs (e.g. Low rabbitbrush and Greenmolly) 1-3%, perennial forbs (e.g. Scarlet globemallow and Cushion wild buckwheat) 3-5%, biological crusts (e.g. lichens, mosses, cyanobacteria) trace%.

Additional: Moss and lichen communities will normally be found under plant canopies while the cyanobacteria will be found throughout the site. Functional/structural groups may appropriately contain non-native species if their ecological function is the same as the native species in the reference state. Perennial and annual forbs can be expected to vary widely in their expression in the plant community based upon departures from average growing conditions.

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** During years with average to above-average precipitation, there should be very little recent mortality or decadence apparent in either the shrubs or grasses. During severe (multi-year) drought or insect infestations up to 80% of the shadscale may die. There may be partial mortality of individual bunchgrasses and other shrubs during severe drought.

14. **Average percent litter cover (%) and depth (in):** Litter cover ranges from 10 to 20% with a spike when Bud Sage and Shadscale drops its leaves. Depth varies from ½ - ¾ inch with depth increasing near plant canopies.

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 450 – 500 pounds on an average year.

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:** Broom snakeweed, Russian thistle, Redstem storksbill, annual bromes and Halogeton are likely to increase in or invade this site.

17. **Perennial plant reproductive capability:** All perennial plant species have the ability to reproduce in most years except drought years.
