SITE INVENTORY

PREPARED FOR

THE SAND CREEK MASSACRE SITE

prepared by

Dr. Roy Roath - project leader

Rachel Ridenour - research technician

Bob Wesley - research technician

Zachary Holmes - research technician

Forest, Rangeland, and Watershed Stewardship Department
Colorado State University

Introduction

The current objective is to identify what the **Range of Natural Variability** is for the potential rangeland communities on the area so that the National Park Service (NPS) can begin the planning process for management of the Sand Creek Massacre National Monument. An earlier project, by this project leader, focused on the inventory of the vegetation on Sand Creek Massacre National Monument. This inventory included an assessment of the seral status of the rangeland vegetation. At that point in time, the vast majority of the land managed by the NPS was in lower seral status as a reflection of past activities on the land foot print. It is a critical conceptual juncture to realize that some the past actions on the land have changed the land and its communities for very long periods of time. Perhaps these changes will be evident for by either altered ecological process and/or the plant communities for up to five hundred years. Examples of this are those areas that have experienced large scale soil disturbances or movement in farming activities or construction of ditches, landing strips, et cetera.

It then falls to the project leader to make: 1) "educated" guesses as to what the land and its communities might have been at the time of the Sand Creek Massacre event; 2) what that means relative to what communities are present now; and 3) what type of management actions might produce an array of communities over the long term that might be similar to what would have been in a naturally functioning prairie landscape.

Chapter 1. Conceptual Basis for Range of Natural Variability

The **"Natural Range of Variability"** has its roots in ecological literature (Swetnam et al. 1999) and (Holling, 1973). It has been an evolving area of ecological understanding based on the dynamics of ecological systems. No system is inherently stable over time. It will be "driven" by disturbances that alter the underlying ecological processes that determine both the structure and function of the communities that we see. Clearly, rangeland communities are going to be dynamic, over time. However, the question is what seral state would "we" prefer the community to be in, with what diversity, at what geographic and temporal scale. The choices are inherently driven by the biology and physics of the interacting ecological processes. We, however, heap value sets on top of those relationships insisting on an image of what the system should look like or produce some desired output.

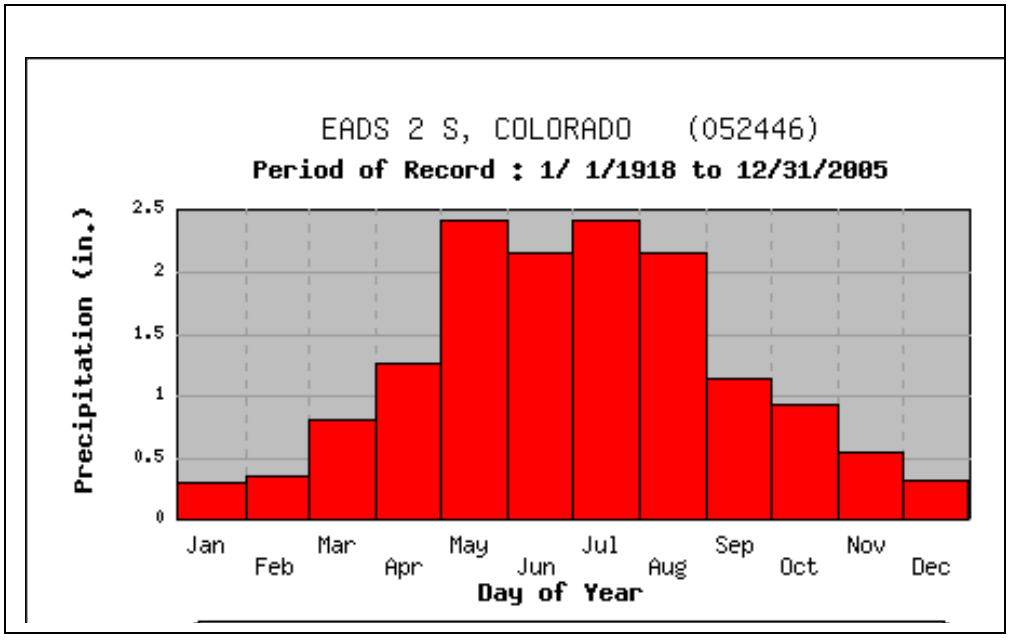
Base understanding of these rangeland systems is greatly assisted with a view of what ecological processes are the primary drivers and how do they interact with management and disturbance regimes that produce the dynamics observed and thus the "Natural Range of Variability". The underlying theme is that community will naturally have an array of possible communities within a particular soil-weather interface. What that community will be is the some product of the frequency and intensity of the disturbance and the time since that disturbance last occurred (recovery). The inherent understanding is that early seral community (r selected communities)

will have less resilience (resistance to change), greater response to pressures and less dependability of output than seral positions later in the successional scale. Mid-seral communities often have the greatest diversity of perennial species, great output and intermediate resilience. Later seral communities have great resistance to change (high resilience), lower overall diversity and lower output than lower seral positions. Brian Walker and David Salt in "*Resilience Thinking"* (2004) liken late seral communities to K selection, in the classical ecological understanding. They state that these K selected communities ultimately must be disturbed, release resources, and be reorganized in order for ecological systems to persist. That being stated, those systems that persist in one state (community assemblage) are referred to as stable states. They resist change without additional energy or disturbance to jostle them of that state. Alternatively, those systems that are pressured excessively may achieve a state that lies beyond the boundaries of the natural array of communities responses and structures making it very difficult to return it to the natural array of communities that may be expected. This is said to be beyond the "natural range of variability". These communities will have ecological processes that are profoundly different for m the original array of communities and will create a new array of communities whose successional trajectory may be very different than the prior communities. An example of this may a community that through some excessive disturbance of soils has lost the majority of its tops soil. This community will "never" function within the array of communities defined by the "Natural Range of Variability" of the original communities.

It is the focus of this paper to: 1) Define the likely historic range communities; 2) Link them with what we know about the current communities and their successional potentials; 3) Define the appropriate geographic and temporal scale for the array of plant communities on the Sand Creek site; and 4) Provide a model for understanding the influence of management and disturbance on the community dynamics through time.

Weather:

The climate and soils are the factors that determine the types of vegetation communities that can be present. The insert below is the characteristic climate in the Eads area that is the driving factor in both the formation of rangeland communities and the dynamics of those communities, temporally.



EADS 2 S, COLORADO

Period of Record General Climate Summary - Precipitation

Station:(052446) EADS 2 S														
From Year=1918 To Year=2006														
	Precipitation											Total Snowfall		
	Mean	High	Year	Low	Year	1 Day Max.		>= 0.01 in.	>= 0.10 in.	>= 0.50 in.	>= 1.00 in.	Mean	High	Year
	in.	in.	-	in.	-	in.	dd/yyyy or yyyymmdd	# Days	# Days	# Days	# Days	in.	in.	-
January	0.30	1.34	1947	0.00	1920	1.03	23/1921	2	1	0	0	3.6	15.5	1984
February	0.35	2.71	1960	0.00	1920	0.96	27/1939	2	1	0	0	3.2	42.0	1960
March	0.81	3.62	1924	0.00	1920	1.75	16/1946	4	2	0	0	4.0	35.7	1924
April	1.28	5.36	1999	0.00	1935	2.19	30/1999	4	3	1	0	1.5	17.5	1959
May	2.42	6.56	1928	0.00	1942	3.18	26/1996	7	5	2	1	0.0	0.2	1978
June	2.16	6.41	1951	0.00	1952	2.55	13/1996	6	4	1	0	0.0	0.0	1918
July	2.43	5.85	1958	0.02	1952	2.75	19/1985	6	5	2	1	0.0	0.0	1918
August	2.17	7.58	1997	0.00	1918	6.15	14/1968	5	4	1	1	0.0	0.0	1918
September	1.14	5.71	1969	0.00	1931	4.50	09/1969	3	2	1	0	0.1	4.0	1936
October	0.94	4.91	1923	0.00	1931	2.07	16/1942	3	2	1	0	0.4	10.0	1959
November	0.55	4.46	1946	0.00	1920	3.00	05/1946	2	1	0	0	3.2	50.0	1946
December	0.32	2.20	1924	0.00	1928	1.00	02/1921	2	1	0	0	2.6	13.5	1924
Annual	14.87	23.29	1941	6.09	1956	6.15	19680814	47	31	9	3	18.6	72.5	1960
Winter	0.97	3.58	1960	0.00	1957	1.03	19210123	6	3	0	0	9.3	52.0	1960
Spring	4.51	10.38	1980	0.71	1934	3.18	19960526	14	10	3	1	5.6	35.7	1924
Summer	6.75	13.81	1923	1.94	1918	6.15	19680814	18	13	4	2	0.0	0.0	1918
Fall	2.64	8.99	1969	0.43	1956	4.50	19690909	9	6	2	0	3.7	50.0	1946

Both the averages and the extremes of precipitation and temperature are critical relationships relative to vegetation responses. The long term weather demines what the community can be and the short term determines what the community is. The drought from 2000 to present is creating and impact of causing some plants to diminish in the community and others to increase. Sand bluestem and important forbs are underrepresented in the current communities and this is likely related to the drought as well as prior poor grazing practices. The current weather relationships are also slowing plant recovery and impeding succession. All indication are that the drought prior to the Sand Creek Massacre had profound influences not only on the vegetation but also the Native Americans themselves and perhaps created the exacerbated conditions that may have caused the event.

Chapter 2. What Did the Range Look Like in the Past?

The following discussion is presented to "paint" a picture of what the rangeland communities might have been at the time of the massacre. This will include a discussion of interacting factors, especially those that would be considered key disturbances. Subsequently the paper will present the most likely rangeland communities present at that time

The following ecological sites were present in the inventory: (See Appendix A for Ecological Site Descriptions)

- Salt Meadow
- Overflow
- Sands
- Sandy
- Loamy
- Sandy Salt Flat
- Wetland

There is every reason to suggest that these ecological sites were present in one seral state or another at the time of the Massacre. The important question at hand is: ***What was the frequency of use by Native Americans of immediate area occupied by the current footprint?*** This is a critical question because it would have determined the kind of plant communities in each of the ecological sites that might have been present at that time. Historical documentation is largely silent on the frequency of use because the recount of memories of interviewed Native Americans only mentions Sand Creek in the broad sense without the explicit indication what area "Sand Creek" means. It seems likely that the general area was used relatively frequently (every 1-5

years) but that frequency was regulated primarily by water availability, wood for fires, and forage for horses but perhaps secondarily by shelter from the prairie winds. The site contains a spring and a wetland area that probably were reliable, continuous supplies of water (Kevin Noon personal comm.). It makes sense that this area having both with wood and water would be used more frequently than other areas.

Lowland Communities

Human Interaction Influences: The ecological sites near the stream bed, namely the **wetland, overflow, salt meadow** and the **sandy salt flat** would have been impacted more by use because of their proximity to cover and protection from the wind and the relative proximity to water. The herbaceous vegetation in these areas is quite resilient when used seasonally in the winter but less so at other times of the year. This is much less true of the woody species. The understory woody plants like wild rose (*Rosa* spp.), snowberry (*Symphoricarpos* spp.), coyote willow (*Salix interior*) and others, including any seedling reproduction of the larger trees and shrubs, would have disappeared quite quickly when impacted either by horse grazing or by physical impact of human use in an encampment area. The larger trees like plains cottonwood (*Populus deltoids*), boxelder (*Acer negundo*) or crack (*Salix fragilis*) and peachleaf willow (*Salix amygdaloides*) would have been more tolerant of the use. The pollen study (Mensing, 2007) indicates that plains cottonwood was the only lowland woody species that showed major contribution to the pollen. However, all of the above mentioned plants are either on the site or in similar sites off the site footprint. Although there are plentiful records of plant harvest for food, it is unlikely that this was major activity during the winter period. The fire use by Native Americans for "freshen" feed and attract game is often mentioned in the historical record but it is uncertain of how/if this practice might have been applied to this area. Literature on Native American uses of plants and landscapes indicates that woody species were occasionally/frequently cut and/or stripped of their bark in poor forage years to feed horses. This would have been particularly detrimental to the woody plants large and small.

Grazing Interaction Influences: It is clear the large ungulate grazing was present in the area, especially bison (*Bison bison*) and pronghorn (*Antilocapra americana*). Mule deer (*Odocoileus hemionus*) were native to the plains but very likely endemically quite uncommon in this area. These grazers, particularly bison, likely had significant impacts on the Sand Creek lowland area both because of the shade and moist environments that may have been present causing concentration of use both grazing and physical impacts. Clearly, years of low precipitation would have concentrated that use in perennial water availability areas while above normal precipitation years would have promoted greater dispersion. Documentation of bison influences along the perennial stream in other localities on the plains showed heavy physical impacts on the woody plants caused by rubbing, and browsing. The streams on the plains clearly had fewer galley forest (cottonwoods and others) than at present and all appearances are that the understory

was less rich/diverse with woody species than at present communities under good management. Horses are animals that by habit tend to avoid grazing in the riparian areas. However, the possibility/probability exists that the Native American owners would have corralled some animals in or near the riparian area and/or used the woody vegetation leaders, bark and cambium for horse feed when other forages were unavailable.

Likely Vegetation Communities: This presents a mental picture of a lowland area with dominant grass cover that seasonally was used relatively heavily and/or trampled by Native American occupancy. This use would have recovered relatively rapidly during the "normal" weather regime but may have shown persistent signs of use and reduced forage availability during drier that average conditions. Plants like alkalai sacaton (*Sporobolus airoides*), saltgrass (*Distichlis stricta*) and western wheatgrass (*Pascopyrum smithii*) would have been prominent on the salty areas while big bluestem (*Andropogon gerardi*), sand bluestem (*Andropogon hallii*), green needlegrass (*Nasella viridula*), switchgrass (*Panicum virgatum*)and perhaps yellow Indian grass (*Sorgastrum nutans*) would have joined those species near the stream course. Forbs like purple blazing star (*Liatris punctata*), prairie coneflower (*Ratibida columnifera*), day flower (*Commelina* spp.), prairie spiderwort (*Tradescantia bracteata*) would have been common during the growing season nut much less apparent during the winter. Disturbance related forbs were likely present in the camp areas and or corral areas. These might have been ragweed (*Ambrosia* spp.), snow-on-the-mountain (*Euphorbia marginata*), milkweed (*Ascelpias* spp.) and salsify (*Tragopogon dubius*). Some dominant overstory trees with occasional understory shrubs would have been present. (The tree ring study found cottonwood trees that could have been present at the time of the massacre) Little woody plant reproduction would have been apparent. Four-winged saltbush (*Atriplex canescens*) would have been present on the benches away from the stream but still on the stream terraces. However, it is likely that it would have been much reduced in density and shown clubbed-off growth form in response to moderate to heavy winter use by horses. The likely vegetation communities represented would have been largely lower mid-seral communities having been disturbed by human and grazing uses. The key woody species would have been much reduced in the moist areas.

The wetland areas likely would have been little altered except where there might have been intensive disturbance related to watering of horses or excavation to pool water. The areas would have been dominated the wetland species including bull rushes (*Scirpus* spp.), sedges (*Carex* spp.). Recovery during the growing season would have allowed significant recovery form disturbance.

Water

It is likely that water historically in Sand Creek would have been relatively more abundant and that perennial pools would have been more evident, than now. Some on and off stream course pools exist today. It seems clear, viewing the present day relationships, that the stream course

historically would have been narrower and more vegetated especially by herbaceous plants. This probably would have allowed greater water presence and perhaps stream flow, in some areas. It seems probable that the stream pools and existing flow would have been in the areas with finer textured bed materials (clay and silt) and less in areas with sand bottoms. Currently, adjacent stream reaches in the watershed above the Sand Creek footprint show flow even on sandy area where there is a heavy soil layer below the sand (e.g. Rush Creek and upper reaches of Big Sandy Creek). This water presence would have created far more dynamic plant communities, including the woody plants that would have allowed them show more growth and recovery following disturbance events

The evidence of the drought in the years just prior to the massacre event probably limited the stream flow to pools and the spring which shows all evidence of being perennial. The summary history of the event reported by Mitchell and Fiege indicated large expanses of bare sand and high banks. This apparently is the impact of increasing grazing use in the areas with water and the drought impacts.

Sandy Upland Communities

These are several ecological sites in the Monument that have sandy soil textures. These include: **Sands, Sandy and Sandy Salt Flat.** The **Sandy Salt Flat** was discussed above in the lowland communities, therefore will not be included in this discussion.

The **sands** ecological sites is one that should have dominant warm season tall grasses present on the site (NRCS Ecological Site Descriptions) (available on-line in Colorado NRCS Electronic Field Office Guide). This site would be represented by the sandhills area of the Creek. It seems likely that the winter use placed on it by the Native Americans and their animals would have had small impacts during normal years on this site. The expectation is that horse grazing might have occurred but the grasses present on this site are low in palatability and high in fiber during the winter season, providing little quality. Other communities on the Monument would have been preferred for grazing use, at that time of the year. The grazing use by bison and others would have occurred primarily spring and summer. It is likely that bison grazed this area because of adjacent water availability. This use may have been heavy at times but overall the expectation is that light to moderate use would have been most common with recovery in the following season. The result would have been a community dominated by an overstory of sand sagebrush (*Artemsia filifolia*) and yucca (*Yucca glauca*) with warm season tall grasses represented by sand bluestem, switch grass, little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), and prairie sand reedgrass (*Calamovilfa longifolia*). Some cool season grasses would have been present including western wheatgrass, needleandthread (*Hesperostipa comata*), prairie Junegrass (*Koeleria macratha*) and several native bluegrasses (*Poa* spp.). One notable grass-like plant, sun sedge (*Carex heliofila*) would have also been present. The short grass component would have been weak but present primarily in the form of blue grama (*Bouteloua*

gracilis). The forb component would have included purple prairie clover (*Dalea purpurea*), prairie coneflower (*Ratibida columnifera*), bush morning glory (*Ipomoea leptophylla*) several species of scurfpea (*Psoralea* spp.), spiderwort, and winecup (*Callirhoe involucrata*) with many others. This type would have had the most diverse forb community of any of the other upland sites.

The expectation is that this community was the close to the high seral community with the exception of localized disturbances physical impacts of horses or bison.

The **sandy** ecological site is on the south end of the property. This type is unusual for the sand y plains ecological site because it is shallow aeolian sand overlaying a claypan. This creates a much shallower top soil than would be typical of this type. This would be more xeric and much more subject to drought and disturbance. Also, the expected plant community would be less diverse than the expected community. Historically the site would have had some sand bluestem needleandthread and prairie sandreed as the dominants with a greater amount of blue grama and sedge than the sands site. The additional grass component present would have been sand dropseed (*Sporobolus cryptandrus*). The forb component would not have been diverse or abundant. It is likely that the bison grazing and perhaps the horse grazing would have had greater impacts both by grazing and by dusting areas, in the case of the bison. Sand sagebrush would have been scattered, but yucca all but absent on this site because of the shallow soil profile above the claypan.

Upland Loamy Communities

The **loamy site** is one ecological site but several seral communities were probably present. This community in high seral status would have co-dominant grasses of blue grama and western wheatgrass with smaller amounts of needleandthread and green needlegrass. Buffalo grass (*Buchloe dachyloides*), tumblegrass (*Schedonardus paniculatus*), red threeawn (*Aristida longiseta*) and sand dropseed are lower seral representatives of the plant community on this site. The site would have forbs like purple prairie clover, dotted gayfeather, prairie coneflower and slimflower scrufpea (*Psoreala tenuiflora*) but the forb community would not be and diverse as the **sands** or **sandy** ecological sites (less than 5% of the total herbaceous component). This site would have had both four-winged saltbush and winterfat (*Krascheninnikovia lanata)* but the four-winged saltbush, in particular, is quite sensitive to heavy use.

It is entirely possible that the loamy area on the Monument would have been variably grazed with short-term heavy use when the Native American encampment was near and when bison herds travel through. This certainly would have been the preferred area for horse grazing because of forage close to a probable camp site but also because it would have had the highest quality of forage during the winter period. The horse use in the winter would have impacted the cool season grasses like western wheatgrass to some extent but only changing the lands capability to

catch snow and store water. Plains prickly pear (*Opuntia polyacantha*) would have been locally abundant in heavily grazed areas and would likely have increased during the drought period prior to the massacre. The shrubs would have been impacted much more. (Physiology and structure of shrubs makes this group of plants more susceptible to heavy use.) The bison use during the summer could have reduced the cool season grass component and/or reduced the shrub component. This impact would have been totally related to the frequency and intensity of use, especially in drought periods. Bison use in the winter would have been much the same as horse use. The concentration of animals near the spring and/or travel to and from the spring would have caused physical disturbance to the system encouraging lower seral plants to be present in those areas. Additionally, the dusting areas for the bison would have created patch disturbances form 8-15 feet in diameter (based on measures of current impacts of bison on occupied ranges). These areas would have been bare to occupied by low seral plants including both grasses like red threeawn and tumblegrass and forbs that might have included forbs like frog fruit (*Phyla cuneafolia*), fringed sagewort and ragweed.

The **loamy ecological sites** are the ones that would have been occupied by prairie dogs. This relationship would have caused several plant communities to be present. Please see the discussion below for more explanation of how this process happened and what communities would have been formed.

Prairie Dogs

Cleary, prairie dogs were a prevalent grazer, historically, at Sand Creek. Their influence would have been large in the areas where they were present and less so in previously occupied habitats, totally depending on the elapsed time since the last occupancy. Recent literature seems to indicate that prairie dogs probably occupied about 5% of the landscape and maybe 20% of the occupiable area, at any point in time. The prairie dog colonies have a finite life span where the center of the colony tends to decline and the edges expand to where unique colonies form. Currently, plague plays a role in the determining the duration that a town may last. The greater the time since the last plague epidemic and the larger the town the great is the likelihood that the town will contract plague. It seems entirely likely that some factors interacted to cause declines of prairie dog colonies in the past but it is unclear whether pathogens were involved. Prairie dog influence on the rangeland environment is a complex one. They clearly graze vegetation in and surrounding the town extremely closely. This grazing use causes first a community that is a prostrate growth (extremely close to the ground) form community of the initial prairie vegetation species discussed above. This growth form is induced by the frequency and intensity of the grazing use by prairie dogs. This will persist only two or three growing seasons and will then be replaced alternative species that are less palatable and/ or more grazing tolerant. The most likely and the common ones that we see now are blue grama mixed with buffalograss with red three or plains threeawn and tumblegrass. Unpalatable forbs increase, as well. They are notably fetid

marigold (*Dyssodia papposa*), hairy goldaster (*Heterotheca villosa*) and fringed sagewort. The grassy phase with forbs remains relatively intact until there are dry years. At that point in time, there become major areas of bare ground. The closer the area is to the center or the town (the oldest area/first colonized area) the more bare ground there will be. As one progresses toward the edge/newer areas of the town one will find more and more grasses and perennial plants.

Conversely, when there is above normal precipitation the grasses phase remains for longer periods of time and, at times the perennial grasses show movement back into the prairie dog areas. Studies and experience have shown that the perennial plants have not been extirpated on any part of the town but are suppressed extraordinarily to where their existence is impossible to tell. Towns that die out show repaid recovery to some perennial plants, even within one season when there is ample rainfall. The common species to respond and occupy these "old" prairie dog towns are western wheatgrass, green needlegrass, squirreltail and at times needle-and-thread. These are cool season species that require somewhat more water than the warm season grasses and therefore respond to the additional resources that are made available. This would be an example of the "back loop" of resource release and community reorganization, as mentioned in *Resilience Thinking*. However, these plants communities show disturbance plant community characteristics for many years.

Prairie dogs cause patch dynamics across the prairie. These dynamics have formerly occupied area, currently occupied area and recovering areas. This adds notable sub-landscape scale diversity. Rangeland that has had a history of heavy season-long grazing forms a blue grama-buffalograss stable state. This stable state is not diverse in either structure or plants species. Prairie dogs create patch disturbance in this type of community. The immediate impact may be less diverse and notably less herbaceous production, but over time the dynamics of the town allow for formation of greater diversity on the prairie. The prairie dog creates diversity of habitats when they form the town by creating burrows, bare ground patches and low seral environments that are used by other animals, like burrowing owls, snakes, plovers etc.
The standing questions is how much prairie dog disturbance was present in the historic condition and what does that mean to current day management. Clearly, in land areas with same footprints relative to the landscape or the ecosystem, prairie dogs could dominate all of the occupiable land. All land management agencies are wrestling with this relationship trying to strike the balance necessary of ecologically and politically.

Chapter 3. Current Conditions

These conditions are well documented in the ***Sand Creek Massacre Vegetation Inventory.*** It must be noted that a large proportions of the land area has been disturbed to varying extents including farming, drought and construction of a variety of structures. The remnant footprint of native prairie is a relatively small percentage of the current area, with the sands area the most intact.

Chapter 4. Future Conditions and Management

The **loamy** area is either occupied by prairie dogs, or has been farmed for crops. The farmed area is very weedy and because of its history has had the soils characteristics changed for a very long time. The organic matter substrates have been diminished, probably greatly (See Burke et. al, 1997). Estimates are that cropping practices may have reduced soils carbon by as much as 50%. This is contingent on the duration of farming/ tillage practices and the amount of soil erosion. In the Eads area wind is abundant and soil erosion from cropped land is a large probability. Since soil carbon recovers slowly, especially those long chain soil carbons,; it is unlikely that this system will function like native prairie for more than 500 years. However, the short term turnover carbon pool can change/ improve significantly faster. Science would indicate recovery of 70%- 80% of this pool in 40-60 years, with 20 % recovery in 10 years. The implications of this are maintaining and increasing perennial cover without sever disturbances that would remove cover. This would keep the soils cool, slowing decomposition, capture more water in the system allowing for increase in Net Primary Productivity (NPP) thus creating and storing more soil carbon.

The following are excerpts of a comprehensive ecological study done in Southeastern Colorado and are included with the specific permission of Dr. Larry Rittenhouse. The descriptions included are comprehensive and apply to the Sand Creek area. The photos are not from the Sand Creek area but are representative of that vegetation type.

Ecological Type: Loamy

Ecological Site Type: Loamy

Location

The loamy plains, moist ecological type is found in southeastern Colorado.

General Description

The loamy plains, moist ecological type occurs on deep, well-drained upland loamy soils. The topography is level to gently rolling. Dominant vegetation includes blue grama (*Bouteloua gracillis*), buffalograss (*Buchloe dactyloides)*, red threeawn (*Aristida longiseta*), western wheatgrass (*Pascopyrum smithii*), sand dropseed (*Sporobolus crytandrus*), and sideoats grama (*Bouteloua curtipendula*). Non-native plant species including yellow sweet clover (*Melelotus officinalis*), Japanese brome (*Bromus japonicus*), and downy brome (*Bromus tectorum*) are common in areas where the soil surface is exposed. Four seral stages have been developed for this ecological type. The seral stages represent vegetative relationships under grazing management. Descriptions of seral stages are found after a general ecological site description.

Physiography: Level to gently rolling upland plains

Average annual precipitation: 14-16 inches

Soils: Soils of the loamy plains, moist ecological type have formed from calcareous material weathered from limestone, shale, and loess derived from sedimentary rock. The surface layer is typically loam, clay loam or silt loam. The subsoil is loam, silt loam, clay loam or silty clay loam. The soils are generally greater than 40 inches in depth over bedrock. The soils are mildly alkaline to moderately alkaline and calcareous in the subsoil. A detailed typical soil profile for this ecological type can be found in Appendix C.

Permeability of the soils is moderately slow to moderate. Water holding capacity is high and water intake is moderate. Runoff is slow to medium. Compaction potential is high which increases runoff and decreases permeability. Water and wind erosion potential are high to very high when surface vegetation is removed and mineral soil is exposed. Mid and late seral vegetation provides the greatest soil protection. Increases in litter cover or surface organic matter increase moisture-holding capacity, reduce erosion potentials and provide for increased nutrient storage.

Use and Management

Grazing is currently the dominant use of the loamy plains, moist ecological type. This type provides productive forage at most times during the year for domestic and native animals. Continuous yearlong grazing or grazing from April to October will probably influence species productivity and diversity. A system of deferred grazing may be needed to maintain a diverse plant community. Rest from grazing during different seasons benefits different plant species. Summer rest (May-September) benefits warm-season grasses such as blue grama and buffalo grass where rest in the spring (March-July) benefits the cool-season plant, western wheatgrass.

Production Estimates (USDA 1981, 1983)

The average total annual production (air dry) for mid to late seral stages of the loamy plains, moist ecological type is given below.

Favorable years	1600 lbs acre^{-1}
Normal years	1200 lbs acre^{-1}
Unfavorable years	600 lbs acre^{-1}

Stocking Rates for Cattle Stocking rates are based on average growing season of high or late seral vegetation. The acres per AUM are based upon 1200 pounds of forage (air-dry) per animal unit month and takes into account forage lost to rodents, insects and trampling.

Percent late *seral* vegetation	**Condition class**	**Acre/AUM**
76-100	Excellent	2.1-2.7
51-75	Good	2.7-3.8
26-50	Fair	4.0-7.6
0-25	Poor	8.3+

Wildfire: Fires historically occurred on this ecological type as prairie fires. Today, wildfires are controlled or contained to relatively small areas. Fuel levels are relatively low due to current grazing activities and precipitation. Fires were probably more important for maintaining species diversity, mosaics of ecological successional diversity, and nutrient cycling in the past.

Grazing: Many of the native plant species we see today evolved with grazing pressures of prehistoric herbivores. In more recent history, buffalo, horses, pronghorn antelope, and deer were common. These herbivores probably grazed intensively in areas where forage values were better due to rainfall patterns, nutrient content, or past grazing. Grazing by herbivores probably maintained the loamy plains, moist ecological type in various seral stages. Current cattle grazing emphasizes mid-seral communities of high forage production over most of the ecological type.

General Characteristics by Seral Stage

Plant Species Diversity

Average number of plant species by seral stage for the loamy plains, moist type. Values may be influenced by sample sizes.

	Seral stage			
Life form	1	2	3	4
Grass	27	22	16	10
Forb	68	46	40	13
Shrub	9	7	6	2
Tree	0	0	0	0

Key Management Species

Average CFI (%over * %frequency) values of common plant species by seral stage for the loamy plains, moist ecological type.

	Seral stage			
Plant species	1	2	3	4
Blue grama (Bouteloua gracilis)	819	3734	6158	317

Buffalo grass (Buchloe dactyloides)	606	208	26	199
Three-awn (Aristida purpurea)	492	87	11	<1
Sideoats grama (Bouteloua curtipendula)	113	10	1	<1
Western wheatgrass (*Pacopyrum smithii*)	313	187	145	3524
Sand dropseed (Sporobolus cryptandrus)	158	10	2	6
Globemallow (Sphaeralcea coccinea)	77	43	43	154
Snakeweed (Gutierrezia sarothrae)	51	40	18	2
Plains prickly pear (*Opuntia polyacantha*)	5	2	3	3

Noxious and Non-Native Plants

Average CFI of noxious and non-native species for the loamy plains, moist ecological type. The Cover Frequency Index (CFI) is the product of %canopy cover * %frequency.

	Seral stage			
Plant species	1	2	3	4
Cheatgrass (Bromus tectorum)	12	6	<1	0
Kochia (Kochia scoparium)	4	0	0	0
Russian thistle (*Salsola iberica*)	<1	0	0	0
Japanese brome (*Bromus japonicus*)	16	0	3	3
Tumblegrass (*Schendonnardus paniculatus*)	13	9	1	2
Lambert's locoweed (*Oxytropis lambertii*)	12	4	19	2
Fixweed (*Descurainia sophia*)	0	3	2	2
Yellow sweet clover (*Melilotus officinalis*)	46	77	12	175
Mexican ragweed (*Ambrosia confertifolia*)	<1	3	0	0
Stickseed (*Lappula occidentalis*)	<1	0	<1	0

Soil Erosion Hazards

Potential wind and water erosion by seral stage for the loamy plains, moist ecological type.

		Seral	stage	
Erosion	1	2	3	4
Wind	High	High	Moderate.	Low
Water	High	Moderate-High	Moderate	Low-Moderate

Ecological Type: Loamy Plains

Seral Stage 1

This seral stage represents the early or recently disturbed successional stage of the loamy plains, moist ecological type (LP02). This stage represents an abundance of early seral annual and perennial species compared to the later seral stages.

Vegetative Composition

The following table shows the dominant plant species found on seral stage 1 of loamy plains, moist ecological type (LP02) and their average percent canopy cover and percent frequency for all sites sampled.

Life Form	Species	Average Percent Cover	Average Percent Frequency
Grass	Blue grama (Bouteloua gracilis)	13	51

Grass	Buffalo grass (Buchloe dactyloides)	8	19
Grass	Three-awn (Aristida purpurea)	7	35
Grass	Western wheatgrass (*Pascopyrum smithii*)	4	38
Grass	Sand dropseed (Sporobolus crytandrus)	3	21
Grass	Side-oats grama (Bouteloua curtipendula)	2	6
Forb	Globemallow (Sphaeralcea coccinea)	1	24
Sub-shrub	Snakeweed (Gutierrezia sarothrae)	1	13
Grass	Ring muhly (Muhlenbergia torreyi)	1	8
Forb	Yellow sweet clover (*Melilotus officinalis*)	1	7
Forb	Indian wooly wheat (*Plantago patagonica*)	<1	4
Grass	Tumblegrass (Schendonnardus paniculatus)	<1	4
Grass	Japanese brome (*Bromus japonicus*)	<1	3
Grass	Cheatgrass (Bromus tectorum)	<1	3
Grass	Crested wheatgrass (*Agropyron cristatum*)	<1	2
Forb	Lambert's locoweed (*Oxytropis lambertii*)	<1	2
Grass	Needle-and-thread (*Stipa comata*)	<1	2
Grass	Little barley (*Hordeum pusillum*)	<1	1
Grass	Silver bluestem (Botriochloa laguroides)	<1	1

Relationship to Other Seral Types

This seral stage represents the early seral stage under the current grazing management. Blue grama occurs at lower cover and frequency compared to other seral stages. It is distinguished from seral stages 2, 3, and 4 by the lesser amounts of blue grama and higher amounts of three-awn and sand dropseed.

Disturbance relationships

This seral stage is maintained by season long or yearlong grazing systems. Long duration summer and early fall grazing reduces the blue grama composition. Many early seral annual

plants are present. These provide high forage values for small rodents, songbirds and insects. There is greater structural vegetative diversity for seral stage 1 compared to the other seral stages. Soil erosion potentials are much higher in this seral stage. A reduction of grazing on this seral stage may show an increase in annual species, non-native, and noxious weeds initially. This stage is generally found near water sources, salting areas, and small areas frequented by cattle. These small areas of early seral stage increase the plant and structural diversity and result in spatially distributed early seral areas throughout this range type.

Vegetative Structural Diversity

Component	Rating
Hiding cover 0-3 inches	Moderate
Hiding cover 3-12 inches	Moderate
Hiding cover 12-25 inches	Low
Shrub density	Low
Perennial grass and forb density	Low
Annual grass and forb density	High

Animal Food Forage Values

Animal Class	Grasses	Forbs	Shrubs
Small mammals	Medium-high	Medium	Very low
Songbirds	Medium-high	Medium	Very low
Game birds	Medium-high	Medium	Very low
Cattle	Low	Low	Low
Deer	Low	Low	Very low
Antelope	Low	Medium	Low
Horses	Low	Low	Very low
Sheep	Low	Low	Very low

Ecological Type: Loamy Plains,

Seral Stage 2

This seral stage represents the low intermediate seral of the loamy plains, moist ecological type. This stage represents an increase in the amount of blue grama and decrease in three-awn, sand dropseed, and annual plants compared to seral stage 1.

Vegetative Composition

The following table shows the dominant species found on seral stage 2 of loamy plains, moist ecological type (LP02) and their average percent cover and percent frequency for all sites sampled.

Life Form	Species	Average percent cover	Average percent frequency
Grass	Blue grama (Bouteloua gracilis)	39	96
Grass	Buffalo grass (Buchloe dactyloides)	4	17
Grass	Western wheatgrass (*Pacopyrum smithii*)	3	25
Grass	Three-awn (Aristida purpurea)	2	16
Forb	Globemallow (Sphaeralcea coccinea)	1	21
Sub-shrub	Snakeweed (Gutierrezia sarothrae)	1	12
Forb	Yellow sweet clover (*Melilotus officinalis*)	1	7

Forb	Indian wooly wheat (*Plantago patagonica*)	<1	7
Grass	Sand dropseed (Sporobolus cryptandrus)	<1	4
Grass	Ring muhly (Muhlenbergia torreyi)	1	4
Forb	Scurfy pea (Psoralidum tenuiflorum)	<1	3
Grass	Side-oats grama (Boutelous curtipendula)	<1	2
Grass	Tumblegrass (Schdonnardus paniculatus)	<1	2
Grass	Needle-and-thread (*Stipa comata*)	<1	1

Relationship to Other Seral Types

This seral stage represents the low intermediate seral stage (2) under current grazing management. Blue grama occurs at moderate cover and frequency. It is distinguished from seral stage 1 by a decrease of three-awn, sand dropseed, and buffalo grass. Seral stage 3 is distinguished from stage 2 by considerably greater amount of blue grama and lesser amounts of the early seral plant species like three-awn, sand dropseed, and annual plants.

Disturbance relationships

This seral stage is maintained by grazing systems that benefit warm season grasses. Spring grazing (May-June) help maintain the blue grama at moderate cover and frequency. A change to seral stage 1 is recognized by a reduction of blue grama, an increase in sand dropseed, three-awn and an increase in exposed soil. A reduction of grazing on this seral stage may show a decrease of sod forming warm season grasses and an increase in cool season grasses and early seral species, depending on total annual and timing of rainfall.

Vegetative Structural Diversity

Component	Rating
Hiding cover 0-3 inches	Moderate
Hiding cover 3-12 inches	Low-moderate
Hiding cover 12-25 inches	Low
Shrub density	Low
Perennial grass and forb density	Low-moderate

Annual grass and forb density Moderate

Animal Food Forage Values

Animal Class	Grasses	Forbs	Shrubs
Small mammals	Medium	Medium	Very low
Songbirds	Medium	Low	Very low
Game birds	Low	Low-medium	Very low
Cattle	Medium -high	Low	Low
Deer	Low	Low	Very low
Antelope	Medium	Medium	Low
Horses	Medium -high	Low	Very low
Sheep	Medium -high	Low	Very low

Ecological Type: Loamy Plains

Seral Stage 3

This seral stage represents the high intermediate seral stage (3) of the loamy plains. This stage is somewhat similar to seral stage 2 but is distinguished from stage 2 by an increase in blue grama cover and a reduction of early seral plants. Plant species diversity is also lower compared to seral stages 1 and 2.

Vegetative Composition

The following table shows the dominant plant species found on seral stage 3 of the loamy plains, moist ecological and their average percent cover and percent frequency for all sites sampled.

Life Form	Species	Average Percent Cover	Average Percent Frequency
Grass	Blue grama (Bouteloua gracilis)	62	99
Grass	Western wheatgrass (*Pascopyrum smithii*)	2	19
Forb	Globemallow (Sphaeralcea coccinea)	1	19
Sub-shrub	Snakeweed (Gutierrezia sarothrae)	1	8
Forb	Indian wooly wheat (*Plantago patagonica*)	<1	8
Grass	Buffalo grass (Buchloe dactyloides)	1	4
Grass	Three-awn (Aristida purpurea)	1	4
Forb	Lambert's locoweed (*Oxytropis lambertii*)	<1	4
Forb	Yellow sweet clover (*Melilotus officinalis*)	<1	3

Relationship to Other Seral Types

Under current grazing management this seral stage represents the high intermediate seral stage (3). Blue grama occurs at high cover and frequency. It is distinguished from seral stage 4 by the lack of western wheatgrass canopy cover. The earlier seral stages (1 and 2) have considerably less blue grama cover, greater amounts of bare soil, and greater percentage of early successional plant species.

Disturbance relationships

This seral stage is maintained by grazing systems that benefit warm season grasses. Spring grazing (May-June) helps maintain the blue grama at moderately high cover and frequencies. A change to seral stage 2 is recognized by a reduction of blue grama, and an increase in three-awn. A change to seral stage 4 may require a change in grazing management, but also is closely related to annual precipitation that falls during the months April-June.

Vegetative Structural Diversity

Component	Rating
Hiding cover 0-3 inches	High
Hiding cover 3-12 inches	Moderate-high
Hiding cover 12-25 inches	Low
Shrub density	Low
Perennial grass and forb density	Moderate
Annual grass and forb density	Low

Animal Food Forage Values

Animal Class	Grasses	Forbs	Shrubs
Small mammals	Medium	Low	Very low
Songbirds	Medium	Low	Very low
Game birds	Low	Low	Very low
Cattle	High	Low	Low
Deer	Low	Low	Very low
Antelope	High	Medium	Low
Horses	High	Low	Very low
Sheep	High	Low	Very low

Ecological Type: Loamy

Seral Stage 4 (Western Wheatgrass Phase)

This seral stage represents the late seral (4) of the loamy plains, moist ecological type. This stage is not an undisturbed late seral stage but represents a late seral plant community under current grazing use of this ecological type. This stage is dependent upon high soil organic matter and moisture conditions that are favorable to cool season grasses. This stage is very dependent on spring precipitation and timing of grazing.

Vegetative Composition

The following table shows the dominant plant species found on seral stage 4 of the loamy ecological type and their average percent cover and percent frequency for all sites sampled.

Life Form	Species	Average Percent Cover	Average Percent Frequency
Grass	Western wheatgrass (*Pascopyrum smithii*)	36	99
Grass	Blue grama (Bouteloua gracilis)	6	33
Grass	Buffalo grass (Buchloe dactyloides)	4	11
Forb	Globemallow (Sphaeralcea coccinea)	2	19
Forb	Yellow sweet clover (*Melilotus officinalis*)	2	10

Forb	Spiderwort (Tradescantia occidentalis)	<1	9

Relationship to Other Seral Types

This seral stage represents the late seral stage under current grazing management. The grazing systems favor cool season grasses and the production of high carbon contents in the surface soil. Western wheatgrass occurs at high cover and frequency compared to earlier seral stages. It is distinguished from seral stages 2 and 3 by the dominance of western wheatgrass and the low abundance of three-awn, and sand dropseed. This seral stage is very moisture dependent. Changes of species composition can occur quickly depending on the amount of available moisture that is favorable to cool season grasses. Species composition and amount of canopy cover of seral stages 2 and 3 fluctuate less with yearly precipitation changes compared to stage 4.

Disturbance relationships

This seral stage is maintained by grazing systems that benefit cool season grasses. Summer grazing (late June-August) helps to maintain the western wheatgrass dominated late seral plant community. A change to seral stage 2 or 3 is recognized by a reduction of western wheatgrass, an increase in sand dropseed, buffalo grass, and three-awn. Blue grama will increase within this seral stage with spring-early summer grazing or with inconsistent annual weather patterns that favor warm season grasses (low soil moisture during spring months).

Vegetative Structural Diversity

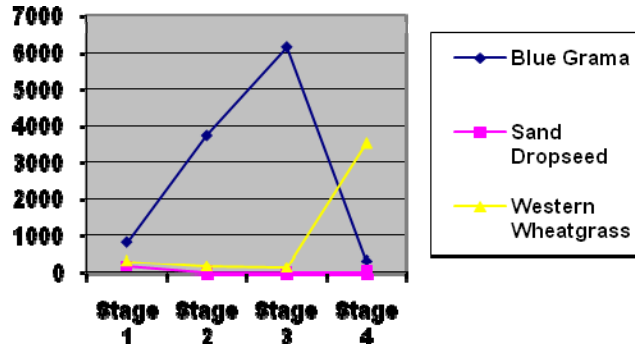
Component	Rating
Hiding cover 0-3 inches	High
Hiding cover 3-12 inches	Moderate
Hiding cover 12-25 inches	Low-moderate
Shrub density	Low
Perennial grass and forb density	High
Annual grass and forb density	Low

Animal Food Forage Values

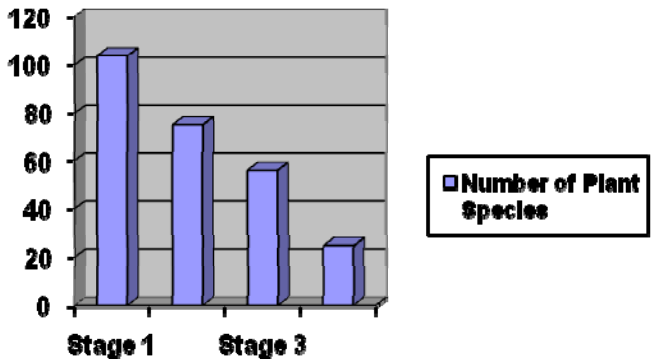
Animal Class	Grasses	Forbs	Shrubs
Small mammals	Medium	Low	Very low
Songbirds	Medium	Low	Very low
Game birds	Medium	Low	Very low
Cattle	High	Low	Low
Deer	Medium	Low	Very low
Antelope	Medium-high	Medium	Low
Horses	High	Low	Very low
Sheep	High	Low	Very low

Summary Information for Loamy Plains

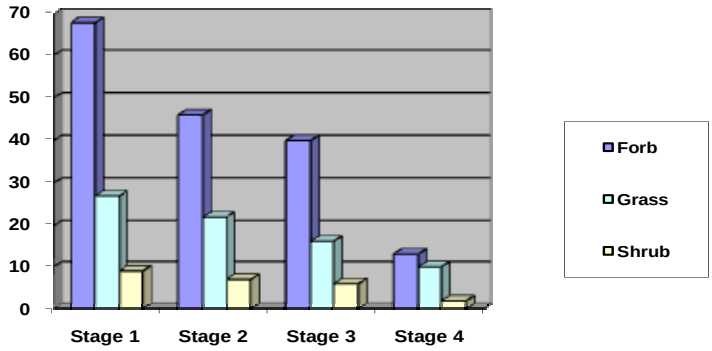
Average CFI (% cover * % frequency) of indicator species for each seral stage of the loamy plains, moist ecological type.



Number of plant species recorded for each seral stage of the loamy plains, moist ecological type. The number of species may be influenced by the number of samples collected within each seral stage.



Number of species by plant form for the loamy plains, moist ecological type by seral stage. The number of species may be influenced by the number of samples collected within each seral stage.



Ecological Type: Sandy

Ecological Site Types: Sandy

Location

The sandy ecological type is found in southeastern Colorado and southwestern Kansas (Figure 1-1). This type is separated into ecological groupings by the abundance of sand sage (*Atrtemesia filifolia*), blue grama (*Bouteloua gracillis*), and buffalograss (*Buchloe dactyloides*).

General Description

The sandy plains and deep sand ecological type includes recent wind blown sandy deposits on moderately deep to very deep, well-drained upland sandy to loamy soils. Topography is level to gently rolling to steep and choppy. Dominant vegetation includes sand sage, three-awn (*Aristida purpurea*), buffalograss, blue grama, sand dropseed (*Sporobolus crytandrus*), yucca (*Yucca glauca*), sideoats grama (*Bouteloua curtipendula*), and numerous annual forbs. This range type is common on the eastern portion of the Pritchett and Campo Grazing Associations of the Comanche National Grasslands and most of the Cimarron National Grasslands (Figure 1-2). It is distinguished from other ecological types by the sandy soil and presence of sand sage. The low amount or lack of western wheatgrass and low cover of blue grama compared to loamy plains ecological types also distinguish this type.

The sandy soils of this ecological type support a variety of annual and perennial plants. Plant species diversity is generally much higher in this ecological type compared to the loamy plains ecological types. Non-native annual species including kochia (*Kochia scoparia*), Russian thistle

(*Salsola iberica*), and annual sunflower (*Helianthus annuus*) readily establish areas where the surface soil is exposed and recent wind blown deposition has occurred.

Five seral stages have been developed for the sandy plains and deep sands ecological type. One of the seral stages is a high canopy cover of sand sage (early or stage 1). The sand sage seral stage generally represents early soil development of recent wind blown soil deposits. This early sand sage seral stage, if viewed as a distinct ecological type, could be further divided into discrete seral stages. The plant community that develops very soon after recent wind blown sandy deposits is generally composed of annual forbs and grasses. This very early seral stage of annual forbs and grasses has not been represented in this classification. This very early stage can be seen along roadsides, blowouts, or active sand dunes where soil movement has recently been active. This very early stage may be an important component of maintaining plant species diversity and supporting wildlife species. Sand sage appears to become established soon after the very early annual plants have colonized. Over time and under grazing management, sand sage seems to decrease and perennial grasses increase in cover and composition on the sandy soils.

The successional pathways in the sandy soils appear to be linked closely to carbon content and texture in the soil. In general, the greater the carbon content and finer (fine sands to silt) the soil surface texture, the greater the proportion of mid to late seral grass species present. Moderate grazing appears to move the systems toward grass communities from sand sage communities. The other four seral stages of this ecological type represent soils where an accumulation of organic matter and finer textured soil material has accumulated in the soil surface. The seral stages represent vegetative relationships under grazing management. Many of the sandy plains and deep sands probably cover historic or prehistoric loamy plains range types. The seral stage descriptions follow the general ecological type description. Many areas represented by this type have been re-seeded to grasses, particularly side-oats grama and may not be accurately represented within these seral stage descriptions.

Physiography: Level to gently rolling upland plains and active sand dunes

Use and Management

Grazing is currently the dominant use of the sandy plains and deep sands ecological type. Continuous grazing or grazing from April to October will influence species productivity and diversity. A system of deferred grazing is needed to maintain a diverse plant community. Grazing rest during different seasons benefits different plant species and communities. Summer rest (May-September) benefits warm-season plants such as blue grama whereas spring rest (March-July) benefits cool-season plants such as western wheatgrass.

Production Estimates

The average total annual production (air dry) for the mid to late seral stages of the sandy ecological type is given below.

Favorable years	2500 lbs/acre
Normal years	1600 lbs/acre
Unfavorable years	800 lbs/acre

Stocking Rates

Stocking Rate estimates are based on average growing season of high or late seral vegetation. The acres per AUM are based upon 1200 pounds of forage (air-dry) per animal unit month and takes into account forage lost to rodents, insects and trampling.

Percent late seral vegetation	Condition class	acre/AUM
76-100	excellent	1-2
51-75	good	2-2.5
26-50	fair	2.5-4
0-25	poor	4-10

General Disturbance Relationships

This sandy plains and deep sands ecological type is being described as a vegetative successional pattern that also follow a soil successional pattern. All of the seral stages described can be set back to an early seral stage by loss of surface cover and subsequent wind blown erosion and deposition. An accumulation of soil organic matter in the soil surface helps retain fine sands and silts and move the soil and associated vegetative communities toward later seral stages. In general, the early stages represent recent wind blow deposits that support annual forbs, grasses and some sand sage. An increase in sand sage represents a move toward a grass-dominated seral stage, but still represents a very early seral condition. A dominance of three-awn and sand dropseed represents an early seral stage of grasses and greater accumulations of organic matter in the soil. A low intermediate stage is identified by a mix of early and mid seral grasses. The mid intermediate state is represented by a dominance of buffalo grass. A high intermediate stage is represented by a decrease of buffalo grass and an increase of blue grama. A late seral stage is represented by a dominance of blue grama, decrease in grass species diversity, an increase in soil organic matter content, and soil profile development.

Human: The sandy plains and deep sands ecological type occurs within an area that was greatly influenced during the Dust Bowl of the 1930's. Soil loss as well as soil deposition occurred and altered the ecological types as well as seral stages in many areas. Lands that were plowed generally were set back to an earlier seral stage due to losses of organic matter and fine textured soil. The recovery time of many areas since the dust bowl to later seral stages have been decreased by range seeding, water conservation, and grazing management. However, some of the seeded areas, particularly those areas seeded with side-oats grama are dense monoculture plant communities.

Wildfire: Fires historically occurred on this sandy plains and deep sands ecological type as prairie fires that were ignited by lightning strikes, Native Americans, and settlers. Fires in this ecological type were probably much larger and created greater ecological changes than fires on loamy plains ecosystems. Today, wildfires are controlled or contained to relatively small areas. Fuel levels are relatively high in some areas on this ecological type due to early seral vegetation such as sand sage and sunflower. Fires were probably important for maintaining species diversity and mosaics of ecological successional diversity.

Grazing: Grazing by bison probably maintained various seral stages of vegetative communities. Current cattle grazing emphasizes mid seral communities of high forage production over most of the sandy plains and deep sands ecological type. Early seral stages are found in areas of recent eolian deposits or where wind erosion has removed some of the soil surface. Very intense cattle use near water sources can influence wind erosion and create or perpetuate early searl conditions. However, these early seral conditions provide a mosaic of different seral stages, increase plant species diversity, provide necessary habitat for many wildlife species, and are generally small in total area.

Plant Species Diversity

Average number of plant species by seral stage for the sandy ecological site. The number may be influenced by sample size.

	Seral		Stage	
Life Form	1	2	3	4	5
Grasses	19	50	25	25	31
Forbs	50	151	50	91	82
Shrubs	4	15	8	17	6

Key Management Species

Average CFI (percent canopy cover * percent frequency) of key plant species by seral stage for the sands ecological type.

Key Species	Seral Stage 1	2	3	4	5
Sand sage (Artimisia filifolia)	1692	79	9	78	23
Blue grama (Bouteloua gracilis)	71	126	369	1792	4196
Buffalo grass (Buchloe dactyloides)	3	145	3300	267	110
Three –awn (Aristida purpurea)	186	622	334	271	68
Sand dropseed (Sporobolus cryptandrus)	267	621	95	158	61
Side-oats grama (Bouteloua curtipenula)	48	60	22	130	46

Ground Cover

Average CFI (% canopy cover * % frequency) of ground cover by seral stage for the sandy plains and deep sands ecological type.

Ground Cover Type	Seral Stage 1	2	3	4	5
Litter	3663	3622	4401	3128	3127
Basal vegetation	2487	2357	4348	2930	2685
Bare soil	3060	2717	2014	2398	1903
Gravel	5	12	20	21	1

Noxious and Non-Native Plants

Average CFI (%cover * %frequency) of noxious and non-native plant species by seral stage for the sandy ecological type.

	Seral Stage				
Species	1	2	3	4	5
Cheatgrass (Bromus tectorum)	<1	8	5	3	4
Kochia (Kochia scoparium)	<1	1	0	2	<1
Russian-thistle (*Salsola iberica*)	2	15	12	0	4
Mexican ragweed (Ambrosia confertifolia)	<1	0	0	<1	<1
Japanese brome (*Bromus japonicus*)	<1	1	6	0	0
Yellow sweet clover (*Melilotus officinalis*)	0	11	<1	<1	14

Soil Erosion Hazards

Potential wind and water erosion by seral stage for the sandy ecological type.

	Seral Stage				
Erosion	1	2	3	4	5
Wind	High	Moderate	Low-moderate	Low	Low
Water	High	Moderate-high	Moderate	Low-moderate	Low

Ecological Type: Sandy

Seral Stage 1

This seral stage represents the sand sage community of the sandy. This stage represents a high abundance of sand sage and active soil movement through wind erosion. This stage is considered an early seral stage for this classification, however an earlier seral stage has been identified and represented by basically all annual plants.

Vegetative Composition

The following table shows the dominant plant species on seral stage 1 of the sandy ecological type and their average percent cover and percent frequency for all sites sampled.

Life Form	Species	Average Percent Cover	Average Percent Frequency
Shrub	Sand sage (Artemsia filifolia)	24	70
Shrub	Spanish bayonet (*Yucca glauca*)	1	4
Grass	Sand dropseed (Sporobolus cryptandrus)	4	32
Grass	Three-awn (Aristida purpurea)	3	22
Grass	Needle-and thread (*Stipa comata*)	2	12
Grass	Western wheatgrass (*Pascopyrum smithii*)	1	7
Grass	Sideoats grama (Bouteloua curtipendula)	1	6

Forb	Western ragweed (Ambrosia psilostachya)	1	9
Forb	Annual buckwheat (*Eriogonum annuum*)	1	6
Forb	Western fleabane (Erigeron bellidiastrum)	1	10
Forb	Annual sunflower (*Helianthus annuus*)	1	9
Forb	Black-foot daisy (Melampodium leucanthum)	1	3
Forb	Indian wooly wheat (*Plantago patagonica*)	<1	5

Relationship to Other Seral Types

This early seral stage represents the sand sage dominated stage. It is considered an early stage following an annual forb community in recent wind blown deposits. It is distinguished from the other seral stages by a high canopy cover and frequency of sand sage and low cover of perennial grasses. A decrease in sand sage and an increase in early seral grasses represent a change to seral stages 2 and 3.

Disturbance relationships

This seral stage is maintained by active wind erosion and deposition. Absence of grazing and destructive grazing that may limit carbon build up in the soil probably help maintain this seral stage. Low amounts of organic matter on and within the soil allow for soil erosion and limited soil structure development. Moderate grazing seems to result in succession toward a more grass dominated seral condition. Many early seral annual plants are present. These provide high forage values for small rodents, songbirds, and upland game birds. There is greater vegetative structural diversity over seral stages 2 and 3. Soil erosion potentials are much higher in this seral stage than some of the later stages.

Vegetative Structural Diversity

Component	Rating
Hiding cover 0-3 inches	High
Hiding cover 3-12 inches	High
Hiding cover 12-25 inches	Moderate to high
Shrub density	High
Perennial grass and forb density	Low

Annual grass and forb density High

Animal Food Forage Values

Animal Class	Grasses	Forbs	Shrubs
Small mammals	Low	High	High
Songbirds	Low	High	High
Game birds	Low	High	High
Cattle	Low	Medium	Low
Deer	Low	Medium	Low
Antelope	Low	Medium	Low
Horses	Low	Low	Low
Sheep	Low	Low	Low

Ecological Type: Sandy

Seral Stage 2

This seral stage represents the low intermediate seral of the sands ecological. This stage represents a forb and grass dominated plant community of early seral plant species. Sand sage occurs as less cover and less frequency than stage 1. Dominant grasses include three-awn and sand dropseed.

Vegetative Composition

The following table shows the dominant species found within seral stage 2 of sandy and their average percent canopy cover and percent frequency for all sites sampled.

Life Form	**Species**	Average Percent Cover	Average Percent Frequency
Sub-Shrub	Snakeweed (Gutierrezia sarothrae)	<1	4
Shrub	Sand sage (Artimesia filifolia)	2	10
Shrub	Spanish bayonet (*Yucca glauca*)	1	3
Grass	Three-awn (Aristida purpurea)	8	42
Grass	Sand dropseed (Sporobolus cryptandrus)	8	48
Grass	Buffalo grass (Buchloe dactyloides)	4	11
Grass	Blue grama (Bouteloua gracilis)	3	16
Grass	Sideoats grama (Bouteloua curtipendula)	2	8
Grass	Silver bluestem (Bothriochloa laguroides)	2	6
Grass	Western wheatgrass (*Pascopyrum smithii*)	1	7
Grass	Hairy grama (Bouteloua hirsuta)	1	3
Grass	Galleta grass (*Hilaria jamesii*)	<1	1
Grass	Squirreltail (Sitanion hystrix)	<1	5
Grass	Needle-and-thread (*Stipa comata*)	<1	1
Forb	Western ragweed (Ambrosia psilostachya)	2	17
Forb	Hairy goldenaster (*Heterotheca villosa*)	<1	2
Forb	Horseweed (Conyza canadensis)	<1	6
Forb	Annual buckweed (*Eriogonum annuum*)	<1	4
Forb	Annual sunflower (*Helianthus annuus*)	1	6

Forb	Scurfy pea (Psoralidum tenuiflorum)	1	8
Forb	Prairie coneflower (*Ratibida columnifera*)	<1	4
Forb	Russian-thistle (*Salsola iberica*)	<1	3
Forb	Globemallow (Sphaeralcea coccinea)	1	12

Relationship to Other Seral Types

This seral stage represents the low intermediate seral stage under current grazing management. Early seral grasses and forbs dominate the plant community. This stage is generally considered an early seral stage of the sandy plains range site. It represents a reduction in sand sage, an increase in soil stability, and an increase in carbon contents in the surface soil compared to stage 1. An increase in buffalograss and a decrease in sand dropseed represent a change to seral stage 3.

Disturbance relationships

This seral stage is maintained by light to moderate soil disturbance or intensive grazing systems that limit the vegetation change to later seral grasses. A change to seral stage 3 is recognized by an increase of buffalograss and blue grama. Severe soil disturbance that creates active soil movement may move this stage initially into a annual forb dominated plant community followed by a sand sage dominated plant community (seral stage 1).

Vegetative Structural Diversity

Component	Rating
Hiding cover 0-3 inches	Moderate-high
Hiding cover 3-12 inches	High
Hiding cover 12-25 inches	Low-moderate
Shrub density	Low
Perennial grass and forb density	Low-moderate
Annual grass and forb density	High

Animal Food Forage Values

Animal Class	Grasses	Forbs	Shrubs
Small mammals	Medium	High	Low-medium
Songbirds	Medium	High	Low
Game birds	Medium	Medium	Low-medium
Cattle	Medium	Medium	Low
Deer	Low	Medium	Low
Antelope	Low	Medium	Low
Horses	Medium	Low	Low
Sheep	Medium	Medium	Low

Ecological Type: Sandy

Seral Stage 3

This seral stage represents the mid intermediate seral of the sandy plains deep sands ecological type (SP01). This stage represents a buffalograss dominated seral stage. It is distinguished by an increase in buffalograss and blue grama cover and a reduction of sand dropseed compared to stage 2. This stage represents a unique plant community type that is identified by the high cover and frequency of buffalograss.

Vegetative Composition

The following table shows the dominant species found on Seral Stage 3 of Sandy ecological type and their average percent cover and percent frequency for all sites sampled.

Life Form	Species	Average Percent Cover	Average Percent Frequency
Grass	Blue grama (Bouteloua gracilis)	6	29
Grass	Three-awn (Aristida purpurea)	5	37
Grass	Buffalograss (Buchloe gracilis)	38	87
Grass	Sand dropseed (Sporobolus cryptandrus)	2	18
Grass	Sideoats grama (Bouteloua curtipendula)	1	4
Grass	Little barley (*Hordeum pusillum*)	<1	2
Forb	Scurfy pea (Psoralidum tenuiflorum)	2	10
Forb	Globemallow (Sphaeralcea coccinea)	1	10
Forb	Western ragweed (Ambrosia psilostachya)	<1	7
Forb	Indian wooly wheat (*Plantago patagonica*)	<1	10

Relationship to Other Seral Types

This seral stage represents the mid seral stage under current grazing management. Buffalograss occurs at high cover and frequency. It is distinguished from Seral Stage 4 by the presence of buffalograss and low coverage of blue grama.

Disturbance relationships

This seral stage is maintained by grazing systems that benefit warm season grasses. Spring grazing (May-June) helps to maintain the buffalograss at moderately high cover and frequencies. A change to seral stage 2 or 4 is recognized by a reduction of buffalograss. Soil disturbance will move the plant community toward seral stage 2.

Vegetative Structural Diversity

Component	Rating
Hiding cover 0-3 inches	Moderate-high
Hiding cover 3-12 inches	Low-moderate
Hiding cover 12-25 inches	Low
Shrub density	Low
Perennial grass and forb density	Moderate-high
Annual grass and forb density	Low

Animal Food Forage Values

Animal Class	Grasses	Forbs	Shrubs
Small mammals	Medium	Low	Very low
Songbirds	Medium	Low	Very low
Game birds	Medium	Low	Very low
Cattle	Medium-high	Low	Low
Deer	Low	Low	Very low
Antelope	Medium	Medium	Low
Horses	Medium-high	Low	Very low
Sheep	Medium-high	Low	Very low

Ecological Type: Sandy

Seral Stage 4

This seral stage represents the high intermediate seral of the sands ecological type (SP01). It includes a dominance of perennial grass vegetation and an increase in soil carbon contents over seral stages 1, 2 and 3.

Vegetative Composition

The following table shows the dominant plant species found on seral stage 4 of the sands ecological type (SP01) and their average percent cover and percent frequency for all sites sampled.

Life Form	Species	Average Percent Cover	Average Percent Frequency
Shrub	Sand sagebrush (Artemesia filifolia)	2	10
Grass	Blue grama (Bouteloua gracilis)	22	81
Grass	Three-awn (Aristida purpurea)	5	27
Grass	Buffalo grass (Buchloe dactyloides)	4	24
Grass	Sand dropseed (Sporobolus cryptandrus)	3	26

Grass	Sideoats grama (Bouteloua curtipendula)	2	9
Grass	Western wheatgrass (*Pascopyrum smithii*)	<1	6
Grass	Silver bluestem (Bothriochloa laguroides)	<1	1
Grass	Needle-and-thread (*Stipa comata*)	<1	2
Grass	Six-weeks fescue (*Vulpia octoflora*)	<1	5
Forb	Western ragweed (Ambrosia psilostachya)	1	10
Forb	Annual sunflower (*Helianthus annuus*)	1	5
Forb	Scurfy pea (Psoralidum tenuiflorum)	1	7
Forb	Globemallow (Sphaeralcea coccinea)	1	13
Forb	Horse-weed (Conyza canadensis)	<1	3
Forb	Russian-thistle (*Salsola iberica*)	<1	2

Relationship to Other Seral Types

This seral stage represents the high intermediate condition under current grazing management. Blue grama occurs at moderately high cover and frequency. It is distinguished from seral stage 3 by a decrease of buffalograss. It is distinguished from seral stage 5 by the lower amount of blue grama.

Disturbance relationships

This seral stage is maintained by grazing systems that benefit warm season grasses. Spring grazing (May-June) helps to maintain the blue grama dominated system. Increased grazing may move this to an earlier stage. A change in grazing may increase the amount of blue grama cover and move this stage to seral stage 5. Soil disturbance or removal of the surface topsoil will initially move this stage to an annual forb dominated system and then more than likely to a sand sagebrush stage (Seral Stage 1).

Vegetative Structural Diversity

Component	Rating
Hiding cover 0-3 inches	Moderate-high
Hiding cover 3-12 inches	Low-moderate
Hiding cover 12-25 inches	Low
Shrub density	Low
Perennial grass and forb density	Moderate-high
Annual grass and forb density	Low-moderate

Animal Food Forage Values

Animal Class	Grasses	Forbs	Shrubs
Small mammals	Medium	Low-medium	Low
Songbird	Medium	Low	Low
Game birds	Medium	Low-medium	Low
Cattle	Med-High	Low	Low
Deer	Low	Low	Very low
Antelope	Medium	Medium	Low
Horses	Medium	Low	Very low
Sheep	Medium	Low	Low

Ecological Type: Sandy

Seral Stage 5

This seral stage represents the late seral sands under current grazing management. This stage is not an undisturbed late seral stage but represents a late seral plant community under current grazing use and past history of this ecological type. In general, it is distinguished by a high cover and frequency of blue grama, high carbon contents in the surface soil, and stable surface soils.

Vegetative Composition

The following table shows the dominant species found on seral stage 5 of the sands ecological type and the average percent cover and percent frequency for all sites sampled.

Life Form	Species	Average Percent Cover	Average Percent Frequency
Shrub	Sand sagebrush (Artemisia filifolia)	1	4
Grass	Blue grama (Bouteloua gracilis)	43	97
Grass	Three-awn (Aristida purpurea)	2	12
Grass	Buffalo grass (Buchloe dactyloides)	2	14
Grass	Sideoats grama (Bouteloua curtipendula)	1	6

Grass	Sand dropseed (Sporobolus cryptandrus)	1	11
Grass	Western wheatgrass (*Pascopyrum smithii*)	<1	4
Forb	Western ragweed (Ambrosia psilostachya)	<1	2
Forb	Annual sunflower (*Helianthus annuus*)	<1	4
Forb	Yellow sweet clover (*Melilotus officinalis*)	<1	3
Forb	Indian wooly wheat (*Plantago patagonica*)	<1	6
Forb	Globemallow (Sphaeralcea coccinea)	<1	11

Relationship to Other Seral Types

This seral stage represents the late seral stage under current grazing management. Blue grama occurs at high cover and frequency. It is distinguished from earlier seral stages by the low abundance of three awn and sand dropseed. It is distinguished from seral stage 3 by the low abundance of buffalograss.

Disturbance relationships

This seral stage is maintained by grazing systems that benefit warm season grasses. Spring grazing (May-June) helps to maintain the blue grama dominated high seral vegetation. A change to earlier seral stages is recognized by a reduction of blue grama, and generally an increase in sand dropseed, red threeawn and increase in exposed soil.

Vegetative Structural Diversity

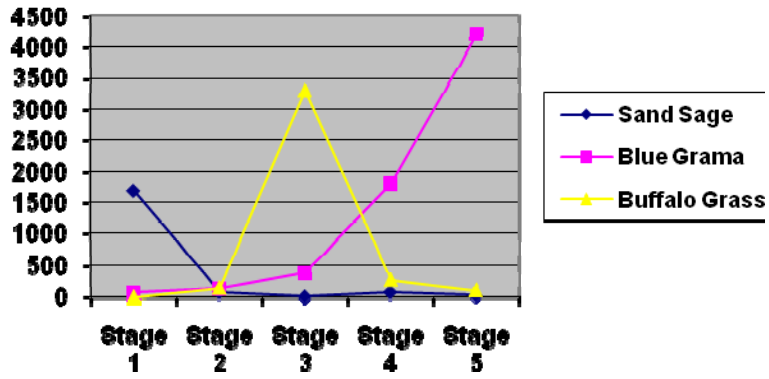
Component	Rating
Hiding cover 0-3 inches	High
Hiding cover 3-12 inches	Low-moderate
Hiding cover 12-25 inches	Low
Shrub density	Low
Perennial grass and forb density	High
Annual grass and forb density	Low

Animal Food Forage Values

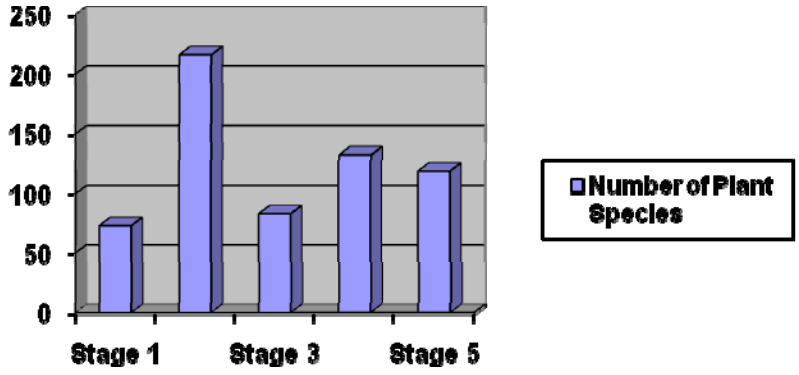
Animal Class	Grasses	Forbs	Shrubs
Small mammals	Medium	Low	Very Low
Songbirds	Medium	Low	Very Low
Game birds	Low	Low	Very Low
Cattle	High	Low	Low
Deer	Low	Low	Very Low
Antelope	Medium-high	Medium	Low
Horses	High	Low	Very Low
Sheep	High	Low	Very Low

Summary Information Sandy

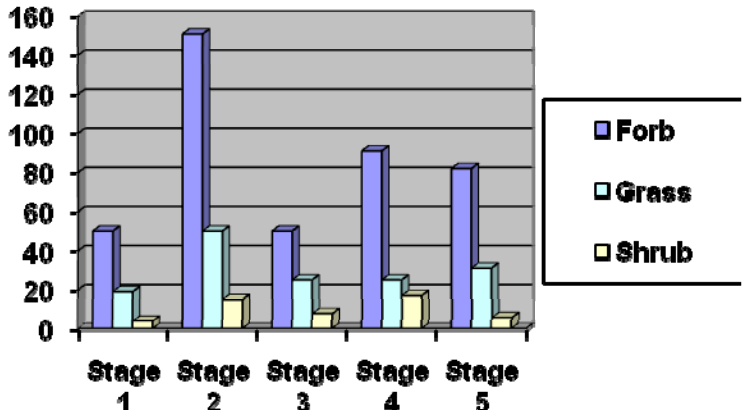
Average CFI (% cover X % frequency) of indicator species for each seral stage



Number of plant species recorded for each seral stage. The number of species may be influenced by sample size.



Number of species by plant life form for each seral stage. The number of species may be influenced by sample size.



Expected/Targets for Vegetation Communities at Sand Creek

Lowland Communities (The historical reference communities were discussed above.)

The **Wetland** community is close to what I would expect the community to be and will not take material intervention or special management to create the communities that is representative for the area. The plants that should be there are largely present. Perhaps, the community size could increase if the hydrology of the area attains it potential or near it. When the communities across the site begin to catch and hold more water, a process called interflow moves water form upland and bench positions toward the lower geographic positions creating bank storage of that water. This would enhance the wetland and the stream area, as well as, those plant communities proximal to the stream (**overflow, salt meadow, and sandy salt flat**). When more bank storage happens there is a greater tendency to cause stream flow and/or create riparian vegetation with

greater woody plant representation and greater diversity of plant species, especially forbs. This would be beyond the conditions the probably existed at the time of the massacre but within the realm of "**range of natural variability**". With this "enhanced" condition there would be greater green forage season for grazers of every kind and more bird and amphibian species. Most guests to the Monument would find these communities and their associated animals attractive. However, these are communities that were grazing "adapted" communities and they accumulate large amounts of biomass quickly creating an excessive build-up of "old dead" materials suppressing the growth of all herbaceous species. This will require periodic intervention to remove the biomass and to stimulate the grasses to tiller to maintain their viability. Periodic grazing and or mowing of fire will be tools to remedy this situation. In any case the application of tools must be done advisedly applying moderate grazing frequently (annually) or heavy grazing infrequently (every 3-4 years) or mowing every 2-3 years or infrequent fires (every 10-20 years) These tools are not ecologically surrogates for one another and have different affects. E.g. fires applied at the frequency of mowing would dry the sites out through the loss of plant cover, damage woody plants and perhaps loss of plant crown material and causes decomposition of soil organic matter. Fire does increase the diversity of plants, especially forbs. The responding plants are lower and mid-seral plants that are part of the communities' range of natural variability. Mowing would materially cause negative impacts on woody plants.

The **Sandy Salt Flat** ecological sites are prominent adjacent to the stream course but on the first terrace. The sandy slat flat is, by far, represented by more acreage on the Sand Creek site. It is north and east of the creek bed and is the likely site for most of the Native American encampments. The vegetation would have been dominated by alkalai sacaton and four-winged saltbush with a variety of tall grasses and western wheatgrass. This type is largely intact on the Site but is not nearly as diverse and it could/should be. This ecological site is productive and potentially diverse. The salinity limits its diversity in xeric conditions. Augmenting the water availability through bank storage would foster diversity. Excessive vegetation removal would reverse this relationship.

Salt Meadow type is a habitually more mesic site that the site discussed above. It would have water in the soil profile the greatest portion of the time. This provides greater resources for plant growth and provide for more diversity that would be typical of the Sandy Salt Flat. The overall productivity would be greater and would host willows or cottonwoods here. This site would also require thatch removal to maintain its integrity and productivity. The area on the north side of the Creek south of the old headquarters was farmed. It overlapped the salt meadow and the overflow site. This area had good soils with high organic matter content and a high water table most of the time. The disturbance here will be evident for a long time. However, the apparent brevity and the high resource availability will allow this area to recover and a rate beyond the other cultivated areas on the Monument.

The **Overflow** site is similar to the Salt Meadow type but does not have appreciable salts in the soils. This eliminates the competition from the soil solution for water and allows great plants *growth and a greater diversity of plants, especially woody plants and forbs. This site has the* greatest potential of any site on the Monument and will have the greatest appeal to guests. It is also one that can be damaged by excessive trampling and traveling. The cottonwoods present are on this site and there is greater potential for expansion beyond what is currently present in both quantity and diversity. This would have been core to the encampment but more sparse that the current community. The understory woody plants are currently under represented. These will come as the conditions foster their presence in the stand.

Upland Communities

Sands ecological site is the most productive and the potential the most diverse of the upland types. This type has deep soils and high water availability relative to the other sites. This allow for more mesic species and great diversity of plant s to inhabit this site. Tall water season plants like sand bluestem and switch grass should be the dominant grasses on this site. However, drought and poor grazing practices likely caused the decline in these species. However, they are present and have the capability to reoccupy the site, rapidly. This site is quite dynamic but quite fragile if the perennial cover is lost. It needs frequent (annual to biennial)) light to moderate defoliation to maintain its resiliency of the grasses. Because this site is steep and rough it really only lends itself to grazing applications. Fire on this type removes cover and exposes its rapid erosion and is detrimental to many species that occupy the site. This site is by far the most fragile to fire applications. Blowouts form rapidly and can take tens of years to repair. This site is also not compatible with frequent travel.

The **Sandy** ecological site is on the south side of the Monument. Approximately ½ -2/3 of this site have been farmed. This site has a shallow sandy horizon over claypan subsoil. This causes it to be less productive and more xeric than the typical Sandy site in Eastern Colorado. In many places the sandy mantel has been lost exposing the claypan creating a playa situation where there is standing water after precipitation events. This does create diversity not common to this type for plants and animals that can use this short-term free water. The potential vegetation on the site normally would be blue grama mixed with tall grasses but the restricted soils depth reduces the tall grass potential greatly. This site is also fragile and should see limited travel. The grasses present are tolerant; in fact thrive under moderate grazing use. This site probably needs planned defoliation to maintain it integrity but care should be made to keep the grazing interval short and recovery periods long.

Loamy ecological sites on the Monument can be split into farmed areas, native remnants and prairie dog towns. This site is normally the dominant site on the prairies of Eastern Colorado. However, the sites and the conditions of the vegetation on the Monument offer small views of the native vegetation. This type is resilient to all type of ecological pressures. The short grass

phase with primarily blue grama and buffalo grass is very stable but not productive or diverse. The prairie dog disturbed areas are, at times devoid of vegetation and in the best of times have a great deal of bare ground. These areas, however, host a large number of other animals and provide key habitats for them. They also represent areas that can recover with amazing speed to lower or mid-seral community when high rainfall coincides with change in prairie dog density. This is likely to happen at some time because of the presence of plague on the plains of Eastern Colorado. It causes recurrent losses of individual towns fallowed by dynamic recovery of vegetation. This has the appearance of a boom and bust scenario. Most plague affect towns do not lose all of the inhabitants and recovery relatively quickly. The potential curse to these natural phenomena is the risk of invasion by some unnamed but pernicious weed that will require intervention to prevent it from occupying the town and beyond.

The farmed area is discussion in tangent above. The soils have been altered and will for a very long time not be capable of supporting a native community on this part of the Monument. The best strategy is to foster a perennial cover of as many native plants as possible to create a community “moving toward” some similar community in the array of native communities possible on the loamy site. The current weedy component will subside over time as nutrient, primarily nitrogen is reduced in its turn-over rate and begins to approach the natural range of variability found in the intact community. All the sites above are tolerant, in fact favored by moderate grazing use.